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TRANSACTIONS

OF THE

WISCONSIN ACADEMY

OF

SCIENCES, ARTS, AND LETTERS

VOL. X

1894—1895

Edited by the Secretary

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ORIGINAL PAPERS.

THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS.

PROCEEDINGS OF THE ACADEMY.

EMENDATIONS.

p. 2, line 7 from bottom before sign of equality insert (
p. 10, line 5 from bottom, transpose Reed and Read.
p. 10, line 2 from bottom, for "*Reed*" read *Read*.
p. 11, line 1, for "Reed" read Read.
p. 11, line 6, for "*reed*" read *read;* for "*green, grene*" read *leef*.
p. 11, line 7, for "*green*" read *leaf*.
p. 11, line 1 of table, for "Reed" read Read.
p. 15, line 1, for "cephalotherax" read cephalothorax.
p. 26, line 6 from bottom, for "the the" read the three.
p. 28, second integration, in limits, for "x" read z.
p. 28, eighth and ninth integrations, in upper limit, for "x" read z.
p. 33, in fourth formula, for "$>$" read $<$.
p. 40, add the following note:

GRAPHICAL APPLICATION.

The application of the general equation (1) may be made graphically, by a method which may be briefly outlined as follows:

Let a curve be drawn of which the ordinate at any point represents the total load from the head of the train up to that point. From the points A, B, C, D (Fig. 1, 2, 3, or 4) draw vertical lines, intersecting the curve in points a, b, c, and d respectively. Then whenever equation (1) is satisfied, the straight lines ab and cd (produced if necessary) intersect in a point lying on the vertical line through F.

In a paper presented to the American Society of Civil Engineers (Transactions, Vol. XXII), Professor H. T. Eddy gave graphical constructions for determining the position of the train for maximum stress in any member of a truss with both chords horizontal. The construction above outlined includes these as special cases and applies also to all members of a truss with curved chords. This general construction would probably not have occurred to the present writer had he not read Professor Eddy's paper.

p. 42, line 20, for "*soun*" read *sound.*
p. 43, line 2 from bottom, for "Berkley" read Berkeley.
p. 44, line 8, for "except on the gallows where he should hang read except where he should hang—on the gallows.
p. 46, line 15 from bottom, before snakes insert venomous.
p. 48, line 4, for "Cecelia's" read Cecilia's.
p. 48, line 11 from bottom, for "it" read that.
p. 51, line 17 from bottom, for "sable" read sables.
p. 76, line 31, after "*ludoviciana*" insert a comma.
p. 78, line 25, after "*Piranga rubra*" insert a reference-figure [1]
p. 83, line 22, for "*furcescens*" read *fuscescens.*
p. 83, line 28, for "Farm" read Farms.
p. 85, line 21, for "*Cucophrys*" read *leucophrys.*
p. 90, line 2, for "fewer" read less.
p. 92, line 18, for "*œestiva*" read *œstiva.*
p. 117, line 13, for "Sune" read June.
p. 129, line 17, for "singign" read singing.
p. 132, line 21, dele "narrow."
p. 158, line 16, for "meadow" read meadows.
p. 158, line 18, for "Farm" read Farms.
p. 228, line 21, for "5 cm." read .5 cm.
p. 229, line 17, for "igenous" read igneous.
p. 239, line 7, for "hymenopteras" read hymenopters.
p. 248, line 14 from bottom, for "Dendryphants" read Dendry phantes.
p. 249, line 12, for "vittila" read vittata.
p. 264, line 3, for "soeiety" read society.
p. 264, line 21, for "Hustings" read hustings.
p. 268, line 6, for "gentleman aud" read gentlemen and.
p. 268, line 8 from bottom, for " ges" read judges.
p. 282, line 15, after is, insert there in.

p. 284, line 21, after though, omit that.
p. 285, line 7, for "or" read of.
p. 285, line 8, for "effect" read affect.
p. 291, line 4, for "said" read aids.
p. 299, line 1 from bottom, for "ca" read can.
p. 308, line 25, for "husbard" read husband.
p. 315, line 11 from bottom, for "replacable" read replaceable.
p. 325, line 12, for "less" read lest.
p. 339, line 3, for "corrode" read corrade.
p. 359, line 9, for "agent" read agents.
p. 393, line 10 from bottom, for "measure" read measures.
p. 398, line 7, for "n" read in.
p. 398, first foot note, insert reference figure [1].
p. 405, line 5, for "join-tstock" read joint-stock.
p. 414, line 6, omit either.
p. 561, as Curator read G. E. Culver, State Normal School, Stevens Point.

ENGLISH SURNAMES.[1]

ALBERT H. TOLMAN, PH. D.,

Assistant Professor of English Literature in the University of Chicago.

What's in a name? As was remarked by a school-boy who was ambitiously attempting to quote Shakespeare, "A nose by any other name would smell as much." There is a great deal to interest one, however, in names, even in those which are apparently the most arbitrary and meaningless of all, surnames.

Two points in connection with surnames have been of especial interest to me: first, the record of former stages of civilization that is preserved for us in our surnames taken from occupations; and second, the illustrations of the laws of sound-change in the English language which are offered us by many surnames whose original forms are known. This second point deserves to be worked out systematically in the light of our present knowledge of the history of English sounds. Perhaps no class of words show the phonetic laws of our language more plainly than do surnames. These names early and easily became *mere* names, having for their users no inherent meaning. Indeed, surnames *originate* by disregarding the meaning of some personal name. When a name given to a father in baptism as his personal name, or given to him by common consent as a descriptive designation, is applied to his children and his children's children without reference to its original meaning, the name has become a surname. All surnames originate in this way. When a man who was originally called Robert's-son because the personal name of his father was Robert, has a child born to him to whom the name Robertson is given in disregard of the fact that its father's personal name is not Robert, then the name has become a surname. Because surnames have ceased to have any inherent

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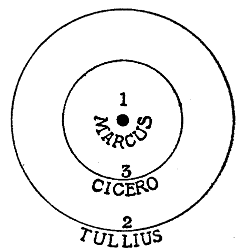
[1] This paper was written at the city library, Springfield, Mass. It was my intention to revise it at the Boston public library, but I have been unable to do so.—A. H. T.

meaning, their phonetic development has been very largely free from those disturbing influences of analogy which have often affected the ordinary words of the language. I hope to give a few illustrations of this point.

The first characters in Bible history — to begin at the beginning — have each a single name, Adam, Seth, Enoch. As the earth became more fully populated, individuals of the same name came to be distinguished from one another by additional names. These second names were personal and descriptive; they were not proper surnames. Joshua the son of Nun, Simon Barjonas, afterward called Simon Peter, Simon of Cyrene, and "Simon called Zelotes," are instances of these additional, personal names.

The well-known Roman system of naming was very elaborate. Let us put down a dot upon our sheet, and number it 1; around this dot as a centre let us draw first a smaller circle, numbered 3; and then a larger circle, numbered 2. The resulting figure will be a good symbol of the Roman system of personal nomenclature. The person whom we call Cicero was of the *family* of Cicero; this family was a division of the Tullian *stock*, or *clan;* the personal name of the great orator was Marcus. We must call him, for short, either Tully or Cicero; since there were many famous men named Marcus.



No surnames existed in Great Britain previous to the Norman Conquest. The *second*-names that are found before the Conquest are purely personal *nicknames.* No better examples of these can be found than those given in the table of the English kings: Harold Harefoot, Alfred the Great, Ethelred the Unready = lacking in good counsel), Edward the Confessor, Edmund Ironside.

The Normans brought the use of surnames into England. The fashion was a new one in Normandy itself; and no surnames in the Teutonic nations were in use much before 1066. The Normans were proud of owning much land, and took their surnames from their large estates in Normandy or their new possessions in

England. Bruce, Percy, Montgomery, and Montmorice are Norman place-names. The French *mont*, mountain, is seen in two of these. The use of surnames was at first confined to the nobility. The practice did not become general among the common people of England until the fourteenth and fifteenth centuries.

There are four great classes of surnames, as follows: first, *place-names;* second, those derived from the Christian, or baptismal name of the father, or, in some cases, from that of the mother; third, surnames derived from occupation, rank, or official position; fourth, those which were originally nicknames. Rev. C. W. Bardsley gives [2] the result of a careful analysis of all the names in the London Directory which begin with A, B, C, D, or E. The total number of names examined was over 30,000. I turn his figures into percentages.

Surnames originally place-names	37.5 per cent
Derived from baptismal names	27. per cent
From rank, office, or occupation	14.5 per cent
Originally nicknames	10.2 per cent
Foreign and doubtful	10.8 per cent
	100.

In another work Mr. Bardsley says: "In England our *local* surnames are two-fifths of the whole. In France *patronymic* [baptismal] surnames are almost two-fifths of the whole."

Let us give attention for a few moments to each of the four great classes of surnames.

PLACE-NAMES.

Names beginning with *At* come from a prepositional phrase; as, At (the) well, At (the) wood, Atwater, Atterbury, etc. Nash is from atten-ash, i. e., at the ash. Local names of French origin often begin with Dela-, Del-, or Du-; as in Delamere, Delisle, Dupont. Van and Von are Dutch and German prefixes of place. Buren in Holland, for example, gives the name Van Buren. Wood, Shaw, Holt, Hurst (all having much the same meanings), Thwaite, Thorp(e), Den, Comb, Gate(s), Down(s), Croft, and Clough are all local designations of known meaning.

[2] "English Surnames," 3d Ed.

Many of them are used much more frequently as parts of compound words than as independent names; as in Bradshaw, Henshaw, Lyndhurst, Denman. An old but inaccurate proverb says:

> "In *ford*, in *ham*, in *ley* and *ton*,
> The most of English surnames run."

All such names are place-names. The independent, *accented* words *home* and *town* go back to the same words as do the *unaccented* suffixes *-ham* and *-ton*. Lee (a shelter) and lea (a pasture) explain -ley as a suffix, and also the names Leigh, Lee, Lea, etc. *Lea* is also a Celtic river-name we have one River Lea at London; another flows into Cork Harbor. Hence *Lee* as a place-name may have three separate sources. The names of small towns are more apt to furnish place-names than those of large cities like London. Such names were more distinctive, and the movement of population was toward the cities. We see the English counties in such names as Kent, Norfolk, Lincoln.

The syllable *-ing* was the Anglo-Saxon patronymic suffix, meaning *son of*, and then *descendant of*. "A whole clan or tribe," says Isaac Taylor, "claiming to be descended from a real or mythic progenitor, or a body of adventurers attaching themselves to the standard of some chief, were thus distinguished by a common patronymic or *clan* name."[3] The Anglo-Saxons seem to have settled in England by families; and these clan-names gave rise to place-names, such as Barking, Dorking, Hastings, Kensington, Wellington, and Banningham. More than one-tenth of the towns and villages of England contain this syllable in their names. These places have in turn produced surnames. The clan-names of the Scotch have passed into surnames directly, without first becoming place-names.

In the fall of 1888, when in the Black Forest of Germany, I noticed that the eastern border of my map of that region contained many places ending in *-ingen*. I at at once connected this suffix with the English *-ing*, plural *-ings*. But I did not then know that this suffix is found abundantly in the names of places nowhere in Europe except in England, in northern France, and in he district on the edge of which I then was. I was just west of

[3] Words and Places, p. 83.

the old district of Suabia, the heart of which is the modern kingdom of Würtemberg, or better, the region around the head waters of the Neckar and Danube rivers. Baedeker's map of the country lying between the famous Tübingen on the Neckar, and Ulm on the Danube, has the names of twenty-three of the more important places printed in capitals; eleven of these end in *-ingen.* I judge that one-half of the names of towns and villages on this map have this ending. Taylor in *Words and Places* holds that a comparison of the English and Suabian place-names is a sufficient proof that England and Würtemberg were settled by the same Saxon stock. This fact is otherwise unrecorded.

SURNAMES FROM BAPTISMAL NAMES.

The custom of giving to a child the Christian name of the father with the word *-son* or *-daughter* added thereto, as a personal, descriptive second-name, has been a favorite one in Scandinavian countries. This custom was recently observed in the Shetland Islands, where the inhabitants are of Norwegian blood; and it may still be in force there. The names John Magnus'-son and Magnus Johnson, for example, marked successive generations in Shetland. A sister of Magnus Johnson would be known as "Mary, John's-daughter." Such a fluctuation as this marked the first use of patronymic names in *-son* in England and Scotland. For example, Richard Johnson, son of John Richardson, is named in an English document of 1402. The possessive (')s has the same meaning as *-son*, as in Williams.

I cite a passage from a standard work concerning the use of such names at the present time in Norway and Sweden:

"I alighted at a farm called Husum [in southwestern Norway], and was welcomed by old Roar Halvorsen and his family, which consisted of Roar Roarsen, his eldest son, Haagen, Iver, Halvor, and Pehr, and two daughters, Sönneva and Sigrid. The way of keeping family names is very peculiar among the bönder [farmers] of Norway and Sweden. For instance, the head of the family of Husum is Roar Halvorsen (Roar, the son of Halvor); the eldest son, as we have seen, is called Roar Roarsen;

and all the other children, whatever the first names may be, have added the name of Roarsen or Roar's datter; then the eldest grandson's name goes back to that of the grandfather, and by this method the family name is preserved for generations."[4]

The following fact came to my notice while I was writing this paper: Mr. Holver Thompson, a Norwegian, the son of Thomas Holversen, died at Doylestown, Wis., in 1891. I feel sure from this fact and from similar instances of which I have learned, that there are many Scandinavians in the United States whose last names are not proper surnames, *or at least were not given to them as such.*

By a patronymic surname is meant, the personal name of the father used, either alone or with some prefix or suffix, as the surname of a son and then of the descendants of that son. A large number of the most common surnames that we have are of this class, such as Jones (John's), Davi(d)s, Williamson, Johnson, etc.

It would be useless for me to name one in a hundred of the common names of this class; but a few facts firmly grasped will enable any one to understand a vast number of names which will be left unmentioned.

The Scotch and Irish prefixes Mc- and Mac-; Ap-, a Welsh prefix; and Fitz-, a Norman one; all mean *son of*. The Anglo-Saxon patronymic suffix -ing has already been mentioned. The Irish O' is said to mean properly grandson of, as in O'Brien, grandson of Brien. The O' represents a Celtic word, not the English *of*. Perhaps the presence of the Welsh prefix Ap- explains as large a number of otherwise inexplicably disguised surnames as any other single fact. The names Parry and Barry (from Ap- Harry), Perry (Ap- Henry), Bowen (Ap- Owen), Pritchard (Ap- Richard), Bevan (Ap- Evan), Bethel (Ap-Ithel), Powell (Ap- Howell), suggest the way in which many more words are explained. The present professor of Celtic at Oxford University is named Rhys. This name is said to mean rushing, impetuous (compare English Swift); it explains our Reese, Breese (from Ap- Rhys), and many similar forms. The same name taken into English before our long i took its modern

[4] Du Chaillu's "Land of the Midnight Sun." 1881. Vol. I, p. 391.

diphthongal sound (i. e. before the fifteenth century), explains Rice, Price, Brice, Bryce, etc. The royal name of *Tudor* is a Welsh form of Theodore.

The Old-English (Anglo-Saxon) personal names were abandoned for the most part at the time of the Norman Conquest; Edward and Edmund were, perhaps, the most common ones that remained. Norman personal names, including many names of saints from the church calendar, now came into use. Hence, these are the source of our patronymic surnames.

After the Norman Conquest the fashion of making *pet-names* out of common personal names became universal. We are all familiar with this tendency to-day; but nothing that we now know can give us any idea of the vast number of pet-forms which at that time were made from well-known personal names, or of the extent to which they were used. The diminutive and affectionate suffixes –ie or –y (still in use), –kin, –cock, –ot or –et, –on, –en or –in, were in constant use, and help us to unriddle many a strange-looking surname. Wills, Willy, Willis, Wilson, Wil(lia)mot, Willot, Willet(s), Wilkins, Wilkes, Wilkinson, Wilcox(–cocks), Wilcoxson are all names which go back to different pet-forms of the name William. Hewett (Hugh), Collins (Col, from Nicholas), and Simpkins (Sim, from Simeon) are as plain as they are common.

The fashion of making *rhyming* pet-forms will explain many more names. Rob, Bob, Hob, and Dob are derived in this way from Robert. Hence such names as Bobson, Hobbs, Hobson, Hopkins, Dobbs, etc., are as clear as Roberts and Robinson; and we must add to our list of common names derived from William, Bill, Bills, Billson, Gilson, etc. Ralph has many names connected with it through pet-forms, that are not at first clear, such as Rawson, Rawlin(g)(s), Randall, Rollins, etc.; and Richard has some names that no one would at first thought assign to it, such as Rix, Rickson, Dixon (Dick's son), Dickens, Hitchcock. Bates, Batty, Bartlett, and many other forms go back to Bartholomew.

Drew, Warin (giving Warren, etc.), Paine, Ivo, and Hamon (giving Hammond) are some personal names that were common after the conquest, but are now out of use.

The crusades gave a great impulse to the use of the name John, with reference to John the Baptist. John was the most common English personal name from 1300 to 1700. The other name of the Baptist, Elias, also became very popular; Ellis, Elliot, Elkins, etc., show this. The river Jordan, inseparably associated with John's labors, became a popular personal name, and then a surname. Judd (giving Judson) is thought to be a pet-form of the word.

Jack (French *Jaques*, *Jacques*, from Latin *Jacobus*) was not properly a pet-form of John, but was always looked upon in England as a more familiar form of that most common of names. Hence *Jack* is found everywhere in our common speech, and shows us how natural, even instinctive, the process of personification is to the popular mind. We have Jack everywhere in folk-tales, in Mother Goose, and in popular proverbs. We have such words as jackanapes, Jack-o'-lantern (the rival name William appears in the rival term Will-o'-the-wisp), Jack-of-all-trades, jack-ass, jack-daw, jack-knife, boot-jack, jack-et, and so on through an endless list. Jackson is a very common surname.

Some names are *metronymics*, or surnames made from the personal name of the *mother*. Adoption, posthumous birth, the higher rank of the mother, and similar causes explain the origin of these names; but undoubtedly they were often applied to illegitimate children. Emmett (Em), Sisson (Siss, from Cicely, Cecilia), Tillotson (Til, from Matilda), and Nelson, are common *metronymics*.

The Puritan movement brought in a change in the fashion of personal names almost as marked as that following the Norman conquest. Old Testament names, the Christian graces, and motto-names, which were often condensed prayers (Standfast, Livewell), indicate the new fashion. But surnames were already fixed, and some additional personal names, such as Josiah, Rachel, Hope, Faith, and Prudence are all that is left us from that convulsion in our nomenclature. Said one writer, with amusing exaggeration: "Cromwell hath beat up his drums clean through the Old Testament; you may know the genealogy of our Saviour by the names of his regiment. The muster master hath no other list than the first chapter of St. Matthew."

It should be said that the use of *two* Christian names, now so common, was an unusual thing before 1800. The heroes of the Revolution were content with two names each, including the surname. George Washington and Thomas Jefferson are examples. These names serve merely for the *beginning* of some modern names.

SURNAMES OF RANK, OFFICE, AND OCCUPATION.

From the frequency of the name King, one might think that "kinging it" was at one time a very common occupation in England; but the name is, of course, always a nickname, having at least three different sources, and belongs properly in the next class. In the first place, a person with a haughty bearing sometimes found himself dubbed King, much against his will.

The name of Shakespeare's comedy, "Twelfth-Night," calls to mind the festivities which marked the twelfth day after Christmas, or Epiphany. The three wise men, whose visit to the Saviour was commemorated at that time, were known in legend as "the three kings." A person who took the part of one of these royal visitors in a rude Twelfth-Night representation of the coming of the Magi, might henceforward be called King. Again, the old English custom of marking shops as well as inns with some distinctive sign, and the known popularity of "crowned heads" for use upon sign-boards, makes it almost certain that King sometimes meant originally at-the-sign-of-the-king.

Of the names derived from occupation, I will select a few which need special explanation. Day means dairyman. Chapman means the same as merchant (Kaufmann); his goods were *cheap*. Clark was a clergyman, or one who, like a clergyman (clericus), was a scholar. The Barbers were also surgeons. Fletcher was an arrow-maker (*la flèche*, an arrow). Scribner was a writer (scrivener) by trade. The Arkwright made the great chests, called "arks," in which the family valuables were kept; or less elaborate ones used as bins for the family flour. Bagster and Baxter (bake-ster) were plain Bakers; -ster originally denoted a woman, as in spin-ster, but lost that special meaning.

Let us put together names that come from the manufacture of cloth. These will help us to call back a time when homespun cloth was manufactured in every part of England. The Spinners and spinsters spun the thread. The spinsters, as such, have not given us a surname. The Webbs, Websters, and Weavers wove the thread into cloth. The Fullers trod the cloth with the feet in cleansing it; hence a common name for a fuller was Walker. Walker may sometimes be a nickname; the mighty leader of the Normans was called Hrolf (Rollo) the Ganger (= walker). The Tuckers and Tuckermen were engaged in the manufacture of cloth (cp. the German *Tuch*); but whether they were weavers or fullers is uncertain; probably they were weavers. If the cloth was sold to merchants, it came into the hands of Drapers, Mercers, Chapmen, Merchants, Marchants, etc.

Bailey, Baillie, was a bailiff. The ancestor of the royal family of Stewart was the Lord High *Steward* of Scotland under Malcolm III. The origin of the surname was not forgotten even at the time of James VI. (afterwards James I. of England); at least he is described at his coronation as "Prince and Stewart of Scotland."

NICKNAMES.

The first point to be made in considering this interesting class of names is that they were given by acquaintances, not selected by the ones whom they designated. It is plain that no man ever chose to be known to the world as Wild, Savage, Crook-shank(s) (Cruikshank is a less suggestive spelling), or Longfellow. Hog(g) may have taken his name from the picture on the sign before his door; but undoubtedly in some cases he was dubbed with an opprobrious nickname.

Ames is from an old word meaning uncle. Power(s) is a doublet of Poor.

In considering the names that came from the complexion, we are surprised that *redness* of face seems to be unregistered in our common names. But Reed, Read, Reid, etc., are abundant evidence that ruddy complexions were not wanting in the Middle Ages.

None of the comments that I have seen upon this name *Reed* clearly states the fact that *red* is the word that has been irregular in its development. *Reed* is the regular phonetic successor of the Middle-English word *reed*, in the indefinite form of the adjective, or *rede* in the definite form. Either of these spellings in a well-spelled Middle-English MS. means that the vowel *-ee-*, *-e-*, is long in quantity. This word should regularly give modern English **reed;* as Middle-English *green*, *grene*, has given modern English *green*. During the eleventh and twelfth centuries especially, long accented vowels became shortened before two or more consonants.[5] Hence we have such different vowel sounds in words from the same stem as we find in:

wise,	wisdom,
white,	Whitsunday, Whitman, Whitefield.

But the influence of analogy has been constantly at work to obliterate the traces of the working of this phonetic law. Usually we have what is called "leveling." All the forms take the same vowel sound, either the long vowel of the simple word or the short vowel of the derivative or compound. Phonetic action is followed, so to speak, by a mental reaction, according to the law which Paul has fully illustrated in his *Principien der Sprachgeschichte.* In the following table, Anglo-Saxon forms are put in brackets; forms which have been altered by leveling are put in parentheses:

Reed	redness	sheep	shepherd
	(red)	stone [stân]	Stanton
keep	kept	home [hâm]	Hamwell
	(friend)	(homeward)	Hampton
	friendly		Hampden
white	(sick)		The form *hamward* occurs in Middle-English.
(whiteness)	sickness		
house [hûs]	husband		
		broad [brâd]	Bradshaw
			Braddon
			Bradford

One word in the list calls for comment. *Broad* should regularly have the same vowel-sound as do *stone* and *home*. I would suggest that *broad* has been influenced by the vowel of *long*, with which word it is closely associated in popular speech. "It's

[5] See Kluge, Hist. of Eng. Lang.; Paul's Grundriss der germ. Philologie, I, p. 868.

as *broad* as it is *long.*" A somewhat analogous influence of *far* upon *near* seems to have caused *near*, originally a comparative, to be looked upon as a positive.[6]

Place-names and surnames sometimes contain a vowel which has remained short, though the simple word afterwards experienced vowel-lengthening.

> old [from *âld*, lengthened regularly from the Mercian **ald.* See Kluge, Paul's Gr., I., p. 866. The A-Saxon *eald*, cited in our dictionaries, is the West-Saxon form of the word.]

Aldgate.
Alden.
Alford.

Another illustration of the light which surnames throw upon the laws governing the history of English sounds is given if we ask the question, What is the sound in English to-day which is the regular representative of an accented *er* + *consonant* in a word taken from French into English? The following words are a few of those which show this combination:

merchant	**Merchant, Marchant.**
person, parson	**Parsons.**
clerk, English pronunciation *clark*.	**Clark.**

The surnames Parsons and Clark seem to show what is the regular sound-product in present English of er + cons. in a word taken from French into Middle-English. The knowledge of the French and Latin forms on the part of the learned seems to have influenced decidedly the ordinary English words, and even the surnames in some cases.

Black, White, and Brown(e) are probably complexion-names; though complexion-names can not be separated from those derived from the color of the hair or of the clothing. Hoar must usually come from the hair; Blue, from the clothing, also Green(e) when not a place-name. Curtis was *courteous.* Silliman is a name that had originally a good meaning.

Names taken from the animal kingdom are probably often sign-names. The numberless Lions, Red Lions, Golden Lions, etc., that still exist on English signs, show how many a Lyon origi-

[6] See Skeat, Etymological Dictionary, under *near*.

nated; though, of course, any particular family with that name may have had a lion-hearted ancestor. Rountree (rowan-tree), Cherry, Ash, etc., are either place-names or sign-names.

Some very common surnames that seem at first sight hard to explain are simply common nicknames from Celtic or from French, and correspond to well-known English surnames. To Black correspond the Celtic names Dow, Duff, Duffie, and Macduff. Roderick Dhu, if his name had been taken into English before the change of û to ow, i. e., before the fifteenth century, might have become the ancestor of a race of *Dows.* White corresponds to the Celtic Bean, Finn, and Finlay; Brown, to the Celtic Dunn. Bigg, Mickle, High, etc., are parallel in English to the French Gross and Grant(grand), and to the Celtic More, Moore, Moran. English Small and Little; French Pettit, Pettee, Petty, etc.; and the Celtic Beggs,— have all the same meaning.

CONCLUSION.

Some names, especially foreign ones, have become very much changed in form. One would not at first see in Sidney, Seymour, and Sinclair later forms of the French names, Saint Denis, Saint Maur, and Saint Clair. Bunyan is from Bon-Jean (Good-John).

Popular etymology, the forcing of meaning into words which have no apparent English significance, has altered many names. To illustrate this very common process of putting meaning into words, take the phrase from Tennyson's "Northern Farmer," "Doon i' the woild 'enemies" (anemones). The word *anemone* is meaningless to the rustic, and the well-known *enemy* is made to take its place. Fox is in some cases derived from Fawkes and similar forms. These names go back to the personal name Fulke, which was borne by the paternal grandfather of Henry II, and was in common use after the Conquest. Fox is also a true nickname, denoting craftiness, as well as a sign-name. The threefold origin of this name is typical of what is true in many cases. Doolittle is confidently asserted to be in some cases a popular etymology from *de l'hotel* (from the hotel).

The number of stories connected with names is legion. I will close with a few of them.

In Scott's "Peveril of the Peak" we are told of a cross Mrs. Cresswell who bequeathed 10*l.* to be paid for a funeral sermon in which nothing ill-natured was to be said of her. The Duke of Buckingham wrote the following brief but pointed discourse: "All I shall say of her is this: she was born well, she married well, she lived well, and she died well; for she was born at Shadwell, married to Cresswell, lived at Clerkenwell, and died in Bridewell."

Praise-God Barebone, who gave his name to Barebone's Parliament, had a brother who is said to have chosen for himself the title: If-Christ-had-not-died-for-you-you-had-been-damned Barebone. His acquaintances cut this first name down to the last syllable, thus securing in "Damned Barebone" a designation at once brief, scriptural, and unambiguous.

A certain Dr. Mountain, chaplain to Charles II., was asked by the king if he could recommend a suitable man for a vacant bishopric. "Sire," he replied, "if you had faith but as a grain of mustard-seed, the matter could be settled at once." "How?" inquired the astonished monarch. "Why, my liege, you could then say unto this Mountain, 'Be thou removed into that see,' and it should be done." The witty chaplain secured the bishopric.

Chicago, Ill.

ON TWO NEW SPECIES OF DIAPTOMUS.

C. DWIGHT MARSH,

Professor of Biology, Ripon College.

DIAPTOMUS MISSISSIPPIENSIS. *Plate I, figs. 1–3.*

Of moderate size. The first two segments of the cephalothorax are nearly equal in length, and together form somewhat less than half the cephalothorax. The last segment of the cephalothorax is armed behind with two minute spines.

The first segment of the abdomen of the female is as long as the remainder of the abdomen and the furca; it is dilated laterally and in front, and bears two prominent lateral spines, the right spine being considerably larger than the left. The second segment is somewhat shorter than the third, and the third and the furca are of about equal length.

The antennæ reach beyond the furca. The right antenna of the male is swollen anterior to the geniculating joint, and the antepenultimate joint is without armature.

The outer ramus of the fifth foot of the female is two-jointed, the third joint being represented by two spines. The inner ramus is one-jointed, a little longer than the first joint of the outer ramus, and armed at the tip with minute setæ and two rather long spines.

In the right fifth foot of the male the basal joint is dilated on the inner margin. The first joint of the outer ramus is slightly broader than long. The second joint is elongated, quadrangular, with the lateral spine situated at the distal end. The terminal hook has the symmetry of the curve broken by two rather abrupt angles, and its inner margin is armed with fine serrulations. The inner ramus is one-jointed, and reaches about half the length of the second joint of the outer ramus.

The left fifth foot of the male reaches to about the middle of the second joint of the outer ramus of the right. The first joint of the outer ramus is as broad as long. The second joint is armed at tip with two finger-like processes, and both joints are armed within with minute hairs. The inner ramus is one-jointed, and nearly equal in length to the outer ramus.

Length of female, 1.2 mm.; male, 1.1 mm.

This species was found in some material kindly furnished to me by Professor E. A. Birge. The collections were made in January and February, 1893, in small lakes and ponds in Mississippi. It was the only *Diaptomus* in the collections, and was found in nearly all of them. It will be noticed that it bears a somewhat close resemblance to *D. graciloides* Sars.

DIAPTOMUS BIRGEI. *Plate I, figs. 4–6.*

Of moderate size. The first segment of the cephalothorax is nearly equal in length to the three following.

The first segment of the abdomen of the female is as long as the remainder of the abdomen and the furca. It is much dilated in front. The second segment is nearly twice as long as the third, and about equal in length to the furca. The second and third joints are very closely united.

The antennæ extend to the end of the furca. The right antenna of the male is much swollen anterior to the geniculating joint; the antepenultimate joint is produced on its distal end into a short, blunt process, which makes very nearly a right angle with the longitudinal axis of the joint.

The outer ramus of the fifth foot of the female is two-jointed, the third joint being represented by two spines. The inner ramus is one-jointed, hardly as long as the first joint of the outer ramus, and armed at the tip with minute setæ and two rather long spines.

The basal joint of the right fifth foot of the male is elongated, trapezoidal in form, its greatest breadth being at its distal extremity. The first joint of the outer ramus is broader than long, armed on its inner margin with a broad, thin expansion of the integument. The second joint is elongate, broader at base; the lateral spine is situated at about the middle of its length, is long and stout, and armed on its inner margin with fine serrulations. The terminal hook is slightly angular, and armed with fine serrulations on its inner margin. The inner ramus is one-jointed, equalling in length the first joint of the of the outer ramus.

The left fifth foot of the male reaches slightly beyond the first joint of the outer ramus of the right. The basal joint is quadrangular, considerably shorter than the right basal joint. The first joint of the outer ramus is about twice as long as broad. The second joint is slightly longer than the first joint; it is expanded at base, where it is armed with fine hairs, and terminates in a finger-like process bearing a falciform spine. The inner ramus extends to about one-half the length of the second joint.

Length of female, 1.5 mm.; male, 1.3 mm.

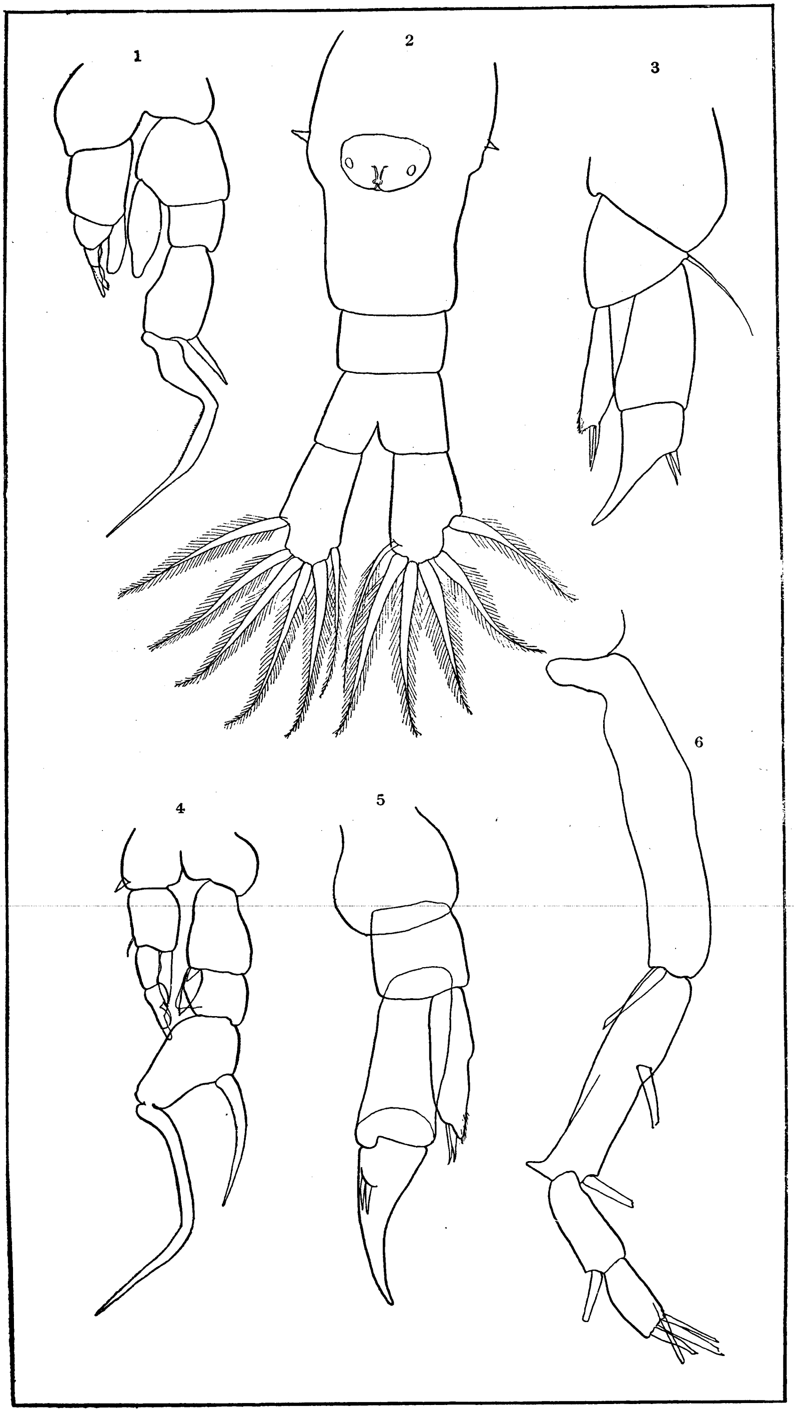
The material in which this species was found was collected by Professor E. A. Birge at New Lisbon, Wisconsin, and only a few individuals were found. I have expected to find it in the collections from other Wisconsin localities; but so far my search has been without success. It is a clearly marked species resembling the European *D. gracilis* Sars more closely than does any other described American species. The characters of the fifth feet, however, separate it from the European form.

I have taken the liberty of naming this species in honor of Professor Birge, to whose kind assistance and encouragement I have been greatly indebted.

Ripon, Wis.

EXPLANATION OF PLATE I.

Fig. 1. *Diaptomus mississippiensis*—fifth foot of male × 163.
" 2. " " abdomen of female × 163.
" 3. " " fifth foot of female × 300.
" 4. " *birgei*—fifth foot of male × 163.
" 5. " " fifth foot of female × 300.
6. " " terminal joints of male antenna × 300.



MARSH ON DIAPTOMUS.

SOME NEW JERSEY ESKERS.

G. E. CULVER.

The terminal moraine of a great ice-sheet is the dividing lin between two classes of drift deposits. On the one side the material is sorted and stratified; on the other, the ice side there is neither sorting nor stratification. The material is piled up in the most miscellaneous manner. Huge boulders and fine clay, with material of all the intermediate grades of coarseness or fineness rest together upon the same bed. This mixture is the work of the ice. The stratified beds are formed by the water flowing from the melting ice. The moraine itself is built up altogether by the ice; but its structure is somewhat modified by water action, so that here and there small areas of roughly stratified material are found.

After an ice-sheet has retreated, if the region vacated by the ice be examined, it will be found in most cases to be covered by the unstratified drift or till to depths varying from a few inches to several hundred feet. This is invariably the case in comparatively level regions like southern and central Wisconsin, southern Michigan, Minnesota, and Iowa.

In regions of greater elevation and of low mountains, it is common to find another class of deposits as well as the usual till. Near the front of the ice, but within the moraine, irregular heaps of rudely stratified sand and gravel occur. These sometimes lie singly, sometimes in groups. Occasionally these groups take on a morainic[1] aspect. These hills of gravel have been called kames by Prof. Chamberlain in distinction from another type of gravel deposits often found in the neighborhood of kames to which the term esker is applied by the same authority. The esker is a long sinuous ridge of gravel extending sometimes for many miles with but slight breaks, and crossing low ridges as

[1] Prof. Salisbury has proposed the term *kame-moraine* for this group.

well as valleys in its course. In appearance an esker is much like a large railway embankment, the main difference being that its course is quite irregular and its surface is more uneven than that of a railway embankment.

The eskers noted in the present paper are found in the northeastern part of New Jersey, a little east of the valley of the Ramapo. The district embraced is about four miles wide by eight long. The series of deposits, including not only eskers, but also other gravel bodies, lies in a broad, gentle depression extending from the point where the Ramapo enters the state, south to the neighborhood of Ramsey's, where it broadens somewhat and connects with other similar valleys, after which all turn southwestward and are noted as far as Wyckoff and Camp Gaw on the Susquehanna railroad. The disposition of all the deposits of gravel found here is to keep well down on the sides or on the bottom of these valleys. Nevertheless their elevation is not constant; and the eskers cross, at different points, small valleys and low ridges to some extent. Of the eskers proper the three best are the Ramsey's, the Allendale, and an esker beginning about a mile west of Ramsey's and running parallel with the Ramsey's esker. These with their branches constitute a group not unlike a river system.

The Ramsey's esker is the central one of the group. It is also the longest and the best type of an esker. It begins north of the state line in the vicinity of Suffern, N. Y., and extends south to the neighborhood of Mahwah, where it is interrupted, and in its course are several flat-topped, delta-like deposits of precisely similar material, i. e., loose textured sand and gravel. These deposits extend south of Mahwah about a mile and a half, at which point they cease, and the esker again becomes distinct and prominent. It crosses the Erie railroad in the northern edge of the village of Ramsey's, then runs southwest for about a mile and a half, where it is again interrupted and is probably represented by various shorter branches or pieces of eskers extending nearly to Wyckoff. This esker has its best development about a half mile southwest of Ramsey's, where it crosses about a half mile of low ground. It stands up clean and clear as a sharp ridge of gravel about twenty-five feet high, and one to two rods wide on top. Its sides are as steep as gravel and sand will lie. Its course is sinuous, like that of a stream.

Besides the wide gaps which occur in nearly all of these eskers there are several narrow gaps through some of which small streams now flow. In the case of the wide gaps, the esker usually thins perceptibly if not greatly before disappearance; but where the narrow gaps are found the esker terminates abruptly on one side of the valley and begins as abruptly on the other. The resemblance to a railroad embankment where a stream is to be crossed by a high bridge is marked. Present appearances indicate not that the stream has cut the gap in such cases, but rather that the gap was either never filled or else the material was removed while the ice was still near. None of the eskers nor the associated deposits seem to have suffered much if any post-glacial erosion.

About a mile and a half southwest of Ramsey's a deposit is found which seems to have been made by the union of three small eskers which come in here.[1] It is an oval, rather flat-topped body of sand and gravel, covering perhaps an acre to the depth of twelve or fifteen feet. Two branches, apparently from the Ramsey's esker, come in from the north, another comes in or goes out from the southwest, while a fourth leads out to the south. The three first mentioned come from higher ground to the junction. The one going south descends from the junction, following the course of a small stream for about a mile, where it enters another and larger junction deposit, through which it connects with the Allendale esker.

This second junction deposit is about a quarter of a mile long by half as wide and rises forty feet above the eskers connecting with it. It is steep-faced on the sides facing the lower ground, but seems to lap on the higher ground on the northwest smoothly as though it were wedge-shaped. The thick end of the wedge lies toward the low ground, and the surface is quite level. In all particulars save one, this deposit is like the bodies of sand and gravel lying in the course of the Ramsey's esker south of Mah-

[1] So far as I know this feature has not been before noted in connection with eskers, and hence no name to designate it has been suggested. In the absence of a distinctive name I have simply called them junction deposits.

wah. Some of those are fifty feet deep, flat-topped, steep-faced on the lower side, and shade into the higher ground gradually. But they are not *directly* connected with an esker. The analogy, therefore, is not complete.

In the esker west of the Ramsey's esker occurs a feature which is perhaps suggestive in this connection. This esker after running as a sharp, well-defined ridge for more than a mile, in which distance it climbs about forty feet, turns sharply to the right, descends about thirty feet in less than a half mile, makes a broader turn into its former course, and then gradually expands to fifteen or twenty times its former width, with a corresponding increase in the quantity of material deposited. It then narrows slightly and terminates abruptly, or rather is interrupted by one of the narrow gaps previously mentioned. Beyond this gap it first widens and then narrows to its original width,—about a rod on top.

Here are three closely analogous types of deposit intimately associated with eskers. In topographic features they are practically the same, in material and texture precisely so. All lie in the path of eskers. But they are differently connected with the eskers. The deposits south of Mahwah simply lie in the course of the Ramsey's esker, but are separated completely from it. The junction deposits are connected directly with the eskers, but show decided differences of level as compared with the associated eskers. The Allendale junction deposit stands forty feet higher than either of the two main esker branches which unite in it. In the third type we have the esker itself gradually widening out into a broad, thick mass without marked change of level. In this case we have also the subsequent narrowing of the deposit to its original esker proportions.

If the first or Mahwah type alone were considered, perhaps the most natural inference regarding its genesis would be that a rapid stream had here debouched into the still water and there built the delta like deposits. Yet even in this group, which includes some half dozen of these gravel bodies, are several that can hardly by so accounted for; and in each of the other types it is clear that the material was brought to its present position by ice-walled streams.

In the case of the junction deposits it seems to this writer that a satisfactory explanation of their origin may be found by supposing that these deposits mark the points at which one or more crevasses in the ice intersected eskers. The radiating gravel ridges now mark the position of the intersecting crevasses.

That all these gravel deposits were made near the ice front is probable from the fact that a little farther south all the gravel is spread out in sheets. It is therefore reasonable to suppose that there were openings in the ice-front, bay-like in character, and that there were other openings within the ice-border less directly connected with the open water along the ice border

The suggestion is offered, therefore, that these variously disposed bodies of esker material mark the places where openings of greater or less size had been formed by various agencies not far from the ice-front and in the path of the ice rivers. The streams would pour their contents into these openings. The water would escape; but the sand and gravel would accumulate in the openings until it either filled them completely, or until new avenues were opened for its onward movement. At the final melting of the ice all these deposiis would be left resting on the till beneath, whether the streams which brought the material were sub-glacial or englacial.

Madison, Wis.

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[1] **It is not meant here to assert that still water of any depth was to be found along the ice-front at the time mentioned, although such might have been the case.**

MAXIMUM STRESSES IN BRIDGE MEMBERS.

L. M. HOSKINS,

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INTRODUCTION.

1. *Object of Discussion.*— It is proposed to consider in as general a manner as possible, the problem of determining what position of a given series of moving loads will produce the greatest stress in any member of a bridge truss. The truss is assumed to be simply supported at the ends, and may be of any form subject only to the restriction that it shall be possible to take any member as one of three through which a section may be passed dividing the truss into two parts.

For such a truss it is found that a general rule can be stated, applicable to any member of the truss, which gives the position of the moving loads causing maximum stress. Moreover, the rule deduced is quite simple and easy of application in all special cases.

Various particular cases of the rule have been deduced and discussed by several writers. I am not aware, however, that the principle in its general form has been before stated, nor that the problem has been discussed by the method employed in this paper.

Before proceeding to the demonstration, the statement of the principle will be given.

2. *Statement of General Principle.*— Let A and B be the projections on a horizontal line of the points of support of the truss. Let the truss be divided into two parts by a section cutting three members, one of which necessarily belongs to that chord at which the moving loads are supported; let $C\ D$ be the projection of this member upon $A\ B$.

Choosing one of the three members cut as that whose stress is to be discussed, let F' be the point of intersection of the

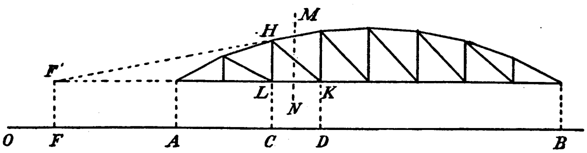

Fig. 1.

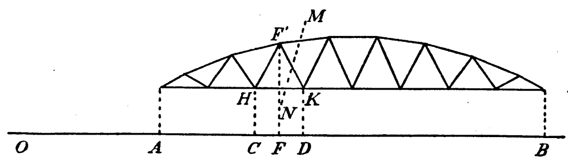

Fig. 2.

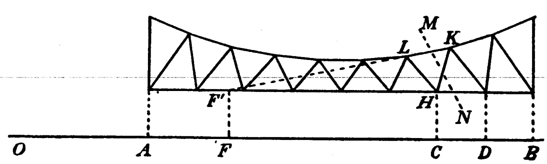

Fig. 3.

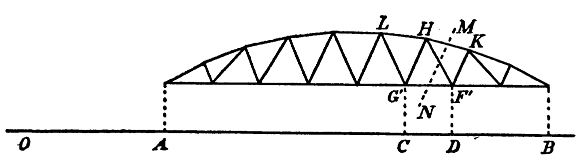

Fig. 4.

HOSKINS ON BRIDGE STRESSES.

other two (produced if necessary), and let F be the projection of F' upon $A B$.

Let l = the span $A B$;
$l_1 = A F$; $l_2 = F B$;
n = panel length $C D$;
$n_1 = C F$; $n_2 = F D$;
P_1 = total load on $A C$;
P_2 = total load on $D B$;
Q = total load on $C D$.

Then when the required stress is a maximum or a minimum, the following condition is satisfied:

$$\frac{P_1 + \frac{n_1}{n} Q}{l_1} = \frac{P_2 + \frac{n_2}{n} Q}{l_2} \text{ .... (1)}$$

Under this general rule there are three principal cases to be considered, according as the point F falls between C and D (Fig. 2), between A and B but outside the length $C D$ (Fig. 3), or outside the span $A B$ (Fig. 1). (In the figures the member whose stress is under consideration is in each case marked $H K$.) In these three cases some or all of the quantities n_1, n_2, l_1 and l_2 will have different signs. To determine these signs in any case let distances from left to right be regarded as plus, and distances from right to left as minus; then the values above given for l_1, l_2, n_1 and n_2 are correct in sign for all cases.

If the loads are concentrated, the general condition (1) requires (unless the case is very exceptional) that a load shall be at one of the four points, A, B, C, D.

To determine whether a given value of the stress is a maximum or a minimum, and to determine which one among several maximum values will be greatest, without actually determining the values, requires a special discussion in each of the three cases above mentioned. It can usually be done, however, with little difficulty.

MATHEMATICAL DISCUSSION.

3. *Proof of General Principle.*—In deducing the general principle above stated, we shall at first refer to the case in which F falls between C and D (Fig. 2), so that n_1, n_2, l_1, l_2 are all positive. We shall then consider the other cases, showing that the same formula applies to all.

Case of Member of Loaded Chord.

The case in which F falls between C and D may occur when the member whose stress is under consideration belongs to that chord along which the moving loads are applied to the truss. This case is represented in Fig. 2, $H\,K$ being the member in question.

Let O be a point on $A\,B$ which is fixed relatively to the loads, but moves with them. Instead of considering the loads to move, we shall, for convenience, assume the truss to move while the loads remain stationary. The point O thus remains fixed, while A, B, C, D and F move. Let $O\,A = z$; then the position of the truss relatively to the loads is given by assigning values to the variable z. If the loads move to the left, we assume the truss to move toward the right, so that z increases; and *vice versa.*

Let the load have any fixed distribution along the horizontal, w being the load per unit length at a point whose abscissa reckoned from O is x. We shall assume at first that w is either zero or finite at every point, reserving for later discussion the case of concentrated loads, in which w becomes infinite at certain points. We shall now determine the value of the tension in $H\,K$ produced by a load P in any position on the truss. Three different expressions are needed, according as the load is on $A\,C$, $D\,B$, or $C\,D$.

1st. *Tension due to a load on A C.* — Let T be the tension in $H\,K$ due to a load P on $A\,C$. Let x = distance from O to point of application of P, and let $z = O\,A$ as before. Then the reaction at B due to P is

$$\frac{P\,(x-z)}{l}$$

Now cutting the truss by a section $M\,N$ as shown (Fig. 2), it is seen that the reaction at B is in equilibrium with the internal forces in the the members cut; hence, taking moments about F', and letting t represent the perpendicular distance from F' to $H\,K$, we have (remembering that $F\,B = l_2$)

$$Tt = \frac{P \qquad {}_2}{l},$$

or

$$T = \frac{P\,l_2\,(x-z)}{lt} \quad\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

2nd. *Tension due to load on $D\,B$.* — For a load P on $D\,B$, we compute the reaction at A, its value being

$$\frac{P(z+l-x)}{l}.$$

Considering the portion of the truss to the left of $M\,N$, we see that this reaction is in equilibrium with the internal forces produced in the three members cut. Hence for the tension in $H\,K$ we have (taking moments about F' as before and remembering that $A\,F = l_1$)

$$T = \frac{P\,l_1\,(z+l-x)}{l\,t} \quad\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

3rd. *Tension due to a load on $C\;D$.*—A load P between C and D comes upon the truss partly at C and partly at D. The part coming at C is

$$\frac{P\,(z+l_1+n_2-x)}{n},$$

and that coming at D is

$$\frac{P\,(x-z-l_1+n_1)}{n}.$$

The tension due to the former part is found from equation (2) by substituting

$$\frac{P(z+l_1+n_2-x)}{n}$$

for P and putting $(z+l_1-n_1)$ instead of x in the factor $(x-z)$. The tension due to the latter part is found from equation (3) by substituting

$$\frac{P\,(x-z-l_1+n_1)}{n}$$

for P and putting $(z+l_1+n_2)$ for x in the factor $(z+l-x)$. Combining the two values thus found, we get for the total tension in $H\;K$ due to a load P between C and D,

$$\frac{P\,l_2\,(l_1-n_1)}{n\,l\,t}\,(z+l_1+n_2-x)+\frac{P\,l_1\,(l_2-n_2)}{n\,l\,t}\,(x-z-l_1+n_1)\ldots.(4)$$

We may now determine the total tension due to all loads on the truss, by putting $P = w\,dx$ in each of the expressions given in equations (2), (3) and (4), and integrating each between limits corresponding to that part of the span to which it applies.

Thus, if T now means the total tension in $H\,K$, we have

$$T = \frac{l_2}{lt}\int_{z}^{z+l_1-n_1} w\,(x-z)\,dx + \frac{l_1}{lt}\int_{x+l_1+n_2}^{x+l} w\,(z+l-x)\,dx$$

$$+\frac{l_2\,(l_1-n_1)}{n\,l\,t}\int_{z+l_1-n_1}^{z+l_1+n_2} w\,(z+l_1+n_2-x)\,dx$$

$$+\frac{l_1\,(l_2-n_2)}{n\,l\,t}\int_{z+l_1-n_1}^{z+l_1+n_2} w\,(x-z-l_1+n_1)\,dx \quad\text{.......(5)}$$

Since w is in general a function of x, the integrations cannot be performed unless the form of this function is known. We can, however, apply the condition for maximum or minimum values of T, namely,

$$\frac{dT}{dz} = 0.$$

Let the values of w at A, B, C and D, respectively, be a', b', c' and d'. Then by differentiation,

$$\frac{dT}{dz} = \frac{l_2}{lt}\left[c'\,(l_1-n_1) - \int_{z}^{z+l_1-n_1} w\,dx\right] + \frac{l_1}{lt}\left[-d'\,(l_2-n_2)\right.$$

$$\left. + \int_{z+l_1+n_2}^{z+l} w\,dx\right] + \frac{l_2\,(l_1-n_1)}{n\,l\,t}\left[-c'n + \int_{z+l_1-n_1}^{z+l_1+n_2} w\,dx\right]$$

$$+\frac{l_1(l_2-n_2)}{n\,l\,t}\left[d'n - \int_{z+l_1-n_1}^{x+l_1+n_2} w\,dx\right]$$

In this expression all terms except those involving definite integrals balance each other. Also, if the total loads on $A\,C$, $B\,D$ and $C\,D$ respectively are denoted by P_1, P_2 and Q, we have

$$\int_{z}^{x+l_1-n_1} w\,dx = P_1,$$

$$\int_{z+l_1+n_2}^{z+l} w\,dx = P_2,$$

$$\int_{z+l_1-n_1}^{z+l_1+n_2} w\,dx = Q,$$

and the above equation may be written

$$lt\frac{dT}{dz} = -l_2P_1 + l_1P_2 + \left(\frac{l_1n_2 - l_2n_1}{n}\right)Q$$

$$= l_1\left(P_2 + \frac{n_2}{n}Q\right) - l_2\left(P_1 + \frac{n_1}{n}Q\right) \quad \ldots\ldots\ldots\ldots\ldots(6$$

Putting $\frac{dT}{dz} = 0$, we get

$$\frac{P_1 + \frac{n_1}{n}Q}{l_1} = \frac{P_2 + \frac{n_2}{n}Q}{l_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7$$

which agrees with equation (1) stated at the outset.

The discussion has thus far referred to the case shown in Fig. 2. Other cases will now be considered.

Case in which n_1 or n_2 is negative.—Considering still a member of the chord to which the loads are applied, a possible (though unusual) case is that in which the member corresponding to $H\ F'$ in Fig. 2 is so inclined that F falls to the left of C. (This case is not shown in any of the figures.) This makes n_1 negative; and an examination of the reasoning by which equations (2), (3) and (4) were deduced shows that these equations are correct for the present case, if regard be had for the sign of n_1. Also, in equation (5), the limits of the definite integrals are correct, if n_1 be given its proper sign.

If F falls to the right of D, n_2 is negative, but the results are still applicable.

As a special case, F may fall at C or D, making either n_1 or n_2 zero.

Deck truss.—If the moving load is supported at the upper chord, and $H\ K$ is a member of that chord, the above reasoning may be repeated, the loads and re-actions being regarded as reversed in direction. The result will be the same, except that $H\ K$ will be in compression instead of tension.

Case of Member of Unloaded Chord.

If $H\ K$ is a member of that chord at which the live loads are not carried, let $M\ N$ (Fig. 4) be a section cutting $H\ K$ and two other members so as to divide the truss into two parts, and let

$F' G'$ be the other chord member cut. Then C and D are the projections of G' and F' upon the horizontal reference line $A B$. Evidently F coincides with D, so that $n_2=0$, $n_1=n$. With these substitutions, equations (2), (3) and (4) give the values of the compressions in $H K$ due to loads on $A C$, $C D$ and $D B$, and the total compression is given by equation (5); hence the result of the foregoing discussion applies to the present case.

If HL were the member considered we should have $n_1=0$, $n_2=n$.

Web Member.

1st.—Case in which l_1 and n_1 are negative.—Let $H K$ (Fig. 1) be the member under discussion, and let $K L$ be the member of the loaded chord cut by the section $M N$. Let F', the intersection of the two chord members cut, fall so that F is at the left of A. Then loads on $A C$, $D B$ and $C D$ respectively will produce stresses in $H K$ whose values are readily seen to be given by equations (2), (3) and (4); the stress being in each case computed as if it were a tension, and regard being had to the signs of n_1 and l_1.

Also, by examination of the general value of T due to all loads (equation (5)), it is seen that the limits of integration as there given are correct for the present case, remembering that l_1 and n_1 represent negative quantities.

If the stress is computed as a compression, the sign of every term in the value of T must be changed.

2nd.—Case in which l_1 is positive and n_1 negative.—This case occurs if the point F is between A and C, and is shown in Fig. 3. If the deduction of equations (2), (3) and (4) be followed through for this case, it is seen that the only changes necessary in the reasoning will be introduced by having regard for the negative sign of n_1. The limits of the integrals in equation (5) are also correct for this case if regard be had for the sign of n_1.

3rd.—Case in which $l_1 = 0$.—This is a limiting case between the two preceding cases, and needs no special discussion. The form assumed by equation (7) in this case will be considered later.

4th.— Web member in deck truss.— This case needs only a passing mention, since evidently the foregoing discussion becomes applicable if in Figs. 1 and 3 the directions of the loads and reactions is reversed; the effect being merely to reverse the stress in every member.

If in Figs. 1 and 3 the member $H\,L$ had been considered instead of $H\,K$, the resulting expressions would be of the same form as those already given; but it is to be noted that when $H\,K$ is in tension, $H\,L$ is in compression, and *vice versa.*

General Result.

We have now shown that equation (7) is a general expression for the condition for maximum values of the stress in any member of a truss of the kind discussed, under any distribution of loads which does not make w infinite at any point. We shall next consider the general condition for discriminating between positions giving maximum values and those giving minimum values of the stress; we shall then discuss the case of concentrated loads; and finally we shall consider the problem of determining which one, of several positions in which equation (7) is satisfied, corresponds to the true greatest value of the stress.

4. *Discrimination between Maxima and Minima.*— From equation (6) we have, by differentiating,

$$lt\frac{d^2T}{dz^2}=l_1\left(\frac{dP_2}{dz}+\frac{n_2}{n}\cdot\frac{dQ}{dz}\right)-l_2\left(\frac{dP_1}{dz}+\frac{n_1}{n}\cdot\frac{dQ}{dz}\right)$$

$$=l_2a'+l_1b'-\frac{l}{n}\,(n_2c'+n_1d')\,\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

If this is negative, the value of T is a maximum; if positive, a minimum.

The application of this condition in special cases will be considered below.

5. *Concentrated Loads.*— By a concentrated load, in the strict mathematical sense, is meant a finite load applied at a geometrical point. At the point of application of such a load the value of w (the load per unit length of the truss) becomes infinite, and the above discussion in its present form is not applicable. As regards train loads actually applied to bridges, however, it is to be remarked that these are not concentrated in

the strict sense of the word, but are in reality distributed over short distances along the track. In the actual case, therefore, the value of w does not become infinite, and the results of the above discussion are applicable.

Even in the ideal case of true concentrated loads, such a series of loads may be regarded as the limiting case of a distributed series, the distribution being gradually varied in any desired manner; and the results of the foregoing discussion, with slight modification in the form of their expression, may be shown to apply to this case also.

When the loads are concentrated, it is usually necessary that a load should be at one of the four points A, B, C, D, in order that equation (7) may be satisfied; and in applying the equation such a load must be regarded as divided between the adjacent portions of the truss in some arbitrary manner. This statement applies both to the ideal case of true concentrated loads, and to the case of train loads as actually applied to bridges.

We shall now consider, in the several special cases, how to determine the greatest among the possible maximum values of the stress in any member, and also how to apply the general condition already deduced for distinguishing whether any given position of the loads corresponds to a maximum or a minimum value of the stress.

6. *Application to Member of Loaded Chord.*—Before applying equation (7), it is well to compare the effects of equal loads placed in different positions. Taking the case shown in Fig. 2, it is easily seen that a load on any part of the truss produces tension in $H K$. Also the effect of a load between A and C is greater the nearer it is to C; and the effect of a load between D and B is greater the nearer it is to D. To determine the relative effects of loads in different positions between C and D, we may compare the effects of equal loads in the extreme positions, C and D. By putting $x = z + l_1 - n_1$ in equation (2) or (4), we find the tension due to a load P at C is

$$\frac{Pl_2(l_1 - n_1)}{lt}.$$

And by putting $x = z + l_1 + n_2$ in equation (3) or (4) we find the tension due to a load P at D is

$$\frac{Pl_1(l_2-n_2)}{lt}.$$

The former of these values will be the greater if

$$l_2(l_1-n_1) > l_1(l_2-n_2)$$

that is if

$$l_1 n_2 > l_2 n_1.$$

The latter will be greater if

$$l_1 n_2 > l_2 n_1.$$

Hence with a given series of concentrated loads, we see that, as a general principle, the whole truss should be loaded, and the heaviest loads should be brought as near as possible to C or to D, according as $l_1 n_2$ is greater or less* than $l_2 n_1$. We have then to find some position of the moving loads which, while satisfying this general principle as nearly as possible, exactly satisfies equation (7).

As a limiting case, $n_1 = 0$ (in which case $l_1 n_2$ is necessarily greater than $l_2 n_1$) or $n_2 = 0$ (which makes $l_1 n_2 < l_2 n_1$).

Also it is possible (though unusual) that n_1 is negative (making $l_1 n_2 > l_2 n_1$) or n_2 negative (making $l_1 n_2 < l_2 n_1$).

7. *Application to Unloaded Chord.*—If $H K$ (Fig. 4) is a member of the chord not carrying moving loads, we have necessarily either $n_1 = 0$ and $n_2 = n$, or $n_1 = n$ and $n_2 = 0$. In either case the reasoning of the preceding case applies without change.

In this case and in the preceding, the condition (7) may be expressed in words thus:

Assume the whole load on $C D$ to be divided between C and D in the ratio of $C F$ to $F D$; then the total loads on $A F$ and $F B$ are to

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* The limiting case between these two is that in which $l_1 n_2 = l_2 n_1$, or

$$\frac{l_1}{l_2} = \frac{n_1}{n_2}.$$

That is, if the point F divides $C D$ and $A B$ in the same ratio, the effect of a load upon the stress in question is the same at whatever point between C and D it be placed.

Let X be a point between C and D so located that

$$\frac{C X}{A X} = \frac{X D}{X B}.$$

Then if F is between C and X, a load will have a greater effect if brought nearer to C; while if F is between X and D, the effect will be greater the nearer the load is to D.

be proportional to the lengths of these segments, that is, to l_1 *and* l_2.

8. *Discrimination between Maxima and Minima in case of Chord Members.*—We have now to examine the sign of the value of $\frac{d^2T}{dt^2}$ given in equation (8).

(*a*) Member of loaded chord.—It has already been mentioned that in the case of concentrated loads equation (7) requires that a load shall be at some one or more of the points A, B, C and D. It is evident also that generally only one of these positions will be occupied by a load at any one time. Hence, when equation (7) is satisfied, one of the four quantities a', b', c' and d' will in general be very great and the other three zero. If l_1, l_2, n_1 and n_2 are all positive, as in Fig. 2, equation (8) shows that $\frac{d^2T}{dz^2}$ is negative when a load is at C or D but not otherwise; and positive when a load is at A or B but not otherwise. Hence when the stress in $H\,K$ is a maximum a load is at C or D, and when it is a minimum a load is at A or B. Conversely, if equation (7) is satisfied and a load is at C or D the stress is a maximum; and if (7) is satisfied while a load is at A or B, the stress is a minimum. [The last statement does not hold if, when equation (7) is satisfied, a load is at A or B and another at C or D; since this would make the value of $\frac{d^2T}{dz^2}$ the algebraic sum of two terms, one positive and the other negative. This case will arise only by a rare coincidence of dimensions.]

If F falls at C or between A and C, so that n_1 is zero or negative, the value of $\frac{d^2T}{dz^2}$ can be negative only when a load is at C; if n_2 is zero or negative (F falling between D and B), a load must be at D to make $\frac{d^2T}{dz^2}$ negative.

(*b*) Member of unloaded chord.—In case of a member of the chord not carrying moving loads, either n_1 or n_2 is necessarily zero. Hence the discussion just given applies to this case, and the conclusion need not be repeated.

9. *Application of General Condition to Web Member—First Case.*—In considering web members two cases are to be distin-

guished; first, that in which F is to the left of A (Fig. 1), and second, that in which F is between A and C (Fig. 3).

In the first of these two cases it may be shown without difficulty that loads on $A\ C$ and on $D\ B$ produce opposite kinds of stress in the member $H\ K$. (This is seen by comparing equations (2) and (3), remembering that l_1 is now negative.) Either tension or compression may therefore be produced in $H\ K$ by the live loads, depending npon the position of the train.

Treating $H\ K$ as a tension member, we see that all loads on $D\ B$ produce tension, and the effect of such a load is greater the nearer it is to D; while a load on $A\ C$ causes a compression which is greater the nearer the load is to C. Hence for the greatest tension in $H\ K$ we must load $D\ B$ as completely as possible, putting heavy loads as near D as possible, and leave $A\ C$ free from loads. These requirements may in some cases be somewhat contradictory, as when the foremost loads are light compared with those that follow. But they serve as a general guide, and must be satisfied as nearly as possible, at the same time that equation (7) is exactly satisfied.

To get the greatest compression in $H\ K$, the load must occupy $A\ C$ as fully as possible, $D\ B$ being free from loads (if this is possible), at the same time that equation (7) is satisfied.

Equation (7) may conveniently be put in another form for use in the present case, as follows: Adding the numerators and denominators respectively of the two equal fractions in equation (7), and putting $W=$ the total load on the truss, we get

$$\frac{P_1+\frac{n_1}{n}Q}{l_1}=\frac{P_2+\frac{n_2}{n}Q}{l_2}=\frac{P_1+P_2+Q}{l_1+l_2}=\frac{W}{l}\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

Now if $H\ K$ is treated as a compression member, P_2 should be zero if this is possible consistently with equation (7). Hence from equation (9),

$$\frac{n_2 Q}{n l_2}=\frac{W}{l}$$

or

$$Q=\frac{l_2}{n_2}\cdot\frac{n}{l}\cdot W\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(10)$$

If this equation cannot be satisfied by any position for which $P_2 = 0$, we may write (9) in the form

$$Q = \frac{n}{n_2}\left(\frac{l_2}{l} W - P_2\right) \dots\dots\dots\dots\dots\dots (11)$$

and seek to satisfy it by a position making P_2 as small as possible.

If $H K$ is treated as a tension member, the load is brought on from the right to such a position that $D B$ is fully loaded and $A C$ free from loads, if this can be done consistently with equation (7) or (9). Putting $P_1 = 0$, (9) may be written

$$Q = \frac{l_1}{n_1} \cdot \frac{n}{l} \cdot W \dots\dots\dots\dots\dots\dots (12)$$

Or, if it is found that P_1 cannot be taken zero, the equation may be written

$$Q = \frac{n}{n_1}\left(\frac{l_1}{l} W - P_1\right) \dots\dots\dots\dots\dots\dots (13)$$

Case of Parallel Chords.—If the chords are parallel, the point F is at an infinite distance, and l_1, l_2, n_1 and n_2 become infinite. But since in this limiting case

$$\frac{l_1}{n_1} = 1, \quad \frac{l_2}{n_2} = 1, \quad \frac{n}{n_1} = 0, \quad \frac{n}{n_2} = 0,$$

equations (11) and (13) both reduce to

$$Q = \frac{n}{l} W$$

or

$$\frac{Q}{n} = \frac{W}{l} \dots\dots\dots\dots\dots\dots (15)$$

10. *Discrimination between Maxima and Minima in Case of Web Members.*—We have now to examine the sign of $\frac{d^2 T}{dz^2}$ as given by equation (8), with reference to the case of a web member. As already stated, all but one of the four quantities a', b', c' and d' will in general be zero when equation (7) is satisfied; each having a positive value whenever a load is at the corresponding point of the truss.

The value of T from which equation (8) was derived applies to the case shown in Fig. 1 (which is the case now under discussion) only on the supposition that $H K$ is in compression. If the member is in tension the value of T and that of $\frac{d^2T}{dz^2}$ must have their signs changed. Take first the case when $H\ K$ is in compression, so that equation (8) gives the correct value of $\frac{d^2T}{dz^2}$. In this case, since the right portion of the truss is free from loads, b' will be zero; and since n_1 is negative, the term involving c' is the only one which can make the whole expression negative. Hence a load will be at C when the compression in $H\ K$ is a maximum. (When it is a minimum a load may be at A or at D.)

If $H\ K$ is in tension, the value of $\frac{d^2T}{dz^2}$ must be the negative of that given in (8), that is

$$lt\frac{d^2T}{dz^2} = -l_2a' - l_1b' + \frac{l}{n}(n_2c' + n_1d') \text{..................} (14)$$

The left portion of the truss being now unloaded, a' is zero. Also, since l_1 and n_1 are negative and n_2 is positive, the only term in (14) which can be intrinsically negative is that containing d'; that is, a load will be at D when the tension in $H\ K$ is a maximum. (Loads at B or at C may correspond to minimum values of the tension.)

12. *Application of General Condition to Web Member— Second Case.*—We now consider the case in which the point F falls between A and C, so that l_1 is positive while n_1 is negative. This case is represented in Fig. 3, the member considered being marked $H\ K$, as in all the figures. It may be shown by the usual method that a load at any point of $A\ C$ produces in $H\ K$ a tension which is greater the nearer the load is to C; and that a load at any point of $D\ B$ produces in $H\ K$ a tension which is greater the nearer the load is to D. We need further to compare the effects of equal loads at C and D. From equations (2) and (3) it is seen that a load P at C produces a tension of

$$\frac{Pl_2(l_1 - n_1)}{lt},$$

while a load P at D produces a tension of

$$\frac{Pl_1(l_2 - n_2)}{lt}$$

The former will be greater than the latter if

$$l_2(l_1 - n_1) > l_1(l_2 - n_2),$$

that is if

$$-l_2n_1 > -l_1n_2.$$

As in the present case n_1 is negative, while l_1, l_2 and n_2 are positive, the above inequality always holds; hence a load at C produces a greater effect than one at D.

The general principle reached for the present case is, then, the following:

To produce the greatest stress in the member $H K$, the loads should cover the truss as completely as possible, with the heaviest loads near the point C.

This principle will usually enable us to choose readily which one, among several positions which may be found to satisfy equation (7), corresponds to the greatest tension in $H K$.

If the member considered is $L H$ instead of $H K$ (Fig. 3), the stress is a compression; otherwise the same results apply.

It remains to apply the criterion for distinguishing between positions giving maximum values and those giving minimum values of the stress. Since n_1 is negative, while l_1, l_2 and n_2 are positive, the only term in the value of $\frac{d^2T}{dz^2}$ (equation (8)) which can be really negative is that containing c'. Hence a load must be at C in order to make the stress a maximum. (Minimum values of the stress may occur when loads are at A, B or D.)

13. *Web member—case in which* $l_1=0$.—If the point F coincides with A, we have a limiting case between the two preceding. No figure is given for this case; but by referring to Fig. 1 or Fig. 3, and assuming that F falls at A, it is easily seen that loads on $D B$ produce no stress in $H K$, and that a load on $A C$ produces a stress which is greater the nearer the load is to C. Hence, for the greatest stress in $H K$, the part $A C$ of the truss should be loaded as fully as possible, the heaviest loads being near C; while no attention need be paid to the loads on $D B$. (They must of course be considered in applying the general condition expressed by equation (7).) In the present case it will be convenient to employ equation (11); and since $l_2=l$ the equation becomes

$$Q=\frac{n}{n_2}(W-P_2)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(16)$$

GENERAL RESULTS.

14. *Summary.*—In the foregoing discussion we have reached a result which, while of great generality, is also simple in form and easily applicable to special cases. We have also pointed out the special forms assumed by the general rule when applied to the most important special cases. In conclusion, it will be well to give a summary of these general and particular results. The reader who has not followed the foregoing mathematical discussion is referred to the opening paragraphs for an explanation of the symbols employed.

I. In every case in which the stress in a truss member has a maximum or a minimum value, the following equation is satisfied:

$$\frac{P_1 + \frac{n_1}{n}}{l_1} = \frac{P_2 + \frac{n_2}{n} Q}{l_2}.$$

II. To get the greatest stress in a chord member, the truss should be loaded as completely as possible, and the heaviest loads should be brought near to C or to D;—the former if $l_1 n_2 > l_2 n_1$, the latter if $l_1 n_2 < l_2 n_1$. When the stress is a maximum a load will be either at C or at D.

III. In case of a web member, if the point F falls outside the span, the greatest stress of one kind occurs when $A C$ is loaded as heavily as possible and $D B$ is free from loads, the heaviest loads being brought as near C as possible and one load being at C; the *general* condition must be exactly satisfied, and takes the form

$$Q = \frac{n}{n_2} \left(\frac{l_2}{l} W - P_2 \right)$$

in which P_2 is to be made zero, or as small as possible. For the other kind of stress a similar statement may be made.

As a limiting case, if the chords are parallel, the last equation becomes

$$Q = \frac{n}{l} W.$$

IV. In case of a web member, if F falls between A and C, the greatest stress will occur when the truss is loaded as heavily as possible, and the heaviest loads are brought as near C as possible; subject to the condition that the *general* equation shall be exactly satisfied.

V. In the limiting case in which F conicides with A, the loads should cover $A\,C$ as completely as possible, the heaviest loads being brought as near C as possible; these conditions being satisfied as nearly as possible while the *general* condition is exactly satisfied. In this case the general condition may be conveniently used in the form

$$Q=\frac{n}{n_2}\,(W-P_2).$$

In deciding which is the probable position for greatest stress, no regard need be paid to loads on $D\,B$, since they do not affect the stress under consideration.

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PHASES OF WITTICISM.

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What is wit? We know if we are not asked, but the more we ask the less we know. What is wit? Aristotle said it was polite insult. Other definers for two and twenty centuries have been busy with it. They have seldom satisfied themselves and more seldom their readers. None of their definitions is so good as that of a miracle by a little Sabbath school girl. When the lady teacher asked, What is a miracle? most of the class were silent, but the youngest of them said, "I can tell. My mother says it will be a miracle if you do not marry the new minister."

It is more than two centuries since the most famous definition of wit was made, in the fourteenth sermon of Rev. Dr. Isaac Barrow. Barrow branches out into twenty-seven ramifications which it would fatigue me to repeat and you to hear, but at last confesses that defining wit is showing the figure of the floating air, for, he adds, "Wit often consisteth in one knows not what and springeth up one can hardly tell how. Its ways are unaccountable, answerable to the numberless rovings of fancy and windings of language."

We all feel that wit defies definition. Its domain expands beyond all bounds, like Attica which Athenian school-boys were taught to say was bounded north by barley, south by vines, east by olives and west by wheat. Its invisible spirit, like the expression on certain faces, is too subtle for the most cunning artist to catch.

But though wit in the abstract cannot be hemmed in by any form of words, we all know it in the concrete, as we know many a man by sight, whose depths we cannot fathom. Nothing so tickles us, nothing so torments us. Now it is a kiss, and anon a stab in the fifth rib.

Without then philosophizing about wit, where we should find no end in wandering mazes lost, my present endeavor is to speak of witticisms known and read of all men; not in all their diversities, but in those few types which are all the proprieties of this occasion will allow. My subject then is wit in some of its Protean shapes.

A minister in the pulpit once burst out in a laugh just after he had risen for prayer. When summoned before a council he was acquitted. The case was this. Two of his wig-wearing parishioners, sitting in church side by side had their pig-tails tied together by a boy in the pew behind them. When they rose at prayer each of them was scalped by the other. The scene caught the minister's eye and he could not control his risibles, especially as he had read in John Locke, that wit consists in joining together things which have some sort of resemblance so as to produce surprise joined with pleasure.

The practical joke perpetrated by the boy's fingers, as it lay in his mind, was a witty invention, and it was a representative specimen of multitudinous witticisms. I mean those based on resemblances, particularly such as have been before undetected, and which therefore, when pointed out, move wonder.

Sundry witticisms owe something to similarities in the *sound* of words. St. Peter's statue at Rome whose toe is so much kissed is reported to have been originally a pagan god. Hence a punster said it was Jupiter, but has now become Jew Peter. Some men of honor, the more's the pity, have no honors. "Other folks," said a grumbler, "bow to the inevitable, I must bow-wow." When we think we have learned the French of a Parisian we have usually gone no farther than that of a parishioner. The first German queen of England when insulted on her drives, cried out: "Englishmans! I come here for your good, for all your goods!" "Yes," said the mob, "for all our goods and chattels too!"

A wit said that in Latin words the sound echoes the sense. A farmer is called a "rusty cuss" (rusticus) and a sailor "naughty cuss" (nauticus). Another wit claimed to be a classic because he had soaked with Socrates, ripped with Euripides and roamed with Romulus.

A man refusing to join a crowd who were gathering to see a man fly, said, "I have seen a horse*fly* and a rope*walk.*" Bismark dropped the letter *c* in spelling his name and it made no difference. But Cass could not afford to part with that letter, and his enemies said in a rhyme that

Future generations would agree
To spell his name without a C.

Playing on the fourfold ambiguities of a couple of syllables an actor won applause. He said:

Like a *grate full* of coals I burn
A *great full* house to see,
And if I be not *grateful* too,
A *great fool* I shall be.

New words are constantly issuing from the mint of wit and pass current as its small change.

When a man had anecdotes on the brain he was told; *non-age* and *dotage* you cannot shun, *anecdotage* you can.

Heresiarchs were denounced as troubling the church, and a wit said, "Heresiarchs are bad enough, but *she*resiarchs are worse."

District lines on a political map of Massachusetts struck one wit as like a salamander. But as they had been drawn by one Gerry, another wit styled them gerrymander.

Wits change a word into another like it yet with a difference.

So we hear talk about *Brag*adiers, Michi*ganders*, Wiscon*sinners*, Bara*boobies*, and Janes*villains*. When a president dies his vice is not called excellency so often as accidency. The iron-clad oath of amnesty was pronounced *damnasty* by not a few who took that pill. A vainglorious valedictorian found his title transformed into valetudinarian.

Ambiguous meanings of the *same* word give occasion for not a little verbal wit.

When a bachelor is urged take a wife he asks, "Whose wife shall I take?"

A conceited man said, "I could write as well as Shakespeare, if I had a mind to." "True," said a wit, "mind is all you lack." We say we are going to see a friend, and wits say, "Let us go with you for we have never seen one,"—no, not one true friend. According to Byron, when Bishop Berkley said there was no matter, and proved it, 'twas no matter what he said.

After Bunker Hill, Franklin, closing a letter to an English correspondent, wrote: "We have been friends but now you are my enemy, and I am yours, B. Franklin." At the Declaration of Independence one signer said, "Now we must hang together." "If we do not", added Franklin, "we shall hang separate and that as high as Haman." An opponent of Pitt, seeing his likeness swinging on a sign-post exclaimed, "He hangs everywhere, except on the gallows where he should hang."

"If those girls," observed a camp-meeting preacher, "knew they had holes in their stockings they would not stand so high on the benches." He meant the holes through which the stockings were put on. When a dull speaker asks, "Have you read my last speech", we are tempted to answer, we are not sure, but we hope so. A certain sort of hospitality makes drinkers say they were never treated so well, nor so often. When a crowd at Niagara were wondering at the waterfall, a wit said: The waterfall is no wonder; there's nothing to hinder; it can't help it. Needles are warranted not to cut in the eye: a wit will tell us, that is more than can be said for the users of them. A king sitting by a dish of peaches and pleased at the pleasantries of a wit, said to a page, "Give this dish to the wit!" The response was, "Does Your Majesty mean that I shall have the peaches too as well as the gold dish?"

There is wit in detecting one point of resemblance, and often more in bringing to light a second, or third. The political platform was said by one wit to be like that of a railroad car, both being something to get on by; "and also", added another, "because neither of them is something to stand on." A third wit declared it equally hard to make men stand on one and stand off the other.

Witticisms turn on many *varieties* of resemblance. A single point, and that so small that it has never been noticed, is so presented by a wit that it seems to prove much more than it does.

The Catholic sacraments are seven, but Mr. Caudle declared they were only six, for he had found marriage and penance to be both one. Guiteau was compared to a crumb of bread which, if it goes down the right way is never noticed, while if it goes down wrong, it gets no end of notice.

A wit was asked, How many professors are there in the University of Wisconsin? His answer was "How many shall I set down the scenery on its grounds as amounting to?"

The smaller the point of resemblance the better for a wit. It was asked, Why do women hate snakes? and a wit replied, "Two of a trade cannot agree." He was thinking of

> "The first that fell of womankind,
> When on that dread yet lovely serpent smiling,
> Whose image then was stamped upon her mind,
> But once beguiled, and evermore beguiling."

A tall fellow in a theater stood bolt upright in spite of hisses and cries of Down! till some one cried out, "Let him alone! it is a tailor resting his legs."

An American tenting in Palestine, when his shoe-black was careless, got up first one morning and did the work well. His hope was to shame the boy into faithfulness, but the Arab merely said, "Now I know what your business is at home. In America you are a boot-black."

Wits are proverbially cynical. Hence it is not surprising that their comparisons often relate to regions infernal. Kansas it was said lacks nothing but water and good society. But a wit rejoined, "So does Hades."

In ante-bellum days Wendell Phillips was blamed by a pro-slavery minister because he did not go South and preach abolitionism there. His reply was: "You have as good reason to go to Hades for your preaching."

A Revolutionary camp-song was:

> "In seventeen hundred seventy-seven
> General Burgoyne set out for heaven,
> But as the Yankees would rebel,
> He missed his route and went to hell."

A bishop who was also a prince acknowledged at the confessional that he had been profane. But said he: "I swore as a prince not as a bishop." His confessor's question was: "When the devil gets the prince what will become of the bishop?"

There is much wit in conjoining things which are *fitted* for each other but have not before been seen to be. In unfitness wit shows a fitness, or a semblance of it.

On this principle Alexander equipped notorious cowards with armor which covered their breasts but left their backs undefended.

In a similar vein, when certain wild fellows had pulled down the sign of a fire insurance office, they put it up over the door of a Universalist church.

I once fell asleep one morning in an Italian diligence, and a native remarked: "No wonder you are drowsy for it is not yet daylight in your country."

There was wonder that Brigham Young never laid a mile of pipe from the sulphur spring to his harem bath. Wits, however, said that was nothing strange, since Brigham knew that he would smell brimstone soon enough at all events.

When others were shocked at the oaths of a swearer, a wit declared that a man on the way to the court of Satan might well labor to learn the dialect of devils.

When the Austrian eagle was put in place of St. Stephen on the topmost pinnacle of his cathedral in Vienna many found fault. But wits saw a fitness in the change inasmuch as all the highest places there were occupied by brutes.

Many have wondered that no snakes are found in Ireland. One wit said that Nature needed so much venom for Burke that she had none to spare for serpents.

Lean folks are long-lived. A wit would say that Death spares them because he is very lean himself, and fellow-feeling makes wondrous kind.

A wit was asked why King George III had not a fool as well as a poet laureate. His answer was; "No greater fool than the king himself can be discovered."

Byron said that he preferred Confucius to the ten commandments. "Well he may", remarked a wit, "for

> " 'No rogue ere felt halter draw
> With good opinion of the law'."

When Xantippe, perceiving that her scolding did not disturb the equanimity of Socrates, drenched him with dishwater, the sage was not surprised but remarked, that after thunder one ought to expect rain.

An Irish woman in the great famine, when some one condoled with her on the loss of her teeth, said: "Time enough for me to lose them now that I have nothing for them to do."

When one said to a drinker: "Don't you know when your guardian angel sees you enter a saloon he stands at the door weeping?" The answer was; "Yes I do, and he has reason to weep, for he has no sixpence to buy himself a glass."

Orientals say that asses bray because they have visions of Satan. Nothing but a satanophany could inspire, as they think, such utterances.

In a dispute about precedence, a German emperor decided that lawyers must go before doctors. His reason was that thieves walked to the gallows before the executioners.

Regarding the text, "A man beholding his face in a glass straightway forgetteth what manner of man he was," a wit would say: "How fitly is the word 'man' here used since the fact asserted is more than can be said about women."

When a self-made man was blamed for self conceit he was defended by wits who said: "When he worships himself he worships his creator."

A wit can also make as much capital out of incongruity or *unfitness*, as out of the fitness of things.

Queen Bess in old age no longer dared look in a glass, and so her maids of honor thought it witty to rouge her nose and whiten her cheeks.

A man was cured of chills by asses' milk, and urged others to try his specific, but the wits told him his experience only proved the medicine to be good for men altogether like himself. "It cured me", said the dullard, and a wit replied:

> "The nostrum cured your chills, 'tis true,
> But then 'twas mother's milk to you."

In a storm at sea a rascal prayed aloud, but a wit bade him hold his peace. "If the gods", said he, "find out that you are here it is all over with us."

I once offered a son of mine $500 if he would give up tobacco for a year. His friends wondered that he did not accept my offer. The boy said his reason was that I could not afford it!

A lady pleaded with her confessor for permission to use cosmetic rouge. He allowed her to apply it to one side of her face.

A cardinal who had been painted in the pit of perdition by Michael Angelo, urged the Pope to make the artist take him out. "I would," said the Pontiff, "were you in purgatory; those in the Inferno are beyond my reach."

When an Athenian miser had presented his sweetheart with a very small bottle of wine, but told her it was of the very oldest brand in the city, her remark was: "It seems to be rather small of its age." Wit of this type is a variation of Æsop's fable about a fox who served up soup to a crane on a broad platter, and about a crane who paid him in his own coin with soup in a narrow-necked bottle. Or we may style it St. Cecelia's invitation to the cherubs who flitted about her new-born organ. She bade them be seated, tantalizing those half-made angels in whose make up there was no provision for sitting down at all.

A man was boasting that he would never see another fool, for he would stay at home, and keep his door locked. But a wit told him, "You will soon see one unless you also break your looking-glass."

President Buchanan sent an army of soldiers to Utah for converting the Mormons. Wits said that if he had not been an old bachelor he would have sent a score of fashionable milliners, and so have turned failure into success.

A man defended his loquacity because it was wrong to hide a talent in a napkin. But wits said: "What right have you to mistake a napkin for a talent and flirt it in our faces?"

Tantalizing concessions thus bring out a witty unfitness. No less of such unfitness is shown by wits in the significance or combination of words.

A wit who gazed at a horseshoe and wondered what it was, when told what it was, said he had been in doubt whether it might not be the shoe of a mare.

A man was praised as a pillar of the church. But as he never saw the inside of one, wits declared that he ought rather to be styled a buttress which supports but remains always an outsider.

Certain victories were described as many and great. "They are divided against themselves," said a wit, "if they were great they could not be many; and if many they could not be great. There could not be more than one Waterloo."

A large class of witticisms may be termed *antithetical*, turning a sentence end for end.

What a contrast between the popularity which a man runs after and the popularity which runs after him.

"Proportion your charities to your estates," cried a preacher, "lest the Lord proportion your estates to your charities."

The cry was, "Howe has taken Philadelphia." Say rather, said Franklin, "Philadelphia has taken Howe."

These inversions abound in American history. When Washington, who had called on a lady and was waited on to the door by her little girl, said, "I wish you a better office!" "You will give me one," was her answer, "when I let you in to see my mother instead of out."

An early member of congress from Vermont when asked what he thought of Washington, said some things were better at home. He was asked what things? and answered, "Butter and girls; for there the butter is yellow and the girls are white, while here you have white butter and yellow girls."

The pilgrims landed on Plymouth Rock; wits have wished that Plymouth Rock had landed on the pilgrims.

The betrayer of a fugitive slave said, "People call me Judas but I don't care for that." But when asked what do you suppose Judas thinks about it? he began to care.

A Nebraska governor on the frontier was bed-fellow of an Irishman, and said, "In your old country, Pat, you would never sleep with a governor." The retort was, "And in my country you would never be made governor."

Mark Twain said he would not give one cent to hear Ingersoll's lecture on Moses, but for hearing Moses on Ingersoll he would give a thousand.

When we ask how far apart are St. Paul and Minneapolis, it is often answered; ten miles of geographical distance, and ten thousand miles of mutual contempt.

Antithetic wit sparkles in all lines of life. Examples crowd upon us.

Chesterfield thought he was a lord among wits when he was only a wit among lords.

The aged sinner says he has abandoned his vices; the truth is his vices have abandoned him.

The Mormon's religion is singular, but his wives are plural.

Honorary medals ill-bestowed led to the saying: Thieves used to be hung on crosses; now crosses are hung on thieves.

Pope translated Homer out of Greek. But his flatterers said;

Future ages will with wonder seek,
Who 'twas translated Homer into Greek.

Antithetical wit is never keener than when the end of a sen tence contradicts the promise of its beginning.

Thus it was said that a certain poem would be read when Homer was forgotten—but not before.

Of this nature is the benediction, "May the blessing of the Lord follow you all the days of your life, but never once overtake you."

In the same spirit a veteran declared McClellan a greater general than Grant, because he kept our army out of Richmond. So a gambler admitted that he lost much time in card-playing, namely, that consumed in shuffling.

Burns's jolly widower felt sure that his wife's soul was not in hell, for the devil could ne'er abide her.

An orator was said to be like the sun, because they both leave every thing as dark as they find it.

A man charged with hard drinking contended that he never drank save on two occasions; one was when he went a fishing, and the other was when he did not.

An ignorant man boasted that he understood two languages, one was English and the other profane.

A lady said to Voltaire, "I want to be as witty as if I saw you every day, and as good as if I never saw you at all."

Pres. Quincy, of Harvard, was celebrated as first in at morning prayers, and also as first to drop asleep when there.

George III is now called the best friend of our fathers in '76, because nobody else could have driven them to independence.

Ethan Allen was at dinner where toasts were drank to his majesty the king of England, and his majesty the king of Spain. When called on for another he gave, "To his majesty the king of hell!"

Time to a common man would seem a poor subject for witticism. But one wit said to his sweetheart, "O, the difference between you and a clock! Clocks teach me to observe the hours, you make me to forget them." Another said:

> "Swans sing before they die; 'twere no bad thing,
> Would certain persons die before they sing."

A wicked doctor who was also a poet had been condemned to take his own pills and to read his own poetry. "Give him his pills *after* the reading," said a wit, "or he will never live to read at all."

Antithetic wit often lies in contrasting the literal and figurative meanings of words.

When punning was decried as a low species of wit, it was answered, "It is indeed its foundation, which cannot be laid too low."

A wit fond of late hours said that he knew no better way to lengthen his days than by stealing a few hours from the nights.

At a governor's funeral where his horse was clad in sable, a wit said that he saw many long faces but none so long as that of the governor's horse.

Scott's poem on Napoleon's last battle was made to order, and provokes the epigram:

> "On Waterloo's ensanguined plain
> Lie many thousands of the slain,
> But none by saber or by shot,
> Fell half so *flat* as Walter Scott."

Addressing Napoleon's St. Helena jailer a wit said:

> Sir Hudson Lowe! Sir Hudson *Lowe*!
> By name—and ah! by nature too.

Antithesis is at its best in *retorts*. Many good retorts have been suggested by parts of the *body*.

A Roman who tried to brow-beat a Briton, was answered, "Many Romans have as crooked noses as Cæsar, not many have such straight arms."

Adams had drawn up a petition to the throne, and when his daughter said, "This paper will be touched by the hand of a king," he exclaimed, "It is more likely to be spurned by his foot!"

A school boy, about to be flogged because his hand was the dirtiest in a school, saved his bacon by showing his other hand which was in yet greater need of washing.

Waste no pity on a bald-headed wit. He will tell you that he is better and happier than anybody else, for there is scarce one hair 'twixt him and heaven.

According to the Biglow Papers, "There ain't no kind of quality for candidates, 'tis said, so useful as a wooden leg,—except a wooden head."

General Pope's bulletin dated, "Headquarters in the saddle," provoked General Lee to say, "Why, his head-quarters are where his hind-quarters ought to be."

Historians wonder why Roman conquests, which spread so widely east and west, never extended far north. Wits say; Roman noses were too long, and were nipped off by Jack Frost.

A corpulent wit riding on horse-back through a strange village, was told, that while other riders carried their portmanteaus behind he seemed to carry his before. His answer was "At home I also would carry mine behind, but among suspicious characters I think it safer before my face."

Gilbert Stuart, painting a lady who tried to make her mouth smaller than nature intended it, bade her not to trouble herself for her portrait should have no mouth at all.

The wide mouth of a French monarch's sweetheart led a wit to say, "O the blessedness of our king who kisses lips which stretch from ear to ear."

Wits hold that cross-eyed men can serve both God and Mammon, for they have an eye on both worlds at once.

When Solomon said, "Answer a fool according to his folly", wits felt authorized to give back lie for lie.

A man kicked a puppy that was biting him and when the owner insisted that the dog had not bitten him, replied, "Nor have I given him a kick!"

A married pair were boasting that they had never exchanged a cross word. A wit's remark was, "What a stupid time you have both had."

In general the best retorts make answer in a vein *contrasting* with that of a charge. The solemn is parried by the sportive, and the sportive by the solemn.

A theologian, answering a letter from a heretical wit wrote, "I have read your letter and wept over it." The wit replied; "I have read your letter and laughed at it."

When Voltaire was ordered to leave Genevese territory within twenty four hours, he said, "Whenever I shake my wig I powder the whole republic, and I will be out of it in five minutes."

Reading the epitaph, "Here lies one who never felt fear", a wit said, "That man never snuffed a candle with his fingers."

When one was talking of converting a Jewish girl, a wit objected because he would thus raise the price of pork.

Burke in a heated declamation threw down a dagger on the floor of parliament. The weapon had tragic force till Sheridan ejaculated, "The speaker has brought us his knife, but why did he forget his fork?"

When Leonidas was told that the Persian arrows would darken the very air he said, "I shall be glad to fight in the shade."

When a contraband was arguing that Jeff Davis must succeed because he was a man of prayer, and was told that Lincoln also prayed, his response was "I know it, but the Lord will think that Abraham is a joking."

"When I forget my country," exclaimed a sham patriot, "may the Almighty forget me!" "That", said a wit, "is the very best he can do for you!"

Retorts often take the form of a plausible *denial.* A man censured because his morals were bad denied that he ever had any.

The saloon-keeper says, "I must live." The wit answers "I see no need of that."

A lover who had been rejected, starting up from his knees cried out, "If my offer had been in earnest, how badly I should feel."

Another style of retort consists in a concession with a drawback, or counter-thrust. We say the Puritan came to New

England to worship God. "Yes", says a wit, "and also to cheat Indians, and hang Quakers."

When an old man boasts of renewing his youth, a wit says, "Youth—and childhood too". If he contends that there is still something of the boy in him, the admission is, "Something at least of the old boy."

When an admirer of Klopstock calls him the German Milton, wits add that he is "very German."

A Boston Catholic when charged by a Protestant with worshiping images answered, "Indeed I do, but I do not worship a cod-fish as you do the image of one you have hung up in your legislative hall." But when the Catholic labored to convert the Protestant, his defence was, "You give my faith too much to swallow and my stomach too little to eat."

The more solemn a scene the more ludicrous is its mocking counterfeit. A missionary in India as he rose in the pulpit saw a boy laughing and pointed him out with words of censure. But the boy laughed all the more, and others began laughing. The preacher became furious adding indignant gestures to his words. The merriment however, ran through the congregation, and soon roared out in a universal guffaw. The man of God was horrified till his eyes glanced above the sounding board where he beheld his own pet baboon. The miscreant had stolen into church and lay hid till service began. Then, perched on vantage-ground he rose when his master rose, and stood over his head mimicking and mocking all his attitudes and movements. Antithetic wit here reached its acme, while nobody laughed louder than the victimized missionary.

My endeavor has thus far been to treat of witticisms with some reference to their *characteristics.*

In regard to their *subject-matter* they are chartered libertines, roving without rein. A few, however, of their favorite sources of themes may deserve notice.

Many smart sayings are based on *Holy Writ.* In general they were not suggested by feelings of irreverence, though devil-wit is too common. They arose because no book is so well known as the Bible and because its solemn utterances enable antithesis to do its most perfect work.

When a man forced to labor on the Sabbath was rebuked by a fellow of notorious laziness his defence was; "You break the commandment on six days, I on only one."

Fasts and long prayers were easy for Pharisees. Without such appetizers they could not have devoured widows' houses with so much gusto.

When Satan took away everything else from Job he left him his wife. "Yet," says a wit, "he over-reached himself. Everything taken away was restored twofold. But this rule did not bring Job two wives. That might have been too much even for his patience."

When Dr. South saw a villain partaking of sacramental bread, he said, "I see Christ again descending into hell."

Rain is sent on the just and on the unjust. "Chiefly," said a wit, "on the just; for the unjust have borrowed their umbrellas."

A man of ostentatious piety is said to enter into his closet, but to forget to shut the door. On the other hand, those who say no grace before meat are likened to pigs under an oak, munching acorns but never looking up to see where they come from.

A Federalist parson could not avoid dining with a Jeffersonian party, and furnishing a toast to Jefferson. He had permission, however, to give one from the Bible. What he proposed was the eighth verse of the 109th Psalm. This text was greeted with cheers and bumpers. As soon as the preacher had taken leave, a Bible was looked up and the sacred words were found to be; "Let his days be few, and let another take his office."

National peculiarities have everywhere been a target for wit.

"The Englishman," said Voltaire, "in a land of three hundred religions and no cookery, cuts off the tail of his horse, and the head of his king."

When it is boasted that the sun never sets on British dominions, it is answered, "No wonder, for he dares not trust an Englishman in the dark."

An English bishop asked an American why we have no good judges of wine, and was told it was because we have no established church.

An English lady wondered that her dresses, though all bought in Paris, were not in good taste. A wit's reason was, that they had been selected by the lady herself.

The Dutch delight in the hexameter

Tellurem fecere Dii, sua litora Belgae.
"God made the world, Dutch made Holland."

An Englishman said, "I believe it. Holland looks as if a Dutchman had made it."

"Holland that scarce deserves the name of land
As but the offscouring of British sand."

In a similar vein frogs have been called Dutch nightingales.

Spain is antiquated, and some wit said that if Adam were to rise again he would find all things remaining there as at the first. "How glad he would be," said a Spaniard, "for Spain is Paradise." We ask, "Has Spain good government?" The answer is, "No, indeed! If it had, not an angel would be left in heaven. All would be down in Spain."

A national weakness of Gascons has made the word *gasconade* cosmopolitan. In allusion to this grandiloquence it is told that when one of these self-sufficients encountered an earthquake he fancied the earth was trembling through fear of him. He sought, however, to calm its terror. The Spanish epigram is:

A Gascon strutting forth in stubborn pride,
Saw earthquakes rend the land from side to side;
"Quake not, O earth!" he cried, "in fear of me,
For from my hand no harm shall come to thee."

"Jews," said Voltaire, "are bad enough though denied the use of pork. What if they had been allowed to eat pork so that all the evil in the hog had been added to the evil in the Hebrew!"

When it was asked in a Sabbath school. "Why did Aaron make a golden calf?" a chorus of voices answered, "Because the Jews would not give him gold enough to make a bull. It was just like them."

A man was commiserating a Jewish friend on his political disabilities. But the Jew's words were: "I may yet become your God. Half Christendom to-day worships the Jew Jesus, and the other half the Jewess Mary."

As to the *Irish*, they are born so witty, and are such a cause of wit in others that, if I should speak of them as they deserve, I suppose that even the world itself could not contain the books that should be written. One sample is all I can give of a million.

An Irishman's horse in lifting his foot caught it in the stirrup and seemed about to climb into the saddle. Thereupon the rider at once dismounted saying: "If you're for getting on, I am for getting off."

Professional or personal *foibles*, actual or attributed, are at the mercy of witlings. Lawyers are called sawyers who pull different ways but cut only the block, or blockhead which comes between them. When doctors hold a consultation the question is not what to give the patient, but how much to take from him.

In more than one Gospel we read of a woman who had spent all her living upon physicians, and was nothing bettered. Mark adds that "she rather grew worse." These words are not found in Luke, who, being a physician himself, is said to have omitted them out of professional pride.

A lawyer, reproached for lack of faith, said ministers had so much that there was none left for him. A soldier said the best preachers fired big guns but not long ones.

An office-hunter, when a man told him he would rather vote for Satan than for him, replied, "If your friend Satan should not be a candidate, will you then go for me?"

Sundry *accessories* render witticisms more effective. We never admire wit more than when it helps its owner out of a tight place.

Jupiter swore that Prometheus should remain chained to the rock forever, but when his anger cooled, said that but for his oath he would release him. Thereupon the prisoner fashioned a link of the chain into a ring for himself and set in it a bit of the rock. He thus kept Jove's oath inviolate and obtained his own freedom.

Persecutors set a roast pig before a starving Huguenot, but told him that whatever he should cut off first, must be cut off from his own body. His first cut was the tail.

A knight, tried by ordeal, was told the red hot ball he must carry would not burn innocent hands. "Then," said he to the judge, who was a bishop, "let your innocent hands give me the ball."

When a dead pope knocked at the gate of heaven and answered the call who's there by declaring his office, St. Peter said, "You have the key yourself, why trouble me to let you in?" The pope answered, "I have the key but it has grown rusty, for it is a long time since I have had any occasion to use it."

A Greek who was condemned by King Philip in his cups, cried out, "I appeal!" "To whom can you appeal?" said the autocrat. The answer was, "My appeal is from Philip drunk to Philip sober."

When a thief confessed stealing a pig his confessor told him that unless he made restitution the pig and his owner would rise up against him at the last judgment. "Will the pig be there?" asked the sinner. "Certainly," was the answer, "he will there raise against you his loudest squeals." "Then," said the thief, "I will catch him up and say to his owner, 'Here's your pig—take him.' Sooner I cannot restore him for I ate him up yesterday."

A negro admirer of the colored congressman Robert Small, maintained that he was stronger than Calhoun or any other statesman. "But," said a by-stander, "Small is not so strong as the Almighty, is he?" The darky was silent a moment, but soon said, "Small is not yet so old as God." The wit's idea was, when he is as old who knows how strong he may become?

A score of convivialists had agreed on a prize for the one of them who could tell the biggest lie. Nineteen of them had done their best, but the nineteenth whopper outdid all before him. The twentieth man took a new departure, and said, "I believe all that the last liar has said, and that you all believe it too, but I can't tell a lie."

The exhibitor of St. Peter's skull at Rome was told by a tourist that he had seen St. Peter's skull in France. "No doubt you have," was the answer; "but what you saw was the skull of Peter the fisher-boy, twelve years old; you here behold the skull of Peter, full-grown and chief of the apostles."

Another sacristan, when he brought out of his reliquary the sword Balaam took to kill his ass with, was told by a Bible reader, "Balaam had no sword; his words were, 'I would there were a sword in my hand, then would I kill thee.'" The rebutter was, "Stranger, this is the sword that Balaam wished he had, —the very one he wished for."

In cases of this sort wit strives with things impossible, yea, gets the better of them.

You have heard my last witticism save one. That one I have reserved for my ultimatum because in my judgment it is the best of all.

My wife said to me; "My dear, you and I know every thing." "How can that be?" said I. Her answer was, "I know that you are a fool, and you know every thing else."

Surveying the world's witticisms I feel as though I had now stolen for you a few scraps from that feast of the gods, or some shreds and patches of their royal apparel. I have brought you bouquets and only claim to be the string which ties their flowers together. The flowers too are all broken off from their native stalks, and have perforce withered. The witticisms now placed before you needed Irish brogue, German labiation, Yankee twang or negro melodies that they might be seen at their best. Besides, wit when time cohered with place and place with wishing is as unlike itself as I exhibit it, as the teeth of a belle where nature set them differ from the same teeeh when extracted and lying on a dentist's plate.

What ecstasies and delectations in that banquet of immortals which Beaumont describes in merry meetings where he heard

> "Words that had been
> So nimble and so full of subtle flame,
> As if that every one from whom they came
> Had meant to put his whole wit in one jest,
> And had resolved to live a fool the rest
> Of his dull life."

Such an encounter of ethereal souls would put a kohinoor on all our fingers, set us in a shower of gold and hail rich pearls upon us, pearls more lustrous than Cleopatra dissolved for mad Anthony to quaff.

Such a kaleidoscopic configuration, "created of every creature's best" is beyond hoping for.

After all, we feel that anthologies of wit are the immortal part of our libraries. Witty utterances,—born, not made up—a bright precipitate of soul,—are like the first Tokay vintage, nectar that trickles out of the clusters from their own weight and needs no pressure. Such jewels five words long on the stretched fore-finger of all time sparkle forever. We shall enjoy them as long as we live and they will even help us to live longer.

Brevity is the soul of wit, and brevity should be the watch-word of all who treat of it. Did I, like Dogberry, have the heart to bestow all my tediousness on you at once, I should only exhaust you and myself, but not my theme. My bald unjointed chat has been prolix already, and when you are asked what my talk was about, you may well answer "It was about—half an hour too long."

So then my last words shall be; "May your lives be as long as my lecture, and not half so dull."

Madison, Wis.

AN IMPROVED HARMONOGRAPH.

CHARLES H. CHANDLER,

Professor of Mathematics, Ripon College.

This harmonograph shows the composition of two simple harmonic motions in the same plane, agreeing or differing in any or all of the following elements: direction, amplitude, period, epoch.

The resultant is described by a pencil (or other recording point) borne upon one end of a straight rod, termed the "recording rod," which is attached at the other end by a ball and socket joint to a bar sliding with a simple harmonic motion in a direction transverse to the recording rod; its motion being given by the familiar device of a crank playing in a transverse slot in the sliding bar. The recording rod at some intermediate point passes freely through another ball and socket joint on a second sliding bar similar to the first, and similarly actuated to a simple harmonic motion.

Obviously the motion of the first sliding bar, the second remaining unmoved, gives the recording point a simple harmonic motion, having the same period as the motion of the sliding bar, but at all times differing from it in phase by one half its period, and of an amplitude having a ratio to the amplitude of the motion of the sliding bar equal to the ratio between the lengths of the segments of the recording rod formed by the intermediate joint. Similarly the motion of the second sliding bar, the first remaining unmoved, gives the recording point a simple harmonic motion of the same period and phase as the motion of the sliding bar, but of larger amplitude, the two amplitudes being proportional to the distances of the recording point and the sliding bar from the end of the recording rod remaining unmoved.

Evidently by simultaneous motions of the two sliding bars the resultant of the two simple harmonic motions may be recorded upon a tablet placed in a plane parallel to the planes in which the sliding bars vibrate, the recording point being pressed upon this tablet by a spring sufficiently yielding to accommodate the distance varying with the obliquity of the recording rod. The two motions are made simultaneous by connecting the parallel shafts bearing the driving cranks by means of gears. Obviously, by changing these gears, the periods of the two motions may be made to have any commensurable ratio desired.

So, too, the length of each crank may be changed by a screw, and thus the amplitudes may be given any desired ratio.

The shaft bearing the second crank, together with that crank and the attached sliding bar, the direction of the shaft remaining unchanged, can be revolved about an axis coincident in position with the central position of the recording rod, and fixed in any desired place, thus determining the angle between the directions of the two simple harmonic motions.

The gear intermediate between those on the two driving shafts may be disconnected from them, and the phases of the two motions may be adjusted at pleasure while they are independent of each other, thus securing any difference of epoch at the commencement of composition.

Since the distances between the three planes containing the two original simple harmonic motions and the resultant are constant, the recording rod slipping freely through the intermediate joint, as the spring near the point lengthens the rod when it is oblique to the tablet, evidently the segments of the rod maintain a constant ratio, and the resultant remains true.

If the two simple harmonic motions have the same direction, is is evident that they will be traced along the same straight line and that their parts in the production of the resultant will be indistinguishable. But this difficulty can be removed in a manner similar to that of several other devices for the composition of such motions, and with more than usual facility. The receiving tablet can be moved transversely with a uniform motion by means of a rack and pinion, the pinion being borne upon the end of a shaft connected at pleasure by gears to the driving shaft of the first crank.

Three or four simple harmonic motions may be compounded by two of these harmonographs combined in a manner somewhat analogous to that employed in Donkin's harmonograph for compounding two motions. Let two harmonographs be so placed that their recording rods, when in their central positions, meet and form the same straight line, this line preferably being vertical; and let an additional shaft with a gear upon each end connect the driving wheels of the two machines. If now the lower recording point be replaced by a tablet moving freely upon ways transverse to the line of the recording rods, these ways being part of a carriage itself movable upon ways transverse to the first ways and also to the line of the recording rods, the desired resultant of three or four harmonic motions having any relative directions, amplitudes, periods and epochs will necessarily be shown.

Ripon, Wis.

NOTE ON THE PROGRESS OF MERIDIAN TRANSIT OBSERVATIONS FOR STELLAR PARALLAX AT THE WASHBURN OBSERVATORY.

A. S. FLINT,

Assistant Astronomer, University of Wisconsin.

The method is that of Dr. Kapteyn, of the Leiden Observatory, 1885–1887, and consists of noting the differences in time between the meridian transits of a selected parallax star and of two comparison stars disposed as symmetrically as possible with reference to the former. This method has scme peculiar advantages. The instrument is the Repsold meridian circle of 12.2 cm. aperture, 143.7 cm. focal length, and with an ocular giving a power of 180. Fine brass wire screens mounted on a travelling frame above the instrument are used to diminish the apparent magnitude of brighter stars. An ordinary chronograph is used for recording the transits. A list of seventy-six stars is under observation, including all available stars having a proper motion of one second of arc or more. The observations were begun October 16, 1893. Each star will be observed at three successive epochs six months apart, so that errors in the adopted proper motions and other progressive errors will be closely eliminated. A series of observations with the zenith distance micrometer is in progress to ascertain what effect the screens have on the path of the light passing through them. Such effect, if any, appears to be extremely small; but a well-marked personal error in the bisection of brighter stellar discs is shown, namely, that the present observer always bisects bright stars too low by 0″.26. The probable error of this result is ±0″.029. This personal error is confirmed, in magnitude and sign, by two independent results for the same observer. First, from the declinations of zenith stars observed alternately as north and as south zenith stars, in 1891–1892, there resulted

0″.23, with a probable error of ±0″.10. Second, for all stars observed in 1891-92 there resulted from a comparison of the differences between the observed declinations and the tabular declinations of the Berliner Jahrbuch, as between brighter and fainter stars, the value 0″.29 with probable error ±0″.10. So far as can be judged, the present series of observations for parallax does not promise such small probable errors for the final results as pertain to the methods with the filar micrometer and the heliometer; but it promises, nevertheless, to make a somewhat valuable contribution to the data for our knowledge of stellar distances.

Madison, Wis.

SPHAGNA OF THE UPPER WISCONSIN VALLEY.

L. S. CHENEY,

Instructor in Botany in the University of Wisconsin

The following is a list of the Sphagna collected along the Wisconsin river from Lac Vieux Desert to Granite Heights, a small station a few miles north of Wausau, between the 9th of June and the 5th of August, 1893. The work of identification was done by Dr. C. Warnstorf of Neuruppin, Prussia, to whom material from every field pocket was sent. The numbers are the field numbers under which duplicates are distributed:

Sphagnum medium, Limpr.—201, Lac Vieux Desert. 307, 311, Pine Lake. 600, State Line. 688, Conover. 1365, 1367, Rainbow Rapids. 1442, McNaughton. 1583, 1586, 1587, 1606, Newbold. 1647, 1671, 1679, 1680, 1685, 1688, 1693, Lake Julia. 2013, Whirlpool Rapids. 2152, 2171, 2174, Tomahawk. 2405, Grandmother Bull Falls.

Sphagnum medium, v. *purpurascens*, W.—309, Pine Lake. 974, Tomahawk Lake.

Syhagnum medium, v. *purpurascens*, f. *brachyclada*, W.—211, Crystal Lake.

Sphagnum medium, v. *roseum*, Röll.—298, Pine Lake. 965, 970, 973, Tomahawk Lake. 1284, 1237, Doherty Lake. 1445, 1452, McNaughton. 1605, 1616, Newbold. 2150, 2173, Tomahawk.

Sphagnum medium, v. *pallescens*, W.—894, Eagle River. 1283, Doherty Lake. 1368,1385, Rainbow Rapids. 1691,Newbold.

Sphagnum medium, v. *glaucescens*, W.—194, 195, Crystal Lake. 476, Lac Vieux Desert. 899, Eagle River. 962, 968, Tomahawk Lake. 1131, Doherty Lake. 1575, 1578, 1585, Newbold. 1678, Lake Julia. 2156, 2157, 2223, 2224, Tomahawk. 2403, Grandmother Bull Falls. 2792, Merrill. 2874, 2876, Pine River.

Sphagnum medium, v. *glaucescens*, f. *euryclada*, W.—1682, Newbold.

Sphagnum medium, v. *glaucescens*, f. *brachy-euryclada*, W.—1697, Newbold. 2172, Tomahawk.

Sphagnum medium, v. *glauco-carneum*, W., f. *brachy-euryclada*, W.—2169, Tomahawk.

Sphagnum medium, v. *versicolor*, W., f. *brachy-euryclada*, W.—213, Crystal Lake.

Sphagnum recurvum, Russ. & Warnst.—63, Lac Vieux Desert. 963, Tomahawk Lake. 1663, 1689, 1690, 1692, 1694, Newbold. 2158, Tomahawk.

Sphagnum recurvum (P. B.) R. & W., v. *parvifolium* (Sendt.), W.—206, 209, 210, Crystal Lake. 231, Lac Vieux Desert. 305, 310, Pine Lake. 602, State Line. 685, 687, Conover. 898, 900, Eagle River. 969, 971, 973, Tomahawk Lake. 1133, 1285, 1286, Doherty Lake. 1361, 1371, 1384, 1386, Rainbow Rapids. 1447, 1448, 1450, 1456, McNaughton. 1580, 1588, Newbold. 1607, 1612, 1615, Newbold. 1661, 1662, 1677, 1681, 1683, 1684, 1687, 1696, Lake Julia. 2154, 2155, 2170, 2191, Tomahawk.

Sphagnum recurvum, v. *parvifolium*, f. *tenuis*, Klinggr.—207, Crystal Lake. 897, Eagle River. 1577, Newbold.

Sphagnum recurvum, v. *parvifolium*, f. *Warnstorfii*, (C. Jens.) W.—299, 300, 304, Pine Lake. 601, State Line. 893, 895, 896, Eagle River. 972, Tomahawk Lake.

Sphagnum recurvum, v. *mucronatum*, Russ.—1689, Newbold.

Sphagnum recurvum, v. *amblyphyllum*, Russ.—1132, Doherty Lake.

Sphagnum rufescens, Bryol. Germ.—464, 479, 480, Pine Lake. 1128, Doherty Lake. 1195, Clear Lake.

Sphagnum obesum, (Wils. Limpr.) W., v. *tenuissimum*, W., f. *immersa*, W.—1200, 1201, 1203, 1204, 1205, Clear Lake.

Sphagnum Wulfianum, Girgens.—192, 232, Crystal Lake. 621, State Line. 753, Conover. 889, 960, Eagle River. 1370, 1370a, Rainbow Rapids. 1576. Newbold. 1672, 1676, Lake Julia. 2406, 2421, Grandmother Bull Falls. 2804, 2829, 2830, Merrill.

Sphagnum Girgensohnii, Russ.—582, Lac Vieux Desert 901, Eagle River. 982, 984, 986, 992, 1034, Tomahawk Lake. 1359, 1360, 1362, 1364, 1369, Rainbow Rapids. 2147, 2148, 2153, Tomahawk. 2401, 2404, Grandmother Bull Falls. 2443, 2482, Grandfather Bull Falls. 2828, 2831, Merrill, 2873, Pine river.

Sphagnum papillosum, Lindb., v. *laeve*, W. (*S. intermedium*, Russ.).—193, 196, 197, Lac Vieux Desert. 230, Crystal Lake. 299, 302, Pine Lake. 599, State Line.

Sphagnum squarrosum, Pers.—581, Lac Vieux Desert. 967, Tomahawk Lake. 1363, Rainbow Rapids. 2420, Grandmother Bull Falls. 2735, 2736, 2806, Merrill.

Sphagnum squarrosum, v. *semisquarrosum*, Russ.—2872, Pine River.

Sphagnum acutifolium, (Ehrh.) R. & W. (with *S. medium*.)—199, Lac Vieux Desert. 1675, Newbold.

Sphagnum acutifolium (Ehrh.) R. & W.—190, 191, 198, 202. Crystal Lake. 303, 306, Pine Lake. 1451, 1455, McNaughton. 1667, 1669, 1670, Newbold.

Sphagnum fuscum, Klinggr.—312, Pine Lake. 684, 685, 689, Conover. 1449, McNaughton. 1582, 1609, 1610, 1611, 1613, 1614, Newbold.

Sphagnum Dusenii, C. Jens.—208, 212, Crystal Lake. 308, Pine Lake. 1444, 1446, 1457, McNaughton.

Sphagnum Russowii, Warnst.—2151, Tomahawk.

Sphagnum subsecundum, Nees.—301, Pine Lake. 964, Tomahawk Lake. 1130, Doherty Lake. 1441, McNaughton. 1654, Newbold. 2149, 2211, 2222, Tomahawk. 2875, Pine River. 2941, Crystal Lake.

Sphagnum teres, Aongstr. v. *squarrosulum* (Lesq.).—580, Lac Vieux Desert. 2024, Whirlpool Rapids.

Sphagnum Warnstorfii, Russ. v. *virescens*, R.—189, Crystal Lake. 1997, 2023, Whirlpool Rapids. 2942, Lac Vieux Desert.

Sphagnum Warnstorfii, v. *versicolor*, R.—203, Lac Vieux Desert.

Sphagnum compactum, DC., v. *subsquarrosum*, W.—1443, 1453, 1454, McNaughton.

Sphagnum subsecundum, v. *microphyllum*, f. *immersa*, W.—481, Lac Vieux Desert.

Sphagnum rufescens, v. *tenue*, f. *immersa*, W.—482, Pine Lake.

Madison, Wis.

PARASITIC FUNGI OF THE WISCONSIN VALLEY.

L. S. CHENEY,

Instructor in Botany in the University of Wisconsin.

This short list represents the parasitic fungi collected along the Wisconsin River from its source, Lac Vieux Desert to Granite Heights, a small station a few miles north of Wausau, between June 9 and August 5, 1893. The material was determined by Dr. J. J. Davis of Racine. The numbers are the field numbers.

Puccinia rubefaciens, Johans.—2861, Pine River.

Puccinia asteris, Duby.—1589, Newbold.

Æcidium grossulariæ, DC.—735, Conover. 1245, Rainbow Rapids.

Æcidium apocyni, Schw.—2399, Grandmother Bull Falls.

Æcidium iridis, Gerard.—2929, Granite Heights.

Æcidium lycopi, Ger.—1017, Tomahawk Lake.

Phyllosticta calaminthæ, E. & E., with *Æcidium lycopi*.—1321, Rainbow Rapids.

Urocystis waldsteiniæ, Pk.—4, 68, 75, Lac Vieux Desert.

Cæoma chiogenis, Dietel (in lit.)—490, Lac Vieux Desert.

Cæoma nitens, Schw.—491, Lac Vieux Desert.

Melampsora farinosa, (Pers.) Schrœt. =*M. Halicina*, Lev.—1423, Doherty Lake.

Dimerosporium collinsii, (Schw.) Sacc. (immature). 2175, Tomahawk.

Cladosporium lathyrinum, E. & E.—2002, Whirlpool Rapids.

Gnomoniella coryli, (Batsch) Sacc.—1728, Rhinelander.

Ustilago caricis, (Pers.)Fckl.—486, Pine Lake.

Uromyces fabæ, (Pers.) DBy.—Uredo- and teleutospores, 2188, Tomahawk.

Madison, Wis.

HEPATICÆ OF THE WISCONSIN VALLEY.

L. S. CHENEY,

Instructor in Botany in the University of Wisconsin.

The Hepaticæ here enumerated were collected along the Wisconsin river from its source to a point a few miles above Wausau The work of identification was done by Dr. L. M. Underwood of De Pauw University, to whom material from each field number was sent. The numbers are the field mumbers under which duplicates are distributed.

Riccia fluitans, L.—1584, Newbold.

Ricciocarpus natans, L.—2324 (terrestrial form), Grandmother Bull Falls.

Marchantia polymorpha, L.—219, Crystal Lake. 1439, McNaughton.

Conocephalus conicus, Dumort.—315, Lac Vieux Desert. 1998, 2005, Whirlpool Rapids.

Anthoceros lœvis, L.— 2725, Grandfather Bull Falls. 2822, Merril.

Anthoceros sp. (*immature*)—2216, Tomahawk.

Aneura latifrons, Lind.—998, 1145, Tomakawk.

Aneura pinguis, Dumort.—570, Lac Vieux Desert.

Aneura sp.—2184, Tomahawk.

Pellia epiphylla, Raddi.— 1381, Rainbow Rapids. 1545, Newbold.

Jungermania Schraderi, Mart.—55, 59, 469, Lac Vieux Desert, 1262, Rainbow Rapids. 2864, Pine River.

Jungermania barbata, Schreb.—105, Lac Vieux Desert. 1844, Hat Rapids. 2559, 2643, 2645, 2650, Grandfather Bull Falls.

Jungermania excisa, Dicks.—636, State Line. 825, near Eagle River. 1247, Rainbow Rapids.

Jungermania incisa, Schrad.—82, Lac Vieux Desert. 1215, 1380, Rainbow Rapids.

Jungermania exserta, Schmidel.—631, State Line.

Plagiochila asplenoides, Dumort.—1526, McNaughton.

Chiloscyphus polyanthos, Corda.—1032, Tomahawk Lake. 1980, 1992, Whirlpool Rapids.

Lophocolea heterophylla, Nees.—52, 576, Lac Vieux Desert. 1741, 1824, Rhinelander. 1267, Rainbow Rapids. 1964, Noisy Creek.

Lophocolea minor, Nees.—2580, 2604, 2624, 2672, Grandfather Bull Falls.

Kantia trichomanis, S. F. Gray.—938, 948, 951, 952, Wisconsin River, 15 miles above Tomahawk Lake.

Cephalozia multiflora, Spruce.—463, 470, Lac Vieux Desert, 698, Conover. 933, 943, 949, Wisconsin River 15 mi. above Tomahawk Lake. 1196, Clear Lake. 1254, 1262, 1263, Rainbow Rapids. 1531, Newbold.

Cephalozia curvifolia, Dumort.—729, Conover. 1281, Doherty Lake. 2297, 2356, 2357, 2359, 2397, Grandmother Bull Falls.

Cephalozia Macouni, Aust.—60, Lac Vieux Desert.

Blepharostoma trichophyllum, Dumort.—1264, Rainbow Rapids. 1522, Rhinelander.

Lepidozia reptans, Dumort.—49, 86, Lac Vieux Desert. 629, State Line. 939, 1021, Tomahawk Lake. 1520, Rhinelander. 1581, Newbold. 2275, Grandmother Bull Falls.

Bazzania trilobata, S F. Gray.—54, 575, Lac Vieux Desert. 724, 826, Conover. 1318, Rainbow Rapids. 2715, Bill Cross Rapids.

Trichocolea tomentella, Dumort.—1165, 1158, Tomahawk Lake.

Ptilidium ciliare, Nees.—15, 20, 25, 47, 48, 89, 355, 561, Lac Vieux Desert. 1560 (close compact form), Newbold. 1757, Rhinelander. 1876, Whirlpool Rapids. 2116, 2127, 2192, 2194, Tomahawk.

Porella pinnata, L.—1839, Hat Rapids.

Porella platyphylla, Lindb.—344, Lac Vieux Desert. 1325, 1327, Rainbow Rapids.

Radula complanata, Dumort.—1026, Tomahawk Lake. 2663, Grandfather Bull Falls.

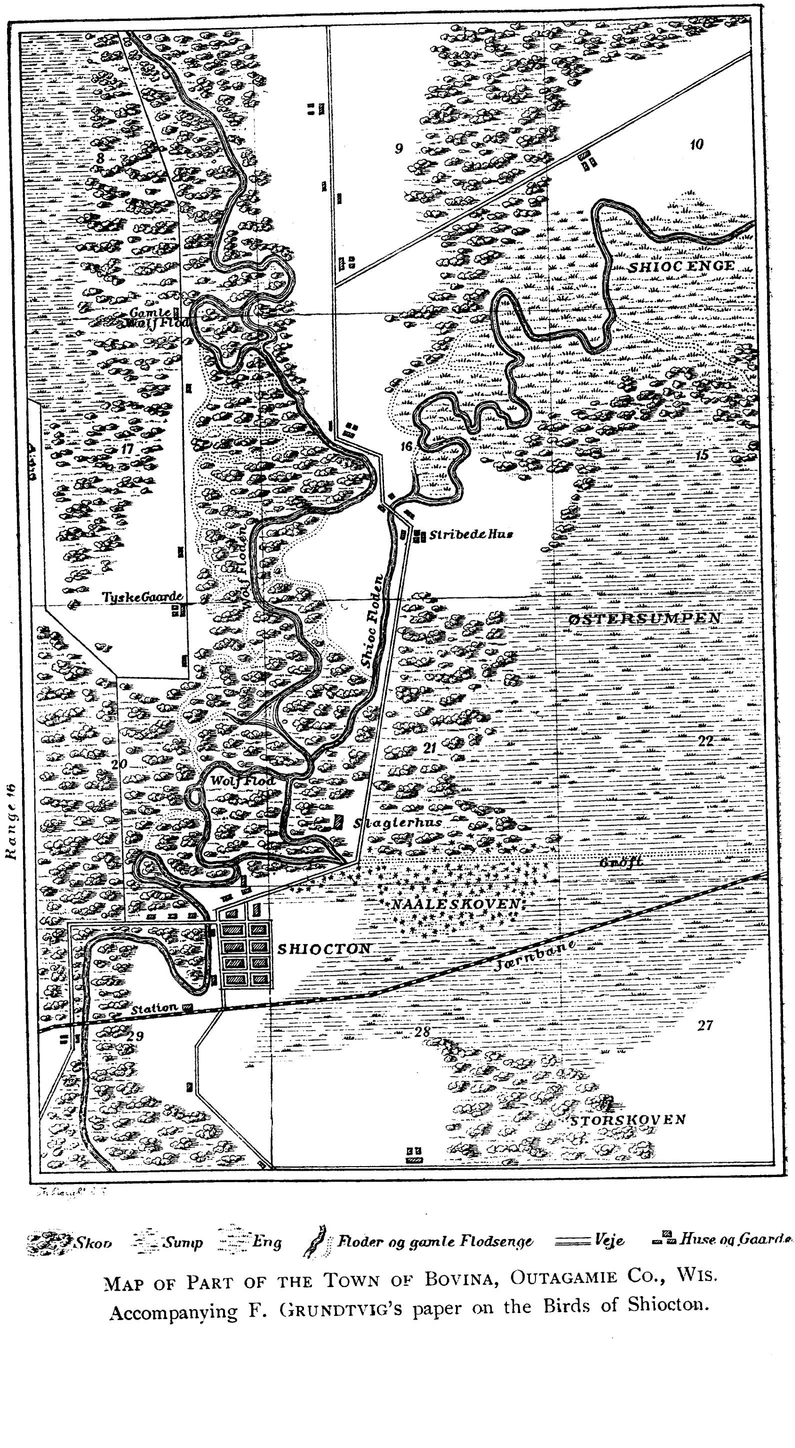
Lejeunea serpyllifolia Americana, Lindb.—2497, 2558, Grandfather Bull Falls.

Frullania Virginica, Lehm.—2276, 2347, Grandmother Bull Falls.

Frullania Eboracensis, Lehm.—1, 35, 320, 325, 342, Lac Vieux Desert. 1165, Rainbow Rapids. 1819, Rhinelander. 2261, 2268, Grandmother Bull Falls.

Frullania Asagrayana, Mont.—1314, Rainbow Rapids. 2353, 2365, Grandmother Bull Falls.

Madison, Wis.



MAP OF PART OF THE TOWN OF BOVINA, OUTAGAMIE CO., WIS.
Accompanying F. GRUNDTVIG's paper on the Birds of Shiocton.

ON THE BIRDS OF SHIOCTON IN BOVINA, OUTAGAMIE COUNTY, WISCONSIN, 1881–83.

F. L. GRUNDTVIG.

[*Translated by* CHARLES E. FAXON, *from the* "*Videnskabelige Meddelelser fra den naturhistoriske Forening i Kjöbenhavn for Aaret* 1887," *pp.* 305–396, *Copenhagen*, 1888.]

WITH A MAP.

The systematic names of the birds are those given in "The Code of Nomenclature and Check List of North American Birds, adopted by the American Ornithologists' Union," New York, 1886. Unfortunately the new edition of E. Coues's "Key to North American Birds" could not be made use of. Measurements are given in millimetres, when not otherwise noted. 1 mile = 1609 metres. Of abbreviations and signs may be named: L., length; B., breadth; E., extent; W., wing; T., tail; B., bill; M., measurement; ×, resident; ××, summer resident; ×××, migrant; <, less than; >, greater than; C. L., above-named "Check List;" Davie, O. Davie's "Nests and Eggs of North American Birds," 1866.

I. INTRODUCTION.

For two years — from October, 1881, to October, 1883 — I lived at the "Striped House" on the Shioc river, a mile and a half north of the village of Shiocton. The situation is given on the accompanying map. I employed a large part of my time in studying the bird-life of the immediate vicinity. It was very seldom that I did not make one or more trips a day for this purpose. I traversed almost daily that part of the region designated by the section numbers 16 and 21, and usually examined all that piece of land situated on the map north of the railway. In what follows I will, for convenience, call this region the *Daily Beat*. South of the railway I went less frequently, but I give my observations there in order to show how cautious one must be in applying to regions of a wider limit conclusions drawn from conditions obtaining in a single locality. I trust that my observations will not be misinterpreted to mean that in the following pages I have represented the condition of things for the whole of Outagamie county. The region explored by me includes an area of only twelve square miles, and the conditions there are not so diverse that I can by any means suppose that all the birds that belong to Outagamie county can be found there. Neither are my observations equally satisfactory as regards all the species found there. I can not deny that here and there a species has escaped my attention and I know that I have seen several that I had no opportunity to determine. This is especially true of birds of prey and water birds. As to the former my observations are very fragmentary. Most of them are seen only in migration time, are very difficult to shoot, and difficult to identify in flight. Many more than I give certainly breed in the region, but I was too much occupied in other investigations to search after their nests. I hoped in a third year to complete my observations as far as possible, but circumstances forbade. I have taken great pains to procure exact information as to the spring migration of some of the smaller birds, especially the warblers (*Sylvicolidæ*). But it must be remarked that the observations were in a high degree difficult after the woods had leafed out. Should any species of these birds have escaped my attention they must certainly be among those that migrate latest. The difficulty of studying birds in tall leafy trees is also the principal reason why I cannot give more information about the fall migration. I saw many of the birds again in the autumn, but I seldom note it, since to my mind such scattered observations are of no value.

Even exact observations of migratory birds at a single station have, on the whole, only little importance in any case when the spot is not in some way especially favored as a stopping point in migration. I supposed I had found on the peninsula in the river an especial stopping point for warblers and birds that accompany them, vireos and certain flycatchers (*Tyrannidæ*). That they have such stopping points I doubt not. I have noticed that many other birds (such as *Turdus aonalaschkæ pallasii*, *Zonotrichia albicollis*, *Passerella iliaca*, waders, and ducks) can be invariably found during migration at certain fixed places. I have since learned however, that the warblers probably have their stopping point on the heights south of the railway.

conclude this partly from my acquaintance with the "Great Wood," spoken of later, partly and principally from the experi ence that the largest flocks are seen most often in the above named peninsula *towards evening* or during the afternoon.

That the migration of warblers takes place during the night is, I think, indubitable. When they were seen on the peninsula towards evening it seems highly probable that they arrived at the stopping point a little south of Shiocton in the morning, and that they slowly moved about in the course of the day in search of food. Perhaps only under certain conditions the newly arrived flock reached as far as the peninsula. On many warm, still days the birds were seen only scattered and singly. When a large flock was seen in the afternoon, it was usually bad weather—rain or high wind. On such days the birds were very restless. The flocks hurried from tree to tree. If the wind became a storm they were unable to continue migration. They sat dishevelled and disheartened in bushes and brush or even on the ground. If the storm continued several days, hosts of birds were seen from morning till evening. That was merely testimony that the migration was arrested. I think for this reason that one should by no means conclude that the greatest migration corresponds to the time when one sees the most birds in a day. The migration is certainly for the most part unobserved. Most of the flocks go over the observer's head while he sleeps. It is therefore largely *accidental* what birds he sees. I suppose however, that after a heavy migration there are almost always scattered individuals to be seen that for some reason have become separated from the flocks. In this way I explain the appearance of single individuals of *Sylvania pusilla.* If this be true the observations have still *some* value. I have sought to give in a list — even if very incomplete — an idea of the numbers of the different warblers seen. It cost me much labor, but I consider it no longer of much value now that I have come to see the conditions under which the observations were made. Many of the gray-green warblers (such as *Dendroica palmarum*, *D. vigorsii* and *Helminthophila celata*) were probably seen oftener than is specified; but they are not easy to identify at a distance, and I was unwilling to shoot a large number.

I can conclude very little from my observations. The assertion that the males *always* come first does not however hold good; but quite certainly most warblers appear to have two flights, with several days interval. In the first, as a rule, most males are seen, in the last most females and *young birds.*

Observations on the birds breeding at a given locality have to my mind greater value than observations onthe passage of migratory birds. I think it must be admitted that the first seen of these birds are as a rule those which nest on the spot. This is naturally in most cases difficult, not to say impossible, to *prove.* I do not rest my belief on the now generally accepted theory that the most northern breeding birds go farthest south in the winter;[1] I support myself only on my own experiences, and for house-birds' appearance these are, I think, sufficient.

The first *Troglodytes aëdon* that I saw in 1883 were a pair which on the seventh of May, early in the morning, sang near the house and immediately took possession of the bird-houses. Both years I saw *Sayornis phœbe* first at the house. *Flocks were not seen until after the native birds had eggs.* Of *Chætura pelagica* I saw in 1883 the first pair near the house on the morning of May 7. In the course of the day they visited the old nest on the chimney. Of *Merula migratoria* I can say this, that flocks were seen when nests in the place were nearly finished. That the first, which were seen Feb. 26, 1882 and March 22, 1883, were those that built on the spot, I cannot of course assert. But it seems to me noteworthy that both times they were seen in the same poplars where one of these birds afterward had a nest. *Dendroica pensylvanica* was seen in 1882 for the first time at a spot were both years there was a nest. That however was perhaps quite accidental. The first *Vireo gilvus* in 1883 was seen not in a flock but singly at its breeding place. *Habia ludoviciana Passerina cyanea* and many others were seen *only* at the breeding-places.[2]

[1] In the autumn the northern birds' migration reached Shiocton probably after—in some cases long after—the native birds of the same species had departed. This was true at any rate of many, such as *Merula migratoria*, *Sturnella magna*, *Chordeiles virginianus*, *Anas boschas* and *Anas discors.*

[2] South of the railway a flock of *Habia ludoviciana* was seen May 22, 1883. On May 16 the single ones were seen at the breeding places.

As a rule the first of the smaller native birds were seen *in the morning*, whilst the migrating birds were often seen toward evening. This also, I think, points in the same direction as the facts mentioned above. I understand, however, that my observations in this respect are too few to draw *with certainty* any general conclusions from. I must, therefore, be contented with a theory.

If one starts with the supposition that the first seen of the smaller birds are those that build on the spot,[3] it is not altogether idle to notice the weather conditions under which these birds appear. In America especially, it is very often considered a fact that birds in migration come with a south wind or a south storm. This rests probably on misinterpretation of observation. That migrants should come with a south storm is certainly unreasonable. I regard it as certain that a storm, whether it come from the south or north, arrests migration. I have spoken of this above. Neither do I believe that a south wind especially favors migration. It may be conceded that a north wind early in the spring appears to hold back migrating birds, but it is perhaps alone on account of the *cold* which accompanies it. Later migrants come with all winds; but they seem to prefer still weather. The most of the native birds came—perhaps accidentally — when a light north wind blew.

Heavy rain surely arrests migration quite as much as storm; but many birds seem to prefer to migrate in dark, damp weather. But only when it is mild. Whether the moon has any influence o migration I shall not undertake to say.

The number of native breeding birds was very different in 1882 and 1883. Certain conditions accounted for the presence of some birds (as was known with regard to passenger pigeons and *Coccyzus erythrophthalmus*); but in the main the change must be ascribed to the character of the previous winter. Many birds doubtless perished during the severe winter of 1882–83; but this does not fully explain the facts, since certain species were more numerous in the summer of 1883 than in the summer of 1882.

[3] The first passenger pigeons in 1882 were not those that built on the spot. Neither the first of other irregularly migrating birds such as *Ampelis cedrorum*, *Spinus tristis*, ducks, etc.

My opinion is that southerly birds after a mild winter are inclined to extend their range northward, while after a hard winter they relinquish their acquisition. Northerly birds will, after a severe winter, breed scatteringly further south than is customary. Such species as breed every year at a given place will, after a rigorous winter, be more abundant than usual, provided that their northern limit of distribution is neither too far from the given point, nor so near that many of them accustomed to breed in the locality settle further south. Unfortunately only very incomplete knowledge of the breeding range of birds west of the Great Lakes exists. Faunal distributions such as that of J. A. Allen, founded chiefly on observations to the eastward in the vicinity of the ocean, are in no way suited to this region. Yet it may, I think, be said that the fauna at Shiocton is mostly Alleghanian; but it is not far from the southern limit of the Canadian.

In 1883 no *Protonotaria citrea*, *Melanerpes carolinus*, *Coccyzus americanus* and *Turdus mustelinus* [4] were seen. *Protonotaria citrea* is regarded as a very southern bird. But in any case it reaches a good distance up into the Alleghanian fauna on the Mississippi. *Melanerpes carolinus* is said to be one of the most characteristic birds of the Alleghanian fauna.[5] The same is true of *Turdus mustelinus*. Of the particularly characteristic birds of the Alleghanian fauna there were in 1883 fewer of the following: *Harporhynchus rufus*, *Dendroica pensylvanica*, *Piranga rubra*, and *Vireo flavifrons*.

There were more *Helminthophila chrysoptera*, which is said to belong especially to the Carolinian fauna;[7] but the northern limit of this bird in Wisconsin will probably be found in the Canadian. I conclude this from the considerable number seen at Shiocton in migration time.

There were more *Turdus fuscescens*, *Carpodacus purpureus*, *Mniotilta varia*, *Compsothlypis americana* and some others

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[4] In Brown county hardly any *Icterus spurius*.

[[5] It is more characteristic of the Carolinian fauna.—TRANSLATOR.]

[[6] *Piranga erythromelas* Vieill —AUTHOR *in litt.*]

[[7] *Helminthophila chrysoptera* is a bird of the *Alleghanian* fauna.—TRANSLATOR.]

which either belong especially to the Alleghanian fauna or are equally numerous in that and the Canadian.

There were fewer of some which according to my general theory one would have expected to find in greater numbers, since they are said to come into the Canadian although especially belonging to the Alleghanian fauna. Of these may be mentioned *Passerina cyanea*, *Pipilo erythrophthalmus*, and *Icterus galbula.*

Many birds which are said to belong to the whole of North America were in 1883 partly more numerous (*Ampelis cedrorum*, *Trochilus colubris*), partly fewer (*Seiurus noveboracensis*, *Dendroica æstiva*, *Habia ludoviciana*, *Quiscalus quiscula æneus*) than in the previous year.

Of more northerly birds, a single *Troglodytes hiemalis*, which belongs to the Canadian fauna, bred in 1883. Besides several *Zonotrichia albicollis*, which however breeds rarely every year at Shiocton. This bird belongs especially to the Canadian fauna, but is met with also in the Alleghanian.

As will be seen, I add a few measurements of birds taken by me. The most of them are of little value, but do no harm. To have much value I am aware that measurements must be taken from many more specimens, but I had no desire to shoot birds merely for the sake of measurements. Moreover, they should be taken from those that breed at Shiocton, but that I did not think of in time. The measurements are taken from old birds, as a rule in the spring.[8]

Besides the species I myself have seen and shot, I add most of the others which are said to be found in Wisconsin. I follow mostly in this: F. H. King, Economic Relations of Wisconsin Birds (Geology of Wisconsin, 1883); S. W. Willard, Migration and Distribution of Birds in Brown Co. (Trans. Wisconsin Acad. Sci., 1883), and W. W. Cooke, Bird Migration in Jefferson Co. (The Ridgway Ornithological Club of Chicago, Bull. Nr. 1, 1883). It is to be hoped it will be always seen when I plough with

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[8]**Length and extent require no explanation. The wing is measured from the carpus to end of longest primary. The tail from coccyx to end of the longest feather. The bill from the point where the feathers cease to the tip of the upper mandible. The measurements give the straight line between these points.**

another's heifer. When no note is found, all remarks rest on my own observations.

II. THE REGION AND THE DISTRIBUTION OF THE BIRDS.

The rivers certainly deserve the greatest attention. Wolf River comes down from the great watershed in Langlade Co. and has flowed over a hundred miles when it reaches Shiocton. It is a tolerably important river and carries a large mass of water. It has its mouth in Winnebago Lake which again empties through Fox River into the arm of Lake Michigan so rich in birds, Green Bay, about 30 miles from Shiocton. The other river should rather be called a rivulet. Its whole length in a straight line is hardly over 25 miles. Yet it is called Shioc River. In autumn the rivers overflow a large tract of country. The water subsides as a rule in the course of the winter, but increases again when the ice breaks up. The highest water is about twenty feet above the lowest. In 1883, when I carefully measured the height of the water, it rose immediately upon the breaking up of the ice a little over a foot; but before the close of April it was three feet lower. Here it remained stationary till May 17, and during that time a very large tract of country was overflowed. Then it began to fall rapidly. June 19, it was five feet, July 2, nearly nine feet lower than at the breaking up of the ice. The 19th of June there was no overflow of any consequence.

On both sides of Wolf River there are a multitude of old river beds. In spring, when all is overflowed, one can hardly see where the main river flows, but in summer the water is stagnant in most of these beds, since the main stream has formed banks along its course which in some cases are overgrown with very old trees. These banks are, as a rule, cut through by ditches which are the remnants of outlets, but after midsummer the ditches are not deep enough in most cases to maintain connection with the river. In the course of a few years the so-called "Old Wolf River" (in section 17) will be an old river-bed. Already a bar almost shuts off the inlet after midsummer, although it is only half a score of years since the river made for itself the present channel.

The old river-beds have great importance in the bird life. Here is a luxuriant plant growth. Many places are full of wild rice, which is a favorite food of ducks. The piece of land which is cut through by the river and its old beds is not swamp. In the spring it is mostly under water, but during summer it becomes quite dry. It is covered with luxuriant old deciduous forest, consisting mostly of soft maple, but which is mixed with other kinds of trees, such as elm, ash, willow, etc.

Many kinds of birds prefer especially to build in the maples near the water. Of these may be mentioned *Setophaga ruticilla*, *Icterus galbula*, *Vireo gilvus*, *Compsothlypis americana* and *Ectopistes migratorius*. The woods near the rivers are a favorite station for the warblers in migration. I could watch them from my boat and without difficulty follow them from tree to tree. When I was in my boat they were not at all afraid. I could often come within a few yards of them. In migration time I took my boat almost daily down the Shioc River and up the Wolf River about as far as the old river. I almost always found most warbler flocks at the point of the peninsula where the rivers come together. Here there is a thick growth of old maples, and along the water stands a row of willows. Of certain species, though, there were generally more in a great thicket in one of the Wolf river's old channels just west of the peninsula and the main stream.

Many of the birds that keep in or near the water seem to have no choice between the two rivers. *Seiurus noveboracensis* is seen everywhere where there are water and woods. *Actitis macularia* cares nothing for the woods, neither does *Podilymbus podiceps*. Other birds are more fastidious. *Aix sponsa* prefers decidedly Wolf River. The same is the case with *Lophodytes cucullatus* and *Urinator imber*. In the isolated groves along its borders *Totanus solitarius* feels truly at home.

On the contrary *Dafila acuta*, *Anas strepera*, *Anas americana*, *A. carolinensis*, *A. discors*, *Aythya collaris*, *Glaucionetta clangula americana*, *Charitonetta albeola* and *Colymbus auritus* are found mostly in the overflowed Shioc Meadows. I so called a large tract of land on both sides of the Shioc River north of the "Striped House." It is not swamp, but the water stands over it into early summer. In old times there were woods there of which scattered, tall, dead trunks are a reminder, outlooks for the hosts of birds of prey which in autumn abound there. Stumps are not much seen elsewhere. The whole tract is covered with luxuriant grass. On the higher spots the grass is cut. Here visit *Totanus melanoleucus* and *T. flavipes* in migration time. When the water subsides Shioc Meadow is used as a breeding ground for a large number of birds. Here there are many colonies of the little *Cistothorus palustris.* Here *Agelaius phœniceus* has its favorite resort. Here both *Anas discors* and *Anas boschas* breed, and in the wettest situations colonies of *Porzana carolina* and *Rallus virginianus.* Of other birds may be mentioned *Circus hudsonius* and *Botaurus lentiginosus.* South and east of Shioc Meadow there is a stretch of luxuriant woods, which with regard to bird life corresponds nearly with a wood which I shall later speak of under the name of the Pine Wood.

The edge is bordered by the mile-wide East Swamp. There is a similar swamp also west of Wolf River, but I have not much acquaintance with it. Indeed it is not easy to make acquaintance with these swamps. Windfalls, young growth, thickets, vines and quagmires make it almost impassable. In the edges of the swamp *Cistothorus stellaris* bustles about, pleased with the wildness. It is here also that *Gallinago delicata* has its play-ground. Here breeds a large number of the everywhere common *Melospiza fasciata.* Here also are both *Troglodytes aëdon* and *Ammodramus sandwichensis savanna. Geothlypis trichas* and *Melospiza georgiana* oftener breed farther out. Formerly there were woods in many places, but fires have raged so often that the most are only stunted remaius. On all sides are seen the tall but never stout dead trunks to remind one of what there has been. Thickets are plenty. Often one gets into an almost inpenetrable scrub, and here and there some scattered green trees, principally tamarack and larch, rise over the shrub growth. There are also bogs and great flats with quagmires, in part old lakes and river-beds. Here is often seen *Gallinago delicata* and *Porzana carolina.* The commonest flycatcher in the swamp is *Empidonax minimus*, the commonest vireo, *Vireo olivaceus.* Many *Spinus tristis* certainly breed here. In the tall dead trunks there are quantities of woodpeckers. Here breed a lot of *Tachycineta bicolor* and several *Parus atricapillus.*

I wandered about a good deal in the East Swamp; but a single mile was always enough to exhaust my strength. *Ardea herodias* must breed in great numbers, but I never saw its nest. Many other large birds also probably breed there; *Cathartes aura* quite surely, possibly *Grus canadensis.*[8]

The swamps lie considerably higher than the usual water level in the rivers, but they have almost no flow, since the land between them and the rivers has, in the course of time, been much raised. Some years ago a ditch was dug through a part of East Swamp. It is now ruined, and could never have done much service, although it carries still, especially in spring time, a great quantity of water into Wolf River.

Where the ditch has its outlet there is on both sides of the river a little thrifty wood which consists of different kinds of conifers. The flowing water has made it a favorite abode of a multitude of birds. I called it the Pine Wood. It consists principally of larch and fir, but other conifers are to be found there and a considerable number of deciduous trees, especially ash. The trees are tall, but not old. *Empidonax minimus* has here one of its favorite resorts. Here breed *Turdus furcescens, Compsothlypis americana, Dendroica blackburniæ, Zonotrichia albicollis* and many other birds. In migration time there are hosts of warblers.

Really old evergreen woods are as good as wanting north of the railway. In many places, especially west of Wolf River, around the German Farm, and north of Shioc River there have stood mighty pine woods, but they were cut down long since. The forest floor however has not yet wholly changed and *Bonasa umbellus* has especially its home there.

South of the railway there is a wood of giant pine trees. I did not go there very often, not at all in the spring of 1882; yet I must refer to it occasionally. I call it the Great Wood. In the Daily Beat there is not a hill to be found, but south of the railway the land rises sharply and the Great Wood lies on a

[8] **I. e., the sandhill crane, *Grus mexicana* of the A. O. U. Check-List.—AUTHOR, *in litt.***

slope down to the swamp. It seems as if the birds staid there in autumn a short time after they had taken leave of the Daily Beat. There were always hosts of woodpeckers there. In the autumn of 1882 there were many *Sitta canadensis.* In winter the tall pine trees were visited by crossbills and grosbeaks. In spring several birds were seen earlier here, and flocks of birds which were not seen in flocks in the Daily Beat, such as *Seiurus aurocapillus* and *Habia ludoviciana.*

North of the railway there have never been coniferous woods on the greatest part of the high land. On the other hand there are some very old deciduous woods consisting of many species of trees. The sugar maple, elm, oak, ash, linden, beech, hickory and butternut may be mentioned. In these woods *Vireo olivaceus, Contopus virens, Pipilo erythrophthalmus* and *Seiurus aurocapillus* breed, besides hawks and crows.

Where the wood is open there are plenty of shrubs. In many places juniper bushes are common, but I have never found nests in them. In other places there is an undergrowth of hazel. The grass that grows here is especially liked by cattle, which always keep it down. Here will be found especially *Passerina cyanea, Dendroica pensylvanica* and *Helminthophila chrysoptera. Spizella socialis* is seen everywhere in the open wood.

In the lower spots little groups of birch and alder are found here and there. There are many flycatchers in the birches. *Habia ludoviciana* builds especially in the alders. In willow bushes *Dendroica æstiva* and *Galeoscoptes carolinensis* often have nests. Isolated willow trees are preferred by *Tyrannus tyrannus.*

It lies in the nature of things that there cannot be very many or large fields in the Daily Beat. As will be seen on the map there are several farms; but the cultivated area is very small, in all not over one-ninth of the whole. Some of the fields are never overflowed; but the most are almost always in danger in the spring. This is possibly the reason that many field birds are missing, such as *Spizella pusilla* and *Chondestes grammacus.* Of peculiarly field birds *Poocætes gramineus* is certainly the most common. In grass fields are seen many *Sturnella magna* and a host of *Dolichonyx oryzivorus.*

The gardens near the houses are, as a rule, small, but many birds have already accustomed themselves to live in the neighborhood of man. In most gardens *Merula migratoria*, *Melospiza fasciata*, *Spizella socialis*, *Icterus galbula*, *Dendroica æstiva*, *Tyrannus tyrannus* and *Ampelis cedrorum* build nests. *Sialia sialis*, *Troglodytes aëdon* and *Tachycineta bicolor* built in our bird-houses.

In barns and stables *Chelidon erythrogaster* breeds, under eaves numbers of *Petrochelidon lunifrons*. *Sayornis phœbe* builds in porches or lofts, *Chætura pelagica* in chimneys. In the town of Shiocton there are multitudes of *Progne subis*.

There is yet one place which I must speak of. That is the town's little slaughterhouse that lies in the woods near the Wolf River. In the winter one meets here almost always *Parus atricapillus*, *Sitta canadensis* and *Dryobates villosus*, which fly in and out through holes and chinks. Back of the slaughterhouse the remains of animals and the contents of their entrails are to be found. Here *Corvus americanus* and *Cathartes aura* are often seen. Many a grain and seed can be discovered here, and in migration time it is the resort of a host of sparrows, especially *Carpodacus purpureus*, *Junco hyemalis*, *Zonotrichia albicollis* and *Z. Cucophrys*.

Much more could be said of the region and the distribution of the birds, but it is hoped that the most important points have been considered.

III. SPRING WEATHER AND THE ARRIVAL OF MIGRATORY BIRDS.

1882.

The winter of 1881–82 was very mild. I saw only a few birds. There were not very many visitors from the north, but a part of those that breed in the region must certainly have been present, at any rate such as I occasionally saw in the severe winter of 1882–83. That I did not observe them must have been partly because I was not yet acquainted with the places the birds liked, partly because I cherished the prejudice that there were none. My trips seldom reached far. Still I often went to Shiocton and visited the swamps a few times.

January was the deadest month. For daily enjoyment the most lively element near the house was a little company of *Cyanocitta cristata*, and a flock of *Parus atricapillus* which paid a short visit in company with *Sitta carolinensis* or *Dryobates villosus*. Occasionally a flock of *Plectrophenax nivalis* was seen and a single hawk circled over the fields or woods. At night the hideous screech of the horned owl (*Bubo virginianus*) was heard. In the swamps not a thing was seen, in the woods here and there a single ruffed grouse (*Bonasa umbellus*).

It was somewhat better in February. I was glad to see and hear the first crow (*Corvus americanus*), and I went into transports over the little lark (*Otocoris alpestris*) that sang and sported on fluttering wings and recalled its sister in Denmark. The 24th was mild and the sun shone. A few tree sparrows showed themselves and a shrike (*Lanius borealis*) sang cheerily.

26th. A single robin (*Merula migratoria*) was seen.

27th. Hard rain, and the following day a thaw. Shioc River began to break up.

March began very mildly.

3d. A few bluebirds appeared.

5th. The first ducks, and a few shivering purple finches (*Carpodacus purpureus*).

6th. Began to be cold again and a plover (*Ægialitis vocifera*) called in vain.

7th. Shioc River began to freeze.

13th. It was closed. Wolf River had not broken up at all. No new birds were seen, but the hardy tree sparrows began to arrive in large flocks. It was wretchedly cold and a north wind blew; but on the 18th it thawed, and the storm broke up the ice in Shioc River, which was open the 19th. Wolf River followed the 25th. It had been clear frosty weather the previous days, but on the 25th in the afternoon it became overcast.

26th. It rained. Wind north, but not strong. Wood ducks (*Aix sponsa*) appeared in great companies, some bluebirds flew over the house and a single creeper (*Certhia familiaris americana*) was seen in the wood.

The night of the 28th was mild and still, but in the morning a storm came on from the south. A crowd of ducks arrived and the first *Sturnella magna* and *Agelaius phœniceus* were seen. In the evening *Antrostomus vociferus* was heard. The storm had spent itself and the clouds broke.

29th. All nature was changed. The wood, so silent before, was ringing. Everywhere the song sparrow *(Melospiza fasciata)* chanted its pretty song, and the bluebird played on its mellow flute. The robin (*Merula migratoria*) bustled about in the garden, and a single swallow (*Tachycineta bicolor*) flew over Wolf River. *Quiscalus quiscula æneus* and *Scolecophagus carolinus* chuckled, each in his way. A little flock of snowbirds *(Junco hyemalis*) was seen in the grove. A multitude of hawks sailed over Shioc Meadows, and thousands of passenger pigeons (*Ectopistes migratorius*) stretched northward.

The following days were not so enjoyable. Even the song sparrows were silent. We had frost and snow again.

31st. In the evening came a change of weather and the snow melted. It became clear and still. The first *Troglodytes hiemalis* was seen.

April thus began very well. A mild wind blew, and the sun shone. Butterflies began to fly. Ducks were very numerous, many plover (*Ægialitis vocifera*) appeared, gulls and kingfishers (*Ceryle alcyon*) flew over Wolf river. Cranes (*Grus canadensis*) [9] called in the swamps, and a flock of small snowbirds (*Junco hyemalis*) was near the house. Also a curlew and a single *Colaptes auratus.*

2d. In the morning we had our flycatcher (*Sayornis phœbe*) at the house.

3d. The first kinglets were seen.

From the 4th till the 14th of April cold north winds were prevalent and only a few new birds arrived. A single *Dendroica coronata.* Also *Turdus aonalaschkœ pallasii* and *Passerella iliaca*

From the 15th to the 18th of April south winds prevailed.

17th. It was delightful summer weather, and the first cowbirds (*Molothrus ater*) were seen. Towards evening it became still and cloudy. Snipes (*Gallinago delicata*) bleated.

[[9] These were sandhill cranes (*Grus mexicana* of the A. O. U. Check List), as pointed out by the author in a letter to the translator.]

18th. Warm and gray weather. Quantities of *Scolecophagus carolinus*, many swallows (*Tachycineta bicolor*), many *Colaptes auratus* and several *Sphyrapicus varius* were seen.

19th. A north storm. The following days till the 25th it was clear with wind north, but generally not very strong.

24th. Very warm. A great multitude of birds was seen. Of new ones *Stelgidopteryx serripennis* and *Totanus melanoleucus* were observed.

25th. The first *Petrochelidon lunifrons* and *Zonotrichia albicollis*. The number of ducks decreased very much in Shioc Meadows.

26th. The wind shifted a little to the east. *Seiurus noveboracensis*, *Pipilo erythrophthalmus* and *Actitis macularia*.

27th. Wind southeast, constantly clear. Wild geese passed over. The first flock of *Spizella socialis*.

28th and 29th. North wind again. The latter day *Chelidon erythrogaster* was seen.

30th. The first *Tyrannus tyrannus*. A single *Helminthophila celata*.

May began with a strong west wind. In the afternoon a single *Mniotilta varia* and *Dendroica palmarum*. Also *Totanus solitarius*. Wind quieted toward evening.

2d. South wind. Large flocks of warblers. Several *Helminthophila celata* and *Mniotilta varia*.

3d. In the morning I shot a female *Dendroica vigorsii*. It began to rain, and a mild rain fell almost all day. A single *Dendroica æstiva* and *D. maculosa* were seen after mid-day. Towards evening the warblers arrived by thousands; but on account of the twilight I could with difficulty distinguish them. Still of new ones I found *Compsothlypis americana*, *Dendroica pensylvanica*, *D. blackburniæ* and *Setophaga ruticilla*.

4th. In the morning many *Icterus galbula* and the warblers seen the day before. In the afternoon *Helminthophila ruficapilla*, *Dendroica virens* and a single *Protonotaria citrea*.

5th. The migration appeared to be retarded by a powerful north wind, but there were many birds. The wind continued to blow the following day, but went down the 7th. It rained during the night.

SPRING MIGRATION OF WARBLERS AT SHIOCTON.

Species	Year	April 29	April 30	May 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Dendroica coronata	1882	¶	¶♀	¶	¶	¶	¶	†	†	....	*	3	4	*	*	1	†	*	*	....	....	♀	♀											
	1883	3	*	¶	*	1	¶	¶	¶	¶	†	....	†	....	*	†	¶	†	....	*	4													
Dendroica vigorsii	1882	....	....	....	....	♀	*♂	*	†	....	....	....	*	....	♀																			
	1883	....	....	....	....	....	....	....	....	....	....	♂																						
Helminthophila celata	1882	....	♀	....	*♂	....	*	†	*																									
	1883	....	....	1																														
Dendroica palmarum	1882	....	....	♂	†	....	†	*	*	....	†	....	¶	¶	¶	....	....	....	1															
	1883	....	....	....	....	....	....	....	....	♂	....	....	†	....	3	....	....	....	†	†	....	....	....	....	....	....	....	....	1					
Mniotilta varia	1882	....	....	2♂	*	*	*	*	*	....	2	†	¶♀	†	*	*	†	*	*	†	*	*	*	†	†	†	†	*	*	*	....	....	*	*
	1883	....	....	....	....	....	....	....	6	¶	*	*	....	1	*	....	¶	*	†	*	*	¶	†	†	†	....	†	....	†	1	*	*	*	*
Compsothlypis americana	1882	....	....	....	....	*♂♀	†	¶	*	....	*	†	†	†	¶	†	¶	†	†	†	....	†	....	†	*	*	....	1						
	1883	....	....	....	....	....	....	....	....	†	*	....	....	....	1	1	¶	*	*	†	¶	†	†	¶	¶	*	¶	†	†	†	*	....	*	*
Dendroica æstiva	1882	....	....	....	....	♂	*	†	†	....	*	....	¶♀	¶	¶	†	¶	†	¶	*	*	†	*	*	*	*	*	*	*	....	*	*	*	*
	1883	....	....	....	....	....	....	....	....	3♂	*	....	1	....	3	3	*	*	1	†	¶	†	†	*	*	†	†	¶	†	*	*	*	*	*
Dendroica blackburniæ	1882	....	....	....	....	♂	*	*	2	....	¶	....	4	†	1	*	*	*	....	....	*♀	†	*	♂	†	†								
	1883	....	....	....	....	....	....	....	....	¶♂	....	....	....	....	....	....	....	1	....	1	....	....	♂♀	♂	¶	....	¶	....	....	¶				
Setophaga ruticilla	1882	....	....	....	....	♀	....	♂♀	....	....	3♂	¶♂	¶♀	¶	¶	†	¶	¶	¶	¶	¶	¶	¶	¶	¶	¶	¶	¶	†	†	†	†	†	*
	1883	....	....	....	....	....	....	....	....	2♂	*	*	1	2	*	*	¶♀	¶	¶	¶	¶	†	†	†	†	†	†	*	*	*	*	*	*	*
Dendroica pensylvanica	1882	....	....	....	....	*	....	....	....	....	†	†	†	¶	¶	†	¶	†	*	....	†	†	†	¶	†	†	†	....	....	....	....	....	....	*
	1883	....	....	....	....	....	....	....	....	....	2♂	2	....	....	1	†	¶	....	2	¶	¶	†	¶♀	¶	†	....	†	†	†	....	*	*	*	*
Dendroica maculosa	1882	....	....	....	....	♂	....	4	1	....	....	†	1	1	3	....	....	....	....	....	*	¶	¶	¶	¶	¶	†♀	*						
	1883	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	♂	....	....	¶	¶	....	1	....	....	....	¶♀	....	¶					
Helminthophila ruficapilla	1882	....	....	....	....	....	*	†	¶	*	....	2	¶	¶	¶	†	†	*	*	1	....	1	†	*	†	*								
	1883	....	....	....	....	....	....	....	....	†♂	....	....	2	....	....	....	....	....	*	*	*♀	....	¶	1	1	....	*							
Dendroica virens	1882	....	....	....	....	....	*♂	2	1	....	†	....	1	1	1	....	....	....	....	....	....	1	1	....	*									
	1883	....	....	....	....	....	....	....	....	2♂	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	*♀	....	†					
Dendroica tigrina	1882	....	....	....	....	....	....	....	....	....	¶♂	¶♀	†	*	¶	2	¶	*	5	....	....	3	*	*	2	†	♀	♀						
	1883	....	....	....	....	....	....	....	....	♂	♂	....	....	....	....	....	....	....	....	....	....	....	....	♀	♀	....	*	....	¶	¶				
Dendroica cœrulescens	1882	....	....	....	....	....	....	....	....	....	*♂	†	†	¶♀	....	1	†	*	....	....	....	2	*	♂	*	1	....	....	....	....	....	....	....	♂
	1883	....	....	....	....	....	....	....	....	....	....	....	....	....	♂	....	¶	....	....	....	2♀	....	....	....	2♂									
Sylvania canadensis	1882	....	....	....	....	....	....	....	....	....	....	....	♂	2	....	....	....	....	....	....	2	¶	¶	¶♀	*	†	....	....	....	....	....	*	....	2
	1883	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	♂	....	†	¶	¶	....	†♀	....	*	♂				
Dendroica striata	1882	....	....	....	....	....	....	....	....	....	....	....	*♂	....	....	....	....	....	....	....	*	*	*	¶♀	¶	¶	¶	¶	¶	*				
	1883	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2♂	....	†♀	*	♂	....	¶	*	*	†	♂♀	♂		
Sylvania pusilla	1882	....	....	....	....	....	....	....	....	....	....	....	....	....	2♂	....	♂	....	....	....	2♂	....	....	....	♂	4♂	♂	♂	....	....	♂			
	1883	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	♂	♂	2♂											
Helminthophila chrysoptera	1882	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2♂	....	....	♂	3♂	*	¶♀	†	†	†	....	....	†				
	1883	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	♂	♂	2♂	*♀									
Dendroica castanea	1882	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	5♂	†	....	†	†	¶	¶	¶♀						
	1883	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	♂	*	*	....	....	....	¶	†♀	....	♀		
Helminthophila peregrina	1882	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	♂	....	¶♀	¶	¶	¶	¶	†	†				
	1883	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2♂	....	†	¶♀	¶	†	†			

* = over 10, † = over 50, ¶ = over 100, (approximately). The sign ♀ denotes the first female, but does not exclude males.

8th. In the morning it was quite cloudy and still. The trees and bushes were full of warblers. So numerous were they that it seemed as if they belonged to one immense flock. Of new species, however, only *Dendroica tigrina*, *D. cœrulescens*, *Vireo gilvus* and *V. flavifrons* were seen.

9th. The north wind again prevailed, but the breeze was mild. No new warblers. But *Chœtura pelagica*, *Galeoscoptes carolinensis*, *Seiurus aurocapillus*, *Habia ludoviciana* and *Trochilus colubris*. Many *Tyrannus tyrannus*. Several *Icterus galbula*.

10th. Rain poured all the forenoon. In the afternoon I went out and found a crowd of warblers. The new ones were *Geothlypis trichas*, *Sylvania canadensis*, and *Dendroica striata*. Besides *Turdus ustulatus swainsonii*, *Turdus fuscescens*, and *Piranga rubra*.[10]

11th and 12th. Cold north wind and rain. Few warblers. *Vireo olivaceus* and *Melanerpes erythrocephalus*.

14th. The water had risen two feet the last few days. Birds were seen only up in the trees. Sunshine and light northerly wind. *Myiarchus crinitus*.

15th. Clear. Still. Only a few warblers. In the afternoon, *Helminthophila chrysoptera*.

16th and 17th. Southwest wind, but almost still. Clear. No flocks of warblers.

18th. Southerly wind. Some few flocks. The first five *Dendroica castanea*. Single *Coccyzus erythrophthalmus*, *Empidonax flaviventris*, and *Passerina cyanea*.

19th. Still. Rainy the greater part of the day. Many birds. In the afternoon, the first *Helminthophila peregrina*.

20th. Gray weather. Many birds. *Contopus virens*. Drizzly in the afternoon. Flock of *Anthus pensilvanicus*.

21st. Cold south storm. Thousands of warblers, mostly on the ground, in bushes and in brush. But no new ones. It froze during the night.

22d. Strong south wind. Even more warblers than on the previous days. *Helminthophila peregrina* was very numerous. Of other warblers many females especially were seen.

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[10] *I. e.*, *Piranga erythromelas* of the A. O. U. Check List.—Author *in litt.*

23d. Weather and conditions about the same.

24th and 25th. Still and very warm. Many fewer birds.

26th. In the morning only a few scattered migrants here and there.

31st. The last remnants.

1883.

The winter was very severe. January had only two thawing days. (Mean temperature, 7° F. Maximum, 37½°. Minimum, —25½°.[12])

In February there were four days of thaw. (Mean temperature, 10½°; maximum, 50°; minimum, —22°.) Of northern visitors were seen *Pinicola enucleator*, *Acanthis linaria* and occasionally some crossbills. Also the birds that I saw in January, 1882, and some that I did not then see, but which were undoubtedly present, namely, *Dryobates pubescens* and *Certhia familiaris americana*. *Otocoris alpestris* first appeared February 21.

March was a real winter month. It had only five thawing days. (Mean temperature, 21°; maximum, 41°; minimum, 0½°.)

4th. Very thick weather and during the day it snowed. Temperature, 20½°. Wind northwest.

5th. Overcast and quite still. Temperature, 14°. Several crows (*Corvus americanus*) appeared.

14th. The snow disappeared in some spots.

21st. Clear. Light north wind, temp., 9½°.

22d. Snow. Light south wind, temp., 36½°. The first robin (*Merula migratoria*).

April had five freezing days (mean temp., 40°, max., 65½° min., 18½°.

1st. Clear. Light N. E. wind, temp., 23°.

2d. Clear. Still. Coldest day in April. Heard a *Sialia sialis* and a few *Sturnella magna*. Saw the second robin.

3d. South wind, but almost still. During the evening the breaking up began, and the themometer rose to 38½°. Partly clear.

4th. Partly clear. Calm, temp., 45½°. Snow melted, and the ice in many places was covered with water. Many *Sturnella*

[12] Thermometer observed at 8 A. M.

magna and *Sialia sialis*. The first *Agelaius phœniceus* and *Ardea herodias*. Several ducks.

5th. Frogs began to pipe. Temp. 39°. From 5th to 7th, northerly wind.

6th. The first song sparrow (*Melospiza fasciata.*)

7th. In the evening half clear and still.

8th. Clear. Wind southerly, but nearly calm, temp., 42°. In the evening at ten o'clock a large flock of ducks whistled over Shioc River.

9th. Clear. Nearly still, temp., 52½°. Shioc River open in places. In the morning the first swallows (*Tachycineta bicolor*). In the forenoon a flock of kinglets, a winter wren, (*Troglodytes hiemalis*), some *Passerella iliaca*, a kingfisher (*Ceryle alcyon*) and a few *Sphyrapicus varius*. At 2 o'clock P. M. the thermometer rose to 75° and the wind went round to the north. A ruffed grouse (*Bonasa umbellus*) was heard drumming. In the evening many *Agelaius phœniceus* appeared, and snipe bleated.

10th. Cold storm from northeast. Shioc river open.

11th. Storm from N. W. Snow and thunder, temp., 33°. Still toward evening. Overcast.

12th. Half clear. Light S. E. wind, temp., 45½°. Near the house in the morning *Spizella socialis*. Many *Scolecophagus carolinus* some *Colaptes auratus* and a single *Dendroica coronata*.

13th and 14th. Wind S. E.. 14th, warmest day in April. *Progne subis*.

15th. Storm from S. W.

16th to 18th. Mostly northerly and easterly winds. Cold.

21st. Rain. Westerly winds, but nearly still, temp., 42°. Maples and willows in bloom. In the afternoon the wind went into the northeast. Overcast.

22nd. Strong N. E. wind. Overcast, temp., 42°. Many birds. *Turdus aonalaschkœ pallasii*. *Zonotrichia albicollis*. Females of *Dendroica coronata*.

28th. Wind N. E.; temp., 30°; snow. In afternoon, wind changed to S. E.

29th. Temp., 34½°. Wind from S. W. to N. E.

30th. Temp., 36½°. Wind from N. E. to E.

May had no frosty day. (Mean temp., 51°; max., 67°; min., 38½°.)

1st. Overcast. S.E. wind. Almost still. Temp., 54½°. In the evening, mosquitos began to swarm, and bats to feed. A single nighthawk (*Chordeiles virginianus*).

2d. Rain. Strong N. E. wind. Temp., 40°. *Petrochelidon lunifrons.*

3d. Storm and thunder.

4th. Overcast. Almost calm. Temp., 43½°.

5th. Clear. Wind from N. W. to S. W., but nearly calm. Overcast towards evening.

6th. Overcast. Occasional rain and thunder. Calm. Temp., 48°. In the afternoon, large flocks of warblers. The first *Mniotilta varia.* Many creepers (*Certhia familiaris americana*).

7th. Overcast. Calm. Temp., 60°. In the morning, *Troglodytes aëdon*, *Chelidon erythrogaster*, *Chætura pelagica*, *Icterus galbula*, and several warblers,— *Compsothlypis americana*, *Dendroica œestiva.* Many *Ægialitis vocifera.* In the afternoon, many large warbler-flocks near the river. Many *Mniotilta varia* and *Dendroica blackburniæ.* Also *Dendroica palmarum* and *Setophaga ruticilla.* Single *Vireo solitarius.* It the evening many warblers in the Pine Wood. The first *Helminthophila ruficapilla*, *Dendroica tigrina* and *D. virens.* Also *Empidonax minimus*, *Tyrannus tyrannus* and *Myiarchus crinitus*

8th. Overcast. N. wind, but nearly calm. Temp., 50°. Small willows begin to burst forth, and some few maples have green buds. Only very few warblers. No flocks. A few *Dendroica pensilvanica.* Some *Galeoscoptes carolinensis* and the first *Melanerpes erythrocephalus.*

9th. Hard rain and wind. Wind east. Temp., 40°. Few warblers. First *Vireo gilvus.* Many *Seiurus aurocapillus.*

10th to 12th. Strong wind from southwest and northwest. 12th, clear. Calm towards evening. Temp., 40°. *Zonotrichia leucophrys.*

13th. Clear. Southeast, but nearly calm. Temp., 48°. Great flock of warblers. Several *Tyrannus tyrannus.* Towards evening it became overcast, during the night it rained.

14th. Overcast. Strong east wind. Temp., 42°. In the afternoon the wind changed to northeast and it poured. Quantities of warblers, mostly on logs and windfalls. First *Dendroica cœrulescens* and *D. maculosa.* Also *Contopus virens.*

15th and 16th. Clear. Northerly wind, but nearly calm. Not many warblers. *Vireo flavifrons* everywhere.

15th. Temp., 43½°. The first *Dolichonyx oryzivorus.*

16th. Temp., 48°. The first *Habia ludoviciana* and *Ampelis cedrorum.* Many *Dolichonyx oryzivorus* and *Actitis macularia.* In the evening thousands of *Tachycineta bicolor* catching mosquitoes and flies over Shioc River. Two *Chordeiles virginianus* took part in the chase.

17th. Half clear. S. wind, but nearly calm. Temp., 60°. Great flocks of warblers. Most of *Dendroica maculosa.* Rained during the night.

18th. Overcast. Strong gale from S. E. Temp., 63½°. In the morning and forenoon *Sylvania pusilla, Vireo olivaceus.* In the afternoon during thunder and drizzle great warbler-flocks appeared. Of new ones *Dendroica striata* and *Sylvania canadensis.*

19th. Strong gale from S. W. Many warblers, but not in flocks. *Helminthophila chrysoptera. Vireo philadelphicus.* Temp., 70½°.

20th. Dull weather and rain. Blow from N. E. Several flocks. Number of warblers very large. Many *Helminthophila ruficapilla.* The first *Dendroica castanea.* Temp., 50°.

21st. N. E. Strong blow. Temp., 40°. Dull weather.

22nd. Clear. Light N. E.. Temp., 40°. Woods nearly in full leaf. *Piranga rubra,*[13] *Passerina cyanea, Trochilus colubris, Empidonax flaviventris, Helminthophila peregrina.*

23d. Still. Temp., 50°. No warbler-flocks. In the afternoon a light S. E. wind began to blow.

24th. Overcast. S. E. wind, but nearly calm. Temp., 66°. In the morning not many birds. During the afternoon, when a heavy rain fell, millions of warblers appeared. Nearly all species were seen; very many females. Not a few *Vireo philadelphicus.*

25th. Overcast. North wind, but nearly calm. Temp., 60°. Many warblers; but not so many as on the 24th. First *Coccyzus erythrophthalmus.*

26th. Clear. Light N. wind. Temp., 66°. Quantities of

[13] *Piranga erythromelas* Vieill.—AUTHOR *in litt.*

Helminthophila peregrina. Many *Coccyzus erythrophthalmus* and *Chordeiles virginianus.*

27th. Clear. W. wind. Several flocks of warblers. In the evening nearly calm. Temp., 67°.

28th. Cloudy. Nearly calm. No flocks.

IV. NOTES ON THE DIFFERENT BIRDS.

1. **Colymbus auritus** Linn. M. of 11, all shot in the spring. L. 317–355. W. 142–158. T. 25–32. B. 22–27. Many are seen in the spring. Some may very likely breed; but none noticed in June. In 1882 none shot before April 16, when two were seen. Most abundant about April 25. Last one shot May 11. In 1883 the first, April 16th. Two the 22d. The day after in flocks. Most numerous about May 4th.

No other *Colymbus* was shot or seen by me. C. *nigricollis californicus* (Heerm.) is said to breed in many of the small lakes of Wisconsin (Hoy) and *C. holbœllii* (Reinh.) is seen in winter in Lake Michigan (Nelson).

2. **Podilymbus podiceps** (Linn.). × × M. of 5 (N.) L. 311–359. W. 126–133. T. 25–32. Extremely abundant in autumn, and seen till the rivers freeze. More rarely observed in the spring. Must moreover breed in large numbers about here; but mostly in the old river-beds. Saw many newly-hatched young.

3. **Urinator imber** (Gunn.). M. of ♀ shot in Shioc River, May 3, 1883. L. 624. W. 343. T. 50. B. 82. Several seen in April and May, mostly in Wolf River. Breeds in Wisconsin and perhaps around Shiocton.

Shot no other *Urinator.* In winter *U. arcticus* (Linn.) and *U. lumme* (Gunn.) are found in Lake Michigan.

Synthliborhamphus antiquus (Gmel.), a western bird, is found in Wisconsin (C. L.).

(4.) **Larus glaucus** Brűnn. Is seen in winter in Lake Michigan. Possibly seen on a dead fish on the shore of Shioc River, April 26, 1883. It might have been, however, *L. leucopterus* Faber, which is said to be more common (Nelson).

5. **Larus philadelphia** (Ord). Seen several times. Cannot say certainly what other species are found at Shiocton. Saw others than these which, however, are the commonest. I think I have seen *L. delawarensis* (Ord), which is a winter visitor in Wisconsin, and *L. argentatus smithsonianus* Coues, which breeds at Green Bay in Lake Michigan. So far as I can see from my journal, gulls were noticed only in the month of April. In 1882, at any rate, on the 1st and 6th. In 1883 a single one on the 9th. Many flocks on the 12th, one of 46. Five on the 21st. A single one, larger than the others, on the 22nd. *Stercorarius parasiticus* (Linn.), *Rissa tridactyla* (Linn.) and *Xema sabinii* (Sab.) appear in Lake Michigan in winter. *Sterna tschegrava* Lepech. breeds at Green Bay and many other places. *S. forsteri* Nutt. breeds here and there in Wisconsin. *S. hirundo* Linn. is seen in winter in Fox River. The southern *S. maxima* Bodd. is met with in Lake Michigan (Nelson). None of these forms were seen at Shiocton.

6. **Hydrochelidon nigra surinamensis** (Gmel.). M. of ♂ shot June 3, 1883. L. 235. W. 214. T. 79. B. 29. Saw a pair in the Shioc Meadows that day. Breeds in Wisconsin in lakes and marshes. *H. leucoptera* (Meisn. & Schinz) has been shot once in Wisconsin (C. L.).

Phalacrocorax dilophus (Sw. & Rich.). Is seen regularly in migration time (King).

7. **Pelecanus erythrorhynchos** Gmel. Seen occasionally at Shiocton. Was seen in Wolf River in the autumn of 1880. A single one was shot in Wolf River, 18 miles north of Shiocton, in Shawano county, in 1881. Preserved in Appleton.

(8.) **Merganser americanus** (Cass.). Seen probably many times in Wolf River, as April 21, 1883. Seen regularly at De Pere, and on the whole a common migrant in Wisconsin. The same is true of *M. serrator* (Linn.), which nevertheless was scarcely seen at Shiocton.

9. **Lophodytes cucullatus** (Linn.). ×× M. ♂ (2) L. 446–455, W. 194–201. T. 88–108. B. 40. ♀ (3) L. 434–455. W. 190–194. T. 76–108. B. 38. King calls this bird "an abundant migrant." At Shiocton it breeds in no small numbers, especially in Wolf River. May 29, 1882, saw a ♀ with new-hatched

young. June 7, 1883, a ♀ with young several days old. It appears in the spring as soon as the rivers are open. In 1882 none were shot before March 27. Most numerous from 2d to the 12th of April. In 1883 none were shot before April 9, when several were seen. Most from that day till April 13.

10. **Anas boschas** Linn. ×× No swimming bird could support itself at Shiocton in winter. This duck was seen in both years a few days before the breaking up of the ice. It breeds in the region in great numbers. On the 11th of October, 1882, all the native breeding mallards had already departed; but between the 9th and 19th of November an extraordinarily large flock came from the north and remained in Shioc Meadows till the water froze.

11. **Anas obscura** Gmel. ♂ shot in a flock September 24, 1882. M. L. 529. W. 270. T. 69. It is said to breed in Wisconsin.

12. **Anas strepera** Linn. Seen in Shioc Meadows the last of April. In 1882 it was most abundant from the 25th to the 30th.

13. **Anas americana** Gmel. Is tolerably abundant, but arrives late and is seen only for a few days. ♀ shot April 26, 1883. M. L. 443 W. 243. T. 75. B. 38.

Anas penelope Linn. was shot in Dane County (Nelson).

14. **Anas carolinensis** Gmel. M. of ♀ shot April 11, 1883. L. 348. W. 176. T. 68. B. 37. Was not seen at Shiocton in summer. But breeds often in Wisconsin. In 1883 was most abundant April 11 and the next following days.

15. **Anas discors** Linn. ×× M. (N.)[14] ♂ (4) L. 380–403. W. 176–194. T. 57–75. B. 38. ♀ (3) L. 373–387, W. 186–189. T. 51–73. B. 38–39. Several breed at Shiocton. Found a nest June 1, 1883, in the Shioc Meadows, which were then dry. Contained 12 slightly incubated eggs. M. L. 47–50. B. 32–34.[15] In the autumn of 1882 it was most numerous from September

[14] (N) signifies that the measurements were taken from birds killed during the breeding-season.—TRANSLATOR.

[15] A few errors in the measurements given in the original paper have been pointed out to me in a letter from the author. The errors have been rectified in the translation.—TRANSLATOR.

14 till October 18. Saw only a single one till November 10, when they were again seen in flocks. In 1883 none seen before April 28. Most abundant about May 3.

16. **Spatula clypeata** (Linn.). ♀ shot in a flock October 30, 1881. Breeds in Wisconsin.

17. **Dafila acuta** (Linn.). M. of ♂ shot May 4, 1883. L. 643. W. 270. T. 160. B. 54. In 1882 only noticed in the autumn about September 24; but surely always very numerous in migration time. In 1883 seen singly from April 11. Very large flocks May 3 and 4. Some few must surely breed at Shiocton. In 1883 a pair were seen in the Shioc Meadows long after the migration was over. After May 26 only the male was seen.

18. **Aix sponsa** (Linn.). ×× By far the most common duck at Shiocton. Breeds abundantly in the old maples near the river. I have however seen its nest many hundred feet from the water. Generally the nest is in a tree-hole *over* the water, at a height of from 30 to 40 feet. April 29, 1882, a female came out when one knocked on the tree; apparently she was sitting. May 28, a female was seen with newly-hatched ducklings. The assertion that the male does not accompany the female to and from the nest after she has begun to sit is untrue. I saw a male and female in company May 17, 1882. M. (N.) ♂ L. 462. W. 230. T. 114. ♀ (2) L. 411–443. W. 201–211. T. 82–88. Often seen in large flocks, when they always have sentinels. Their cry recalls that of gulls. In 1882 this duck appeared the same day the ice broke up. Shot March 24. Abundant after the 31st. Last seen Nov. 4. In 1883, five the 6th of April, when the water was not open. Most about the 30th. Fewer than in 1882.

Aythya americana (Wils.) and *A. vallisneria* (Wils.) are found in Fox River but hardly at Shiocton. *A. marila nearctica* (Stejn.) and *A. affinis* (Eyt.) were shot at De Pere. The last is said to breed in Wisconsin (King). I think I have seen them both in the Shioc Meadows, even in large flocks. In 1883, especially from April 11 till 23.

19. **Aythya collaris** (Donov.). ×× M. ♂ (4) L. 417—430. W. 192—194. T. 50–59. B. 43—50. ♀ (2) L. 408—417. W. 189. T. 54—63. B. 43. The color of the bill is often wrongly given.

The male's is blue gray with small bluish white border. Across the bill a broad white band with bluish cast. The female's is not "plain dusky". The band mentioned is seen on it also. This duck is extremely abundant, especially in the Shioc Meadows. In 1882 it was seen there April 8. Most numerous on that and the next following days. Last flock about April 25. In 1883 seen from April 12. Most abundant from 14th to 26th. Afterwards single pairs in several places, most in Wolf River. June 8, a pair at the German Farm. Must surely breed at Shiocton, although in C. L. only given as breeding "far north", that is to to say, north of the U. S.

20. **Glaucionetta clangula americana** (Bonap.). ×× M. of ♂ shot April 2, 1882. L. 498 W. 239 T. 88. Seldom seen in flocks, but mostly single or in pairs, but often three in company, and then always a male and two females. In 1882 not seen before April 2. Most numerous about the 12th. In 1883 not seen before April 9. Most numerous from 12th to 23d. Afterwards in pairs in several places, as in Wolf River. ♂ in Shioc Meadows May 23. ♀ June 20. Must thus surely breed at Shiocton.

G. islandica (Gmel.) was shot at Racine (Hoy).

21. **Charitonetta albeola** (Linn.). M. ♂ (2) L. 355–369. W. 169–176. T. 68. B. 27–32. ♀ (3) L. 317–355. W. 158–167. T. 63–76. B. 27. Extremely numerous in migration time. Seen mostly in pairs, but often in large flocks. In 1882 a male and two females were seen April 7. In 1883 most numerous about April 23. Still several May 5. On May 8 I shot a solitary female in Shioc Meadows. She sat on a stump that stuck out of the water. Breeds in the northern part of the U. S. (C. L.).

Clangula hyemalis (Linn.) was shot in Fox River (Willard) and is common in winter in Lake Michigan. *Histrionicus histrionicus* (Linn.), *Somateria mollissima* (Linn.), and *S. spectabilis* (Linn.) are found in winter in Lake Michigan.

Oidemia americana Sw. & Rich. and *O. fusca* (Linn.) were shot in Fox River (the last at De Pere, October 23, 1882). *O. perspicillata* (Linn.) was shot at Green Bay, October 1, 1883 (Willard).

22. **Erismatura rubida** (Wils.). M. of ♂ shot in Shioc Meadows May 5, 1883. L. 368. W. 139. T. 69. N. 42. Saw no more. Breeds sparingly in northeastern Illinois (Nelson).

Nomonyx dominicus (Linn.). Southern bird. Shot in Wisconsin (C. L.).

Chen hyperborea (Pall.) and *C. hyperborea nivalis* (Forst.) were shot at De Pere.

Anser albifrons gambeli (Hartl.) is common in migration time and is probably found at Shiocton.

(23.) **Branta canadensis** (Linn.), which breeds in the northern portions of the U. S., and *B. canadensis hutchinsii* (Sw. & Rich.), which is only found in migration time, are certainly the commonest wild geese seen at Shiocton. They have their regular stopping places in the overflowed Shioc Meadows. In 1882 the most flocks were seen from April 25 to 27, and from October 29 to November 9. In 1883, most 29 and 30 April. *Branta bernicla* (Linn.) was shot a few times in Lake Michigan (Hoy).

Olor columbianus (Ord) and *O. buccinator* (Rich.) are seen at any rate in migration. The last is said to breed in the northwest portion of Wisconsin.

Tantalus loculator Linn. was shot at Lake Michigan (Hoy).

24. **Botaurus lentiginosus** (Montag.). ×× M. (N.) ♂ L. 711. W. 290, H. 114. B. 77. Very numerous especially in migration, but is seldom seen. In 1883 it was heard to drum for the first time, April 28. Breeds in great numbers in swamps and in the Shioc Meadows.

Botaurus exilis (Gmel.) was not seen, but may in all probability be found. Breeds in Wisconsin. Shot at De Pere, May 20, 1883 (Willard).

25. **Ardea herodias** Linn. ×× Very abundant, but especially so in the autumn migration. In 1882 the first were seen the last days of March. In autumn most abundant about August 1st. Many still the 24th. Several September 16. Last October 29. In 1883 the first April 3. Afterwards almost daily. Must breed in large numbers in the swamps.

Ardea egretta Gmel., is said to breed not rarely in Wisconsin (King).

26. **Ardea virescens** Linn. Seen May 18, 1882, near one of the old beds of Wolf River. Breeds in many places in Wisconsin (King).

Nycticorax nycticorax nævius (Bodd.). Although I think I have heard and seen this bird in the evening several times, yet it is possible I have been mistaken. It breeds in Fond du Lac county (Davie).

27. **Grus canadensis** (Linn.).[16] In 1882 it was heard in the swamps April 1. The last five were seen October 9. I saw no flocks in 1883. April 21 a pair was noticed at Shiocton. The day after, three flew over Shioc Meadows. Here a pair was seen the following days, at any rate till May 8. When they flew, they always took the same course towards East Swamp. May 12 I saw a pair in the swamp west of the German Farms. It seems to me probable that a few breed in the swamps. *Grus americana* (Linn.) was formerly often seen in the western part of Wisconsin (King).

28. **Rallus virginianus** (Linn.). ×× M. (N.) ♂ L. 256. W. 110. T. 41. B. 41. ♀ L. 235. W. 105. T. 43. B. 36. Breeds in great numbers in Shioc Meadows. Seldom seen, but heard so much the oftener. June 3, 1883, I found a nest in a tussock. It contained 11 slightly incubated eggs. M. L. 30–33. B. 22–24. *Rallus elegans* (Aud.) was not seen at Shiocton, but may very likely be there. It has been observed in Jefferson county (King.).

29. **Porzana carolina** (Linn.). ×× M. of 8. (N.) L. 208–230. W. 106–114. T. 43–54. B. 22–24. It is in autumn the most numerous wader. Breeds in many places, but especially in Shioc Meadows in places where the water stays longest, and where there are tussocks and reeds. *Under* these tussocks I found many nests; but only three with eggs. May 26, 1883, one with eight slightly incubated eggs. June 1, one with nine eggs, some of them much incubated. June 3, one with nine slightly incubated eggs. M. L. 29–33. B. 22–24½. In the spring of 1882, I shot a ♀ April 25. In 1883, I heard the first one in May. In the autumn they were most numerous on Sept. 4. After the 17th only a few. The last, Oct. 9. They are

[16] This should be *Grus mexicana* (Müll.).—Author *in litt.*

often seen swimming. Sept. 4, I noticed one that sat close in open water. I could easily have struck it with an oar. Another flew up and sat on a little branch of a willow, 12 feet from the ground.

Porzana noveboracensis (Gmel.) was not noticed by me; it breeds, however, in Wisconsin (Hoy).

30. **Gallinula galeata** (Licht.). Heard this bird often, and it probably breeds at Shiocton. Saw and shot only one ♂, May 5, 1883. M. L. 355. W. 174. T. 69. B. 47.

Ionornis martinica (Linn.) was shot at Racine (Hoy).

31. **Fulica americana** Gmel. M. of 3. L. 352—355. W. 185—194. T. 44—57. Tolerably numerous in autumn. In 1882 I did not see it in the spring; but I did not then know the places which it especially visited. In autumn most abundant from Oct. 17 to 22. The last Nov. 13. In 1883 three were seen in the Shioc Meadows April 12. Afterwards almost daily. Few seen in May. Shot one May 17. Probably breeds sparingly in the swamps.

Crymophilus fulicarius (Linn.) and *Phalaropus lobatus* (Linn.) are said to be rare visitors in Wisconsin. Willard mentions the last as regularly appearing in Brown Co. *Phalaropus tricolor* (Vieill.) is said to breed in Wisconsin. It was found in large numbers at Fox River in Green Lake Co. (King). *Recurvirostra americana* Gmel. and *Himantopus mexicanus* (Müll.) appear occasionally.

32. **Philohela minor** (Gmel.). ×× M. ♂ L. 277. W. 133. T. 67. B. 63. Breeds in great numbers round about in the wet woods. Is seen especially in autumn. June 10, 1883, I saw a woodcock fly up under a willow bush. It had a young one in its claws. By carefully examining the place I found another young one which squatted. It did not stir a limb till I took it in my hand. Then it kicked and squealed as if to call its mother. In 1882, a single one was seen May 18. Not many before June. In 1883, one was heard in the evening April 26. The first was seen May 1. Not many before June 4. In the autumn most numerous on October 5. The last on the 15th.

33. **Gallinago delicata** (Ord). ×× M. of 8. (N.) L. 259–284. E. 413–417. W. 130–140. T. 54–68. B. 61–68. Breeds

in great numbers about the swamps. Was especially numerous at a place in the edge of East Swamp where it had one of its play grounds. In 1881, the last was seen November 13. In 1882, I did not hear it bleat before April 17. Afterward it was heard from the house almost daily, both morning and evening, till May 6. After that day only occasionally, as May 18 and 19 and June 16. In flocks about July 22. Was heard to bleat again in autumn, as October 17 and 18, and November 10. In 1883, the first were seen at noon April 9. In the evening a single one bleated. Was first heard again April 14, when there were many participants. Afterward almost daily. Fewer than in 1882.

May 17th, 1883, I shot a ♂ sitting on the top of the stump of a young tree, twelve feet from the ground.

Macrorhamphus griseus (Gmel.) and *Micropalama himantopus* (Bonap.) are seen in Wisconsin in migration (King).

34. **Tringa minutilla** Vieill. M. of 2 shot on Wolf River, August 1, 1882, in company with *Actitis macularia.* L. 142–160. W. 88–93. T. 33–43. Middle toe and claw 20½–22. Not seen very often, but said to breed in Wisconsin.

Many small waders of the same genus I had not opportunity of shooting. At Fox River in Brown county *Tringa maculata* Vieill., *T. bairdii* (Coues), and *T. alpina pacifica* (Coues) appear regularly. Besides *T. canutus* Linn., *T. maritima* Brünn., and *T. fuscicollis* Vieill. migrate through Wisconsin (King). *Ereunetes pusillus* (Linn.) is a regular visitor at De Pere (Willard). *Calidris arenaria* (Linn.), *Limosa fedoa* (Linn.), which was shot at Green Bay, and *L. hæmastica* (Linn.) are also seen in Wisconsin.

35. **Totanus melanoleucus** (Gmel.). M. of 11. L. 332–364. W. 180–201. T. 72–84. B. 56–59. Very abundant in migration. Must undoubtedly breed in Wisconsin and possibly at Shiocton. Breeds sparingly in Illinois (King). In 1882 the first was seen April 24. On the 29th, in the evening, a flock of thirty-five alighted near the house. May 4, great flocks; also the following days. The last observed May 16. In 1883 the first, April 24. Some few the following days. In flocks — for the most part very large — from April 28 till May 12. A single

flock numbered several hundred. The last seen May 8. More numerous than in 1882; but the water was lower so that they had better opportunity.

36. **Totanus flavipes** (Gmel.). M. of 5. L. 259–270. W. 155–167. T. 59–66. B. 38. Appears almost exclusively in the Shioc Meadows and is not so plenty as the foregoing. In 1882 I was but seldom during the migration period at the places where they appear. Shot only two, May 28 and July 23. In 1883 two seen the 29th April. In flocks from May 8th to 17th. None the day after. Some appear to breed in Wisconsin (King).

37. **Totanus solitarius** (Wils.). ×× M. of 6. L. 201–223. E. 380–439. W. 130–139. T. 51–63. B. 31. The legs are green, not, as is described, "blackish." Seen in many places, but never in flocks. Must certainly breed here and there in woods near rivers and brooks. I am not certain that I saw it in June, 1882; and although in 1883 I was on the lookout for it, I saw in June only one which I shot in the Shioc Meadows the 30th. I noticed in 1882, that throughout May one could always meet with several pairs of this bird at certain fixed places in the vicinity of Wolf River, and moreover waders often keep so close in breeding time that there were several, even numerously represented species, that surely would have escaped my notice had it not been for their note. This species as a rule utters *no* note. In 1882 the first was seen May 1. The day after several, in one place three in company. Afterwards almost daily, perhaps not in June, but again from the first days in July till Sept. 16. Most numerous about Aug. 1. The last Oct. 1 and 8. in 1883 the first was seen May 8 in company with the two foregoing species of the genus. Afterwards almost daily, but not in nearly so great numbers as in 1882.

Symphemia semipalmata (Gmel.) was not observed at Shiocton, but is said to breed in Wisconsin (Hoy) and to be a regular visitor at De Pere (Willard).

Bartramia longicauda (Bechst.) is said to be common in Wisconsin and was shot at De Pere May 1, 1882; but scarcely appears at Shiocton, as it is essentially a prairie bird. *Tryngitis subruficollis* (Vieill.) appears as a regular migrant in Brown county (Willard).

38. **Actitis macularia** (Linn.). ×× M. of 5 (N.) L. 176–194, E. 334–343. W. 105–111, T. 50–57. Very abundant in summer, but especially in migration. Breeds in many places near the rivers. Newly hatched young were seen June 27, 1883. In 1882 the first appeared April 26, a single one April 30 and May 2. Two May 4. Many the day after. In fall most numerous about August 1. Some few October 10. The last the day after. In 1883 the first April 13. Afterward none before the 29th. Not many before May 5.

39. **Numenius hudsonicus** Lath. On April 1, 1882, I saw a curlew light in a field near Wolf River. I was then quite near. Its cry sounded to my ears like *korle, korle, korle!* When it flew, I saw the sun shine on the bright wing spots. Must probably have been this species, although King calls it "a very rare migrant." *N. longirostris* Wils., which breeds in the United States, and the more northern *N. borealis* (Forst.) appear not to have been seen at Shiocton, but are found elsewhere in Wisconsin.

40. **Charadrius squatarola** (Linn.). Three in the grass field just east of the house, May 27, 1882. Is said to be a regular migrant in Brown county (Willard), but was not met with by King in Wisconsin.

(41.) **Charadrius dominicus** Müll. Gunners assert that they often shoot this species at Shiocton. In Brown county it is a regular visitor (Willard).

42. **Ægialitis vocifera** (Linn.). ×× M. of 3. (N.) L. 235–258. W. 148–173. T. 82–101. B. 18. Breeds at Shiocton in no small numbers. On May 12, 1883, a nest was found beside a stump in a dry field. Four slightly incubated eggs. M. L. 40. B. 27. In 1882, the first was seen March 6. A few later in the month. More in April. Most about May 3, when they were seen in small companies. In autumn most numerous July 22. Some few in August. In 1883, not seen before April 9, when a pair appeared in the grass field east of the house. Seen almost daily after April 30. Most about May 7. More than in 1882.

43. **Ægialitis semipalmata** Bonap. ××× M. of 4. L. 176–184. W. 119–133. T. 52–59. B. 13–14. In 1882, I was seldom at Shioc Meadows in the migration time of waders. Shot a

single one May 28. In 1883, I kept a sharp lookout for them. Four were seen May 18, in the grass field just west of the house and the Shioc River. Shot three of them. This species was not found either by King or Willard. *Ægialitis meloda* (Ord) is said to breed in the U. S. (C. L.) and is seen in Wisconsin at any rate during migration. It was not noticed at Shiocton.

Arenaria interpres (Linn.) is said to be not uncommon at Lake Michigan. Willard met with five at De Pere, June 3, 1882.

(44.) **Colinus virginianus** (Linn.). People in the region are unanimous that this bird is found at Shiocton and I do not doubt it, although I myself have not seen it. It is hardly plenty. It was shot at Green Bay (Willard).

Dendragapus canadensis (Linn.). May well be found at Shiocton. It is common in northern Wisconsin (King).

45. **Bonasa umbellus** (Linn.). × M. of 9. (N.) L. 404—462. W. 163—189. T. 114—155. B. 14. In summer extremely abundant in the woods. Seen in winter only singly and in much less numbers. Lives mostly in places where there were formerly great pine woods, and where the ground partially retains its original character. In winter it probably seeks the yet undespoiled evergreen forest to the north. In January I met with it in very considerable numbers in Shawano county. Its peculiar sound was heard in spring from our house all through the day. April 28, 1883, as late as half past nine in the evening. It is also occasionally heard in the autumn, in 1882 as late as November 4. May 7, 1882, my wife found a nest under the trunk of a fallen tree. It contained 15 new-laid eggs. We set a hen on 8 of them and they hatched in 24 days, but the hen killed the chicks. After we had taken the 8 eggs the bird laid 3 and began to sit. One could have taken her on the nest. When one stood on the trunk it touched the bird's head, but she only ducked and remained sitting. Neither did she fly when poked with a stick. M. of egg. L. 39. B. 29.

Lagopus lagopus (Linn.) is a northern bird which has however been seen at Racine (Hoy).

46. **Tympanuchus americanus** (Reich.). ×× M. of ♀ shot April 5. 1882. L. 417. W. 214 T. 101. Had only fourteen tail

feathers. Is abundant south of the railway. A few breed near the German Farms. Appears during the last days of March.

Pediocœtes phasianellus campestris Ridgw. may probably be found at Shiocton, although I do not know that I have seen it. It is common in northern Wisconsin (King).

47. **Ectopistes migratorius** (Linn.). ×× M. (N.) ♂ L. 411. W. 208. T. 151. ♀ L. 399. W. 202. T. 176. The gunners of the region say that this pigeon formerly swarmed along the rivers. Now the numbers have considerably diminished. When the young were ready to fly, they were collected and a great slaughter took place. In 1883 they did not breed in nearly so great numbers as in the previous year; but one of the reasons was perhaps that a lot of the old breeding trees were felled in the course of the winter. Along Wolf River there were still found a number of small colonies. In 1882 the largest consisted of about fifty nests, which were all built in maples at a height of from 20 to 30 feet above the water. This colony was found directly west of our house; but in 1883 it consisted of only half a score of nests. On June 11, 1882, I shot a female that contained an egg ready to be laid. June 21 I took an egg from a nest in a maple 26 feet over Wolf River. It contained a young one almost ready to hatch. M. L. 39. B. 27¼. In 1882 I saw thousands fly north early in the morning of March 29. After that day small companies of ten or more were seen flying about the woods. None had settled themselves yet on May 24. On June 2 this dove was first seen at the breeding places. In 1883 none were noticed before June 2, when three were seen at a place where the year before there were half a score of nests. June 7 many were seen. The day after great hosts. Later fewer.

48. **Zenaidura macroura** (Linn.). ×× M. (N.) ♂ L., 311. W. 155. T. 142. ♀ L. 289. W. 148. T. 114. Is not very abundant, but found evenly distributed over the whole region. At almost every farm a pair is seen. At our house a single one was seen May 9, 1882. A few days later a pair, which appeared almost daily thereafter and fed with the hens. Had a nest in East Swamp southeast of the house. After June

2 only a single dove was seen as a rule. The other must have been sitting. I saw the last one on the Daily Beat in 1882, Aug. 9. South of the railway, however, 15 were seen Nov. 4. That was the only time I saw more than two together. In 1883 a pair were seen April 23. At our house first from June 2.

49. **Cathartes aura** (Linn.). ×× M. of ♂ shot north of the house May 6, 1883. L. 711. W. 493. T. 265. B. 25. Seen oftenest singly. Most abundant in April and May, August and September. A single time (Aug. 28, 1883) three in company. Must undoubtedly breed in East Swamp, and is hardly so rare in Wisconsin as generally supposed. King has only met with it in Pierce county.

Elanoides forficatus (Linn.) breeds on the Mississippi but is hardly seen at Shiocton. *Ictinia mississippiensis* (Wils.) is met with in Wisconsin (C. L.).

50. **Circus hudsonius** (Linn.). ×× M. (N.) ♂ L. 468. W. 333–337. T. 219–226. B. 27. ♀ (3) L. 513–544. W. 373–398. T. 239–252. B. 30–32. Not a few breed at Shiocton. It is most numerous during the autumnal migration. In 1882 the first male was seen March 5. After the 27th almost daily. Makes its regular rounds, and was seen to fly by the house always at the same hour. In autumn it was noticed last the 9th of November. In 1883, the first male, March 27. After April 11, almost daily. May 23, I found a nest in Shioc Meadows. It was built in the coarse dry grass of last year on a spot where water still stood. Contained four eggs, one slightly incubated. M. L. 45–48. B. 37–38. August 26, 1883, I shot two ducks (*Aix sponsa*) which remained lying on the water. I went to take them up, and was quite near to them, when a marsh hawk came and swooped down on the dead birds. The hawk remained sitting on one of the ducks, and flapped its wings many times as if trying to lift it. I took enough time to fetch my gun and shot the hawk. It was a large female (L. 531). As a rule this bird was very shy; but on that occasion it sat quite still and watched me.

51. **Accipiter velox** (Wils.). M. of ♂ shot May 5, 1882. L. 277. E. 519. W. 169. T. 135. Probably often seen and very likely breeds at Shiocton as in other places in Wisconsin (King).

52. **Accipiter cooperi** (Bonap.). ×× Scarcely seen in winter. M. (N.) ♂ (4) L. 373–404. W. 238–275. T. 151–163. ♀ (2) L. 473–487. W. 265–317. T. 207–214. In a male shot May 11, 1882, the 3d primary was longest, the 2d and 5th of equal length. This hawk is the most abundant diurnal bird of prey at Shiocton. In spring the woods resound with its doleful flute note, and it nests in many places. In 1882 two pairs built on the road between the house and Shiocton. One nest was placed in an elm over Shioc River, the other in a larch in the Pine Wood. In 1883 they were less numerous, and the above mentioned nests were not used.

53. **Accipiter atricapillus** (Wils.). M. of young bird shot September 10, 1882. L. 357. W. 343. T. 252. Probably seen many times. Breeds rarely in northern portions of the United States (C. L.).

54. **Buteo borealis** (Gmel.). M. of ♀ shot October 22, 1883. L. 557. W. 380. T. 194. B. 34. Very abundant, at any rate in migration. *B. lineatus* (Gmel.) is said to breed in great numbers in Wisconsin (King), but was not shot by me at Shiocton. *B. swainsoni* Bonap. is also said to breed in the state (King). *B. latissimus* (Wils.) is common in large woods. I probably saw several species of this genus, but I cannot say so positively.

55. **Archibuteo lagopus sancti-johannis** (Gmel.). ××× M. of 3. L. 529–564. W. 393–417. T. 226–244. Perhaps the most numerous of all birds of prey in migration time. Had its especial haunt at Shioc Meadows.

Aquila chrysaëtos (Linn.) is a winter visitor in Wisconsin (King).

56. **Haliæetus leucocephalus** (Linn.). Frequently seen throughout the summer. A nest was found in an old pine tree near Shiocton about 70 feet from the ground. It had been used for many years; but June 13, 1883 the owner cut down the tree and put the two not fully fledged young in a cage. In 1882 the first was seen April 24; in 1883 two were seen the 28th.

(57.) **Falco peregrinus anatum** (Bonap.). Think I have seen this species several times, even in summer.

58. **Falco columbarius** Linn. M. of ♂ shot Oct. 9, 1882. L. 283. W. 189. T. 119. B. 16. Abundant, at any rate in migration.

59. **Falco sparverius** Linn. ×× M. of ♀ L. 261. W. 183. T. 119. Several build in the Daily Beat high up in dead pine trunks. In 1882 the first was seen April 6, the last Oct. 6. In 1883 the first male April 12.

60. **Pandion haliaëtus carolinensis** (Gmel.). Seen occasionally, always over Shioc Meadows. Perhaps nests in East Swamp. Most seen in 1883, in the month of May. A single one June 12.

Strix pratincola Bonap. is a southern bird, but was shot at Racine (Hoy).

61. **Asio wilsonianus** (Less.). M. of one shot Oct. 27, 1883. L. 362. W. 252. T. 144. B. 27. Breeds in Wisconsin (King).

62. **Asio accipitrinus** (Pall.). M. of one shot in the grass in Shioc Meadows, Oct. 17, 1882. L. 362. W. 305. T. 157.

63. **Syrnium nebulosum** (Forst.). × M. of 3. L. 507–525. W. 317–330. T. 226. B. 32. Most numerous in autumn and winter. Probably the commonest owl at Shiocton. In the first half of January 1883, small companies of 3–5 were seen.

Ulula cinerea (Gmel.) is a winter visitor in Wisconsin (King).

64. **Nyctala acadica** (Gmel.). M. of one shot north of the house, Dec. 14, 1882. L. 194. E. 468. W. 139. T. 68. B. 14. In this specimen the fourth primary was a little longer than the third. Only three primaries were emarginate (the third very slightly). Is probably not rare, though King has met with it only once (in Walworth county, 1877). April 2, 1883, I saw one in the day time in a tree near Shioc River. *Nyctala tengmalmi richardsoni* (Bonap.) is a winter visitor in Wisconsin (King).

65. **Megascops asio** (Linn.). Probably breeds at Shiocton. According to what people say, it is tolerably common. M. of one shot January 16, 1883. L. 223. W. 176. T. 82. B. 18. Some noisy jays drew my attention early one morning to this owl which sat in a tree near the barn. It was bloody all over the breast, but the blood was *dry*. When I opened the barn door I saw that one of our tame ducks was killed. It was the size of *Anas boschas*. Apparently it was only wounded in the neck, but there was literally nothing left but the skin and bones. The little

owl was the murderer. There had been a hard struggle. Many owl feathers lay on the floor. One of the duck's feet was raised as if it had tried to unfasten the owl from its neck. The owl had entered the barn through a hole that was not much larger than the bird. This does not agree with what King writes: "Its small size renders it harmless to poultry, except when young." January 20 an owl of this species was caught in a barn south of the railway.

66. **Bubo virginianus** (Gmel.). × M. of 2 (N.). L. 557–575. W. 393. T. 219. Is most abundant in winter, when the air resounds all night long with its hideous cry. Nests in many places in the Daily Beat. *B. virginianus subarcticus* (Hoy) is a western bird which is occasionally seen in Wisconsin (C. L.).

67. **Nyctea nivea** (Linn.). ××× In Oct., 1881, several were seen. The water was then very high and the ducks extremely numerous. The owls appeared to follow these. Oct. 23 two were seen in company near the house. The day after one was shot near Shioc River. L. 612. In Oct., 1883, one was shot near Wolf River, 12 miles north of the house.

Surnia ulula caparoch (Müll.) is a winter visitor in Wisconsin.

68. **Coccyzus americanus** (Linn.). ×× M. (N.) ♂ (2). L. 277–304½. W. 133–144. T. 144–157. In 1882 I shot one May 29. Was not seen earlier. Afterwards frequently seen. At least two pairs built in the vicinity of our house, one on the peninsula between the rivers, the other in one of the old beds of Wolf River just east of the German Farms. A single one was shot in Shioc Meadows as late as Oct. 17. In 1883 it was not noticed. King has seen this species in Wisconsin only once. Cooke thinks he has seen both cuckoos without being able to distinguish them. They are easy to distinguish even at a long distance.

69. **Coccyzus erythrophthalmus** (Wils.). ×× M. of 6. (N.) L. 279–311. W. 129–144. T. 144–169. B. 24. Bred at Shiocton in very large numbers in 1882. In 1883 it was far different. Only a few nests were observed. The chief reason, perhaps, was that more than half the nests in 1882 were robbed by snakes and squirrels. The squirrels are the worst robbers of

birds' nests, and 1882 was a great squirrel year. At Shiocton there are found at least six species, and although the woods are full of hazel bushes, there is hardly a nut left that is not worm-eaten. The worst for birds is certainly the common red squirrel (*Sciurus hudsonicus* Pall.). In 1882 two cuckoos were seen May 18. Many the 19th, but for the most part only two or three together. Still more the day after. Afterwards fewer. In 1883 none seen before May 25 when two were noticed, each at its breeding place. 26th many. Afterwards much fewer. Out of nine nests one was placed on a willow branch one foot over the water. Three were in young trees, three in bushes, two in brush. When in trees and bushes the nest was placed oftenest in a fork five to eight feet above the ground. In brush one and a half feet from the ground. One of the nests built in brush rested against the trunk of a quite young maple. The other was in a hazel bush. Number of eggs, three or four, generally four. In 1882 the first nest was found June 2. It contained three slightly incubated eggs. June 19 I found one with two newly laid eggs. When I looked June 29 there were two eggs and two young just hatched. June 30 there were three young and no eggs. Incubation must thus, if my observations are not wrong, be at the most, eleven days. In 1883 the first egg was laid in a single case June 9. M. of egg from five nests L. 27–30½. B. 21–24.

70. **Ceryle alcyon** (Linn.). ×× Bred in 1882 at Wolf River in any bank high enough so that the nest would be safe from the water. Such banks were found at many places at the turns in the river; but often the entrance hole was only a foot above the water when it was high. Three pairs had nests between the house and Shiocton. In 1883 they were less numerous. Only one pair had a nest between the house and the town. In 1882 saw a pair and a single one April 1st. 7th, one. Afterward daily. None after October 17. In 1883, the first April 9. Next 12. Afterward daily. The last October 18.

71. **Dryobates villosus** (Linn.). × M. of 5 (N.) L. 226. E. 355. W. 123. T. 84. Breeds in large numbers, but in summer is not so common as *D. pubescens*. Is most abundant in winter. Builds, like all the woodpeckers of the region, chiefly in places

wholly inaccessible to man, high up in old, half rotten, or dead trees, of which there is a sufficient quantity. Seldom lower than 30 feet. When the first egg is laid I cannot say; May 29, 1882, there were young in one nest. November 21 I saw a male busily employed in making a nest in an old larch about 50 feet from the ground. The hole was already so deep that the bird was hidden in it. Each time it came out it brought three or four small chips of wood in its bill. There was an old hole one foot above the new one. That woodpeckers in autumn prepare a hole for a nest next summer I had not observed before. In December I caught a male. It became quite tame and ran up my leg. I fed it with tallow, meat and larvæ of tree-beetles.

72. **Dryobates pubescens** (Linn.). × M. of ♂. L. 160. E. 295. W. 93. T. 58. Breeds in great numbers, but builds high up in old or dead trees. June 21, 1882, there were in a nest 30 feet over Wolf River young so large that they could reach the mouth of the hole. In the winter 1881–82 this bird escaped my notice—if it was present—during the coldest period. In 1882 I shot the first March 27. Abundant after April 2. In the winter 1882–83 a single one was seen occasionally in the Daily Beat (Dec. 22, Jan. 8, Feb. 7). In the Great Wood south of the railway it was always to be met with, although in small numbers only.

Picoides arcticus (Swains.) is said to be common in autumn and winter in the northern portions of Wisconsin where it possibly breeds. King has found it in Price county in July. Comes occasionally, perhaps, to Shiocton. Was shot at Black Creek, 10 miles off. *Picoides americanus* Brehm is a more northern bird, but has been shot several times in southern Wisconsin (Brewer).

73. **Sphyrapicus varius** (Linn.). ×× M. (N.) ♂ L. 207. E. 387. W. 123. T. 82. ♀ (3) L. 192–205. E. 359–361. W. 119–123. T. 68–84. It is the woodpecker breeding in the greatest numbers at Shiocton. It generally has its nests lower than the other species. May 17, 1882, there was a nest just begun in a maple, 12 feet over Shioc River. June 19 there were young in a nest 40 feet from the ground. In 1882 four were seen in company April 18. Afterward daily. Most about the 20th. In the Daily Beat not later than October 13. The greatest part

had gone September 28. A single one seen October 8, 10, 11 and 13. In the Great Wood south of the railway there were still several November 2 and 4, but none the 7th. In 1883 three were seen April 9. Daily from the 12th of April. Most the 16th. It is not for nothing that this woodpecker is called "sapsucker." Early in the spring it feeds a great deal on the sap of the sugar maple. For this — and not, as has been supposed, to get the soft bark (*cambium*)— it makes small holes in the trees. Usually a band of such holes, one just by the side of the other, is found. The bands are commonly regular; but when they are found in old trees with thick bark, they are sometimes a little irregular, since the bird seeks places where the bark is thinnest. The bands as a rule reach only half way round the trunk and are then found mostly on the south side, where the sap runs most freely; in many cases, however, they extend clear around the tree. The most holes are found in trees from one to three feet in circumference, three feet from the ground. All the trees were measured at this height. In a tree two feet in circumference there was a ring of 60 holes. Small trees are also used. In a tree one-half foot in circumference I once found a band with five holes. In trees which measure over five feet in circumference holes are seldom found; the bark is too thick. The woodpecker must make new holes for itself every spring. Consequently in old trees one can often see a large number of bands. Usually the woodpecker begins to tap the young trees high up and makes one band of holes *under* the other. Naturally it would have the sap for itself; but many other birds are fond of the sweet drink. I do not know whether any other woodpecker makes holes to tap sugar-maple sap. But I think so. At any rate *Dryobates pubescens* often came to the holes and drank, and had on this account a quarrel with the rightful owner. The same was the case with *Sitta carolinensis*. Many times I saw *Regulus calendula* drink. It poised fluttering before the hole like a hummingbird seeking honey from a flower. May 16, 1883, when the weather was cold, I saw an *Icterus galbula* drink and drive a woodpecker away from its hole. But it was most interesting to see how *Dendroica coronata*, for a while after its arrival in 1883, mostly fed on sap. Several of them kept constantly in the bushes near the holes, and when the woodpecker was at one band the warblers used the others. The woodpecker chased them but could not possibly take care of all his holes. (In 1882 *Dendroica coronata* was seen, when the sap began to flow, run up and down tree trunks in company with *Dryobates villosus* and search after insects.) Late in May, when the sugar-maple sap ceased to flow, the woodpecker made a few holes in oaks and other trees, but the sap of these appeared not to suit its taste very well.

74. **Ceophlœus pileatus** (Linn.). M. of ♂ shot October 11, 1882. L. 462. W. 239. T. 167. Not noticed except in the Daily Beat, but often seen in the big pine grove 15 miles north of Shiocton.

75. **Melanerpes erythrocephalus** (Linn.). ×× At Shiocton the least numerous of the breeding woodpeckers. In 1882 three, in 1883 only two, built on the road from the house to Shiocton. In 1882 a pair was seen May 12, and afterwards a few almost daily. Never seen in flock. May 16, the full summer number. Not seen after October 1. In 1883, on the morning of May 8, three in company. Afterwards daily, but very few.

76. **Melanerpes carolinus** (Linn.). Seen a few times in the Great Wood south of the railway in November and December, 1882. It seems remarkable that this woodpecker, which is said to belong to the Carolinian fauna, appears so far north in winter. Willard has shot it at De Pere, April 24, 1877, and February 1, 1882. Cooke has not with certainty recognized it in Jefferson county. King has met with a single one in September, 1876.

77. **Colaptes auratus** (Linn.). ×× M. of ♂ (2). L. 299–321. E. 467–512. W. 157. T. 126–129. Breeds in great numbers. Stands in this respect between *Sphyrapicus varius* and *Dryobates pubescens*. In 1882 the first was seen April 1. A few seen on the 7th, 10th and 17th. On the 18th many in the morning, still more in the afternoon. Afterwards daily. Autumnal migration begins about September 14. Great flocks from 18th till 25th. Several till October 6. On the 17th the

last in the Daily Beat; but in the Great Wood south of the railway, ten in company November 3. Several the 4th. None on the 7th. In 1883, the first April 9. Several on the 12th. More afterwards.

78. **Antrostomus vociferus** (Wils.). ×× Was seen very rarely, but was not uncommon. In 1882, heard the first time April 28. Again May 3 and 6. For a long time after May 15 every evening. We very often heard from the house two or three at once. After July 26 only heard September 4 and 18. In 1883, two heard April 26. One May 1. Several May 5, 9 and 12th. After May 21, daily. Not later than July 26. Fewer than in 1882. May 24, 1883, found two eggs, one slightly incubated. M. L. 30. B. 21½.

79. **Chordeiles virginianus** (Gmel.). ××. In 1882, not noticed before May 19, when a single one flew in the evening. Afterward daily. 23d, four over the field west of the house and Shioc River. 30th, eight. 31st, in the day-time, a flock of over 70 migrating north. June 6th, a flock of 21. In the course of the summer seen every evening in scores or more over the above mentioned field near the house. August 16, I thought I had seen the last, but they were as abundant as ever before the 24th. But the customary sound was not heard. The birds flew silent and appeared to be migrating. Several seen the next two evenings. A single one October 4 and 6. In 1883, one seen May 1. Singly near the house 5th and 6th, but not again until the 16th, when two appeared. Afterward every evening in great numbers, but not so many as in 1882. On the 26th in the forenoon a flock that was moving toward the north. Several were still seen in the evening at the end of August. August 29, in the afternoon from 4 to 5 o'clock many thousands came from the northeast. The flock was thin, but it extended over half a mile or more. May 16, 1883, I saw a night-hawk in the day time sitting on a branch in the top of a maple. It cried as it is accustomed to do when it flies.

80. **Chætura pelagica** (Linn.). ×× In 1882 many were seen May 9th. Afterward daily. Most had departed August 26. A single one yet November 7. In 1883 a pair that built at our house, seen May 7th. More the following day. Flew

continually in large numbers over woods and swamps, where a great many must surely have nests. Just south of the house there are a quantity of old dead trees broken off high up. One can see that they are open at the top, and they are probably hollow throughout. I often saw individuals fly down into these trunks, and there was always a company circling over that place. Unfortunately I had no opportunity to examine the inside of the trunks. They have nests very commonly in unused chimneys, but the pair that bred with us had a nest in the garret on the *outside* of the chimney. In 1882 it seemed for a long while that they would not build. *Three* flew constantly together out and in; but at last the nest was built and the first egg was laid July 1. In 1883 the first egg was laid June 16. Both times there were five eggs in the nest; but when the young became larger there was not room for more than two, so the others had to cling with their claws to the chimney above the nest. This gave occasion for continual quarrels and scenes. M. of eggs from two nests, L. 21–22. B. 13–14.

81. **Trochilus colubris** Linn. ×× M. of ♂ (N.) L. 91. E. 101. W. 41. T. 28. Breeds in no small numbers even deep in the swamps where it is seen oftener than in the woods. In 1882 there was a pair that had a nest on a branch of a maple tree, twenty-six feet over one of the old beds of Wolf River. The birds appeared to be still building June 21. July 18, 1883, and later, I saw a female take small insects — perhaps for the young — in a spider's web at the house. In 1882 two were seen May 9. Afterwards none before the 16th. Then frequently till Aug. 20. In 1883 they were present in much larger numbers. The first was seen May 17. Afterwards daily. Oftenest single. June 11, however, I saw five that appeared to be in company. They hovered round our blooming plum-trees.

82. **Tyrannus tyrannus** (Linn.). ×× In 1882 two were seen flying April 30. A single one May 8. The day after, many. None 11th, 13th and 14th, but otherwise daily. Hardly seen after August 23. In 1883, the first May 7. 13th many. Builds mostly over water, not in deep woods, but in the open places, in meadows and near farms, in an isolated tree or a large bush. In 1882 there was a pair at least at every farm. In 1883 this

was not the case. Of 17 nests, 14 were over the water, 9 near dwellings, 8 in woods and meadows; 6 were in willow, 4 in elm, 2 in maple, 4 in other trees (one dead). In the trees over the water the nest was placed in two cases as low as 6 inches and 1 foot. Five nests were at a height of 3–4, four 6–10, two 12–14, and one 40 feet. In two trees over the ground the nest was placed in one case 5, in the other, 12 feet high. In trees and bushes the nest was placed sometimes in a fork, sometimes on upper side of a branch. In a single instance it was built in a hole in the trunk of a young tree 4 feet over the water. One nest was found in a fence, 4 feet from the ground. The number of eggs was 2, or just as often 3. In 1882 the first eggs were laid from May 29 to Sune 13. In most nests June 12. In 1883 the first nest I found was deserted before an egg was laid. It seemed to be finished June 11. June 13 I found a nest wherein there was surely an egg, since the bird sat still on a branch in the neighborhood. The nest was too high for me to examine (40 feet). M. of eggs from 5 nests. L. 24–27. B. 17–19½.

83. Myiarchus crinitus (Linn.). ×× M. of ♂ (N.) L. 219. E. 343. W. 107. T. 97. A few build in the woods near the rivers. Three or four pairs had nests between the house and Shiocton. In 1882, the first was seen May 14. A single one the day after. Afterwards in some places daily. In 1883, two May 7, a single one 11th and 14th. Afterwards more, daily. King has not seen this bird in Wisconsin; but it is said to breed at Racine (Hoy) and in Jefferson county (Cooke).

84. Sayornis phœbe (Lath.). ×× M. of 5. L. 160–183. E. 242–252. W. 81–89. T. 63–75. B. 14. Almost every house has its pair of Phœbes. It builds under piazzas, sheds, and roofs. In a deserted house one pair had their nest on the outside of the chimney, and another on a shelf in the dining room. Most build under bridges and fix their nests to the sides of the timbers much as a swallow does. They were most numerous in 1883. There was a nest under almost every bridge. We had a pair that built over a board in our veranda. Folk said they had built in the same place for many years. The nest was used for several broods. It grew each time a little higher. Number of eggs 4 and 5, oftenest 5. Most of them are quite white; but in almost every brood there was found a single one that was spotted with red. In 1882, the first egg was laid April 28, (under a bridge). In 1883, first egg April 25—our bird. Under bridges the birds were delayed and some of them had, on account of high water, to build new nests. First egg under bridges from May 9–12. First egg of second brood, June 22. With regard to our birds laying I will state the following: In 1882, first egg laid April 29 (5 eggs). The birds began to build again June 9. First egg of second set, June 13 (4 eggs). In 1883, nest building began April 12; first egg 25th (4 eggs). Second time, May 29 (5 eggs). Third time, July 9 (4 eggs). M. from 8 nests L. 18–21. B. 14–16. In 1882, several were seen April 2. Afterwards daily. Most on May 14. None after Oct. 9. In 1883, one pair at the house April 6. The day after single ones were seen in other places. 8th, generally distributed. May 14, large flocks at Wolf River. *Sayornis saya* (Bonap.) is a western bird which however has been met with at Racine (Hoy).

.*Contopus borealis* (Swains.) has been tolerably common at Racine (Hoy). King thinks he has seen it in Pierce county June 2, 1882.

85. **Contopus virens** (Linn.). ×× M. of 5. (N.) L. 157–160. E. 264–270. W. 81–89. T. 62–68. B. 12½. June 4, 1882, I shot a male with a yellowish-white band across the forehead. (It is to be found, with most of the rare birds shot by me, in Willard's collection.) In 1882 the first was seen May 20. Afterwards daily. Many after the 23d. Most about the 30th. In 1883 several May 26th. Most about the 31st. Not nearly so many as the previous year, but generally present in large numbers. Builds here and there in the woods in high trees mostly near the rivers. The nests I saw were placed on a branch from thirty to forty feet over the ground or water. The most were in maple or elm. A single one in a dead tree. I looked *at* many but not *into* a single one. I suppose, however, that the first eggs in 1882 were not laid before June 15. On the 29th many were seen sitting; on July 18, young flying.

86. **Empidonax flaviventris** Baird. M. of 6. L. 132–142. E. 207–213. W. 67–72. T. 50–53. B. 9–11. Wing tips 19mm.

beyond secondaries. Tarsus 16. Middle toe and claw 14½. In 1882, the first May 18. A few 21st and 22d. Most 23d. None 24th. Last 25th. In 1883, several May 22 and the following days. Last the 29th. King has seen this bird only once, but at a time which appeared to show that it must breed at the place, in Price county. Cooke has observed it in migration in Jefferson county.

87. **Empidonax minimus** Baird. ×× Very variable in size, form and color. I doubt not, however, that the specimens examined by me must belong to this species. Since, however, some do not agree with the ordinary descriptions I shall make a few remarks. M. of 15. L. 123–141 ($2 < 133$, $5 = 133$, $1 > 139$), E. 185–204, W. 60–68 ($3 < 63$, $4 = 63$, $2 > 66$). Wing tips reach as a rule 16mm. beyond the secondaries. 1st primary is oftenest between the 6th and 7th in length, nearest 6th. In two cases (females shot June 12 and 14, 1883) the 1st primary = 7th. T. 51–60 ($5 = 51$, $6 = 54$), B. 9½–11. In all the specimens examined the under mandible was *light-colored.* Tarsus 14–16. Middle toe and claw 12½–14. Breast and belly sometimes yellowish. May 24, 1883, I shot an individual peculiar in many ways. Above olive-green. Much white on the wings. The inner secondaries half white. Throat whitish gray. Breast and belly yellowish. Strongest yellow on the crissum and sides under the wings. L. 133. E. 185. W. 60. T. 51. Tarsus 16. Middle toe and claw 12½. It is by far the most numerous flycatcher at Shiocton. Breeds here and there in the woods, but perhaps most often in the swamps. It is inclined to build in dead trees, but it also builds in live ones, especially in larch, birch, and ash, from 12 to 50 feet from the ground or water. The commonest height appeared to be about 35 feet. Of five nests two were placed in the fork of a trunk, one in a fork of a branch, two on the upper side of dead branches. Most of the nests were inaccessible. About the first eggs I cannot say anything definite. In 1882 one was seen sitting, June 11. In 1883 a nest was finished, but without eggs, June 3. In another the first egg was laid June 9. The 14th, a nest was found with two partly incubated eggs. The number of eggs appears to be from 2 to 4. Those seen by me were uniform yellowish white. M. from 1 nest (4 eggs), L. 15–17. B. 13–

14. In 1882 a small company was seen May 5. Afterwards none before the 8th, but thereafter in increasing numbers, but not in flocks. Most about May 11 and 12. The last probably seen Sept. 16. In 1883 several May 7. The next day everywhere. Most from 14th to 16th. *E. acadicus* (Gmel.) is supposed to belong to Wisconsin; but whether this is the case is not certain (King). *E. pusillus traillii* (Aud.) is found undoubtedly and breeds probably in Wisconsin (C. L.). King met with a single one at Waupaca in the beginning of July. Probably found at Shiocton, although I could not refer any of the flycatchers shot by me to this species.

88. **Otocoris alpestris** (Linn.). ××× In 1882 the first was seen February 11. Afterwards almost daily till March 29. Hardly seen after April 3, and not observed in the autumn. In 1883 a single one seen, February 21 and 23. A few the 28th. Afterwards none before March 7. Several from March 14 to April 8.

(89.) **Otocoris alpestris praticola** Hensh. It is this form that breeds in Wisconsin (C. L.), not as King supposes *O. alpestris leucolæma* (Coues). Nest was found in 1882 at De Pere (Willard). Breeds probably also at Shiocton. Thought I heard this bird several times in the fields east of the house, as for instance May 18 and 23, 1882.

Pica pica hudsonica (Sab.) is said to be a winter visitor in Wisconsin (Hoy), but was not seen at Shiocton.

90. **Cyanocitta cristata** (Linn.). × Most numerous in winter, when it is oftenest seen in small companies, but not more than five or six together. Breeds around in the woods. June 9, 1882, I saw newly fledged young. *Perisoreus canadensis* (Linn.) is, at any rate in winter, common in Wisconsin in large pine woods. Found occasionally at Shiocton.

91. **Corvus corax sinuatus** (Wagl.). Gunners say that this bird was formerly very common at Shiocton. It is now certainly rare. A single one was shot near Wolf River, October, 1882.

92. **Corvus americanus** Aud. ×× Only a few nest in the Daily Beat, hardly more than a dozen pairs. The most are seen in migration time. According to King, one would believe

that Shiocton was near to this bird's northern limit. He writes that he has not seen it in the eastern part of Wisconsin, north of Stevens Point (Portage county). But he must have overlooked it. A great number flew north in spring, and in Shawano county this bird was more numerous than at Shiocton. In 1882, the first two seen February 7. Afterward almost daily. Oftenest three and four together. Seldom in large companies. In autumn the last was seen at any rate before November 3. In 1883, two were seen February 28 (the four previous days I was absent). Afterward almost daily. April 17, a flock of 13. October 19, a flock of 20, which was the most I at any time saw together.

93. **Dolichonyx oryzivorus** (Linn.). ×× M. (N.) ♂ L. 173. E. 283. W. 97. T. 68. ♀ L. 169. E. 274. W. 87. T. 63. Breeds abundantly in pastures and meadows where the grass has been cut the previous year. In the pasture between the house and East Swamp (40 acres) about twenty pairs bred. June 11, 1883, I found a nest in Shioc Meadows. It contained five newly laid eggs (four strongly marbled with dark brown, one greenish white with small brownish black dots and hair lines on the large end, and also some almost invisible violet cloudy spots). The female was shot. M. L. 22–22½. B 16½–16¾. In 1882, not noticed before May 17, when a company of two males and one female appeared near the house. The day after, everywhere in the fields. In 1883, saw three males and one female in company May 15. Many the day after.

94. **Molothrus ater** (Bodd.). ×× Appeared, however, to be migrating all summer. M. ♂ (2), L. 182–201. E. 342–345. W. 113. T. 75–81. ♀ (2) L. 169–178. E. 305–308. W. 101–113. T. 66–75. B. 14. In 1882 not seen before April 17, when a male and two females were seen near the house. No flocks seen May 7, but otherwise daily from April 30 to May 11. Afterwards May 14, 19, 20, 23, 30; June 15, 21 and 24. On June 29 an egg was found in a nest of *Vireo olivaceus*, with two eggs belonging to the latter (the following day there were three). The nest was in a maple, 6 feet above the Shioc River. July 21 a very large flock was seen—all probably young birds. In 1883, not observed before April 27, when three males and two

females were seen in company. Flocks May 3 and 8. The 9th a female seen spying about in the edge of the Pine Wood. Flocks again May 26. 28th, in the morning, four together near the house. In the afternoon a female was seen that looked into one of our bird houses where a *Tachycineta bicolor* had a nest containing two eggs. One of the swallows sat on a perch near the hole, but it was uneasy, and occasionally forsook its place angrily to attack the cowbird; so the latter seized a favorable instant to alight on the roof of the bird house and then on the perch. Many times she stuck her head into the hole, but found it too small. She kept near the bird house an hour or more, but at last disappeared without having had the opportunity of giving the swallow the promised present. May 29 an egg was found in an open nest of *Melospiza fasciata* with four eggs of the latter. All the eggs were nearly ready to hatch. The nest was in a clump of ferns. Flocks seen daily from May 29 to June 1. Afterwards June 8, 10, 12 and 13. June 18 found an egg in a nest of *Vireo olivaceus* with three of the latter's. All the eggs slightly incubated. Nest in a bush, three feet from the ground. M. of three eggs. L. 18–23. B. 14–17. July 19 I saw from the house thousands of young swallows (*Tachycineta bicolor*) and among them five young cowbirds.

95. **Xanthocephalus xanthocephalus** (Bonap.). M. of ♂ shot in Shioc Meadows, May 28, 1882. L. 252. E. 411. W. 138. T. 87. Saw no more. Breeds in Green Lake county (Cooke).

96. **Agelaius phœniceus** (Linn.). ×× M. ♂ (2) L. 213–219. E. 373–387. W. 119–123. T. 93–97. ♀ L. 194. E. 330. W. 105. T. 78. March 28, 1882, saw 6 and 3 in two different places. The day after very abundant. In autumn vast flocks on September 22. Not uncommon still, October 14. Hardly seen later. Some few April 4, 1883. In great abundance the 9th. Breeds in many wet places, but the most—several hundred pairs—have nests in Shioc Meadows. In 1882, when the water was high throughout May, most of them built in bushes from 1½ to 4 feet above the water. In 1883, when the water retreated from Shioc Meadows in the middle of May, most

of them built in the dry, coarse, last-year grass, usually a few inches from the wet ground. When the nests were built the water almost touched their bottoms. I found, however, a nest June 27th in a willow bush as much as 12 feet over Shioc River. As a rule this bird has two broods. Number of eggs 4 or 5, mostly 4. In 1882, first egg was laid from May 26 to June 5. In 1883, from May 26 to 31. M. from 5 nests. L. 22–27. B. 17–19.

97. **Sturnella magna** (Linn.). ×× M. of 4. L. 238–255. E. 390–408. W. 117–123. T. 75–81. Very abundant in summer. Builds in grass fields and dry meadows. Found a single nest June 2, 1883. Five slightly incubated eggs. M. L. 28–28½. B. 21–22. March 28, 1882, ten seen in one place, three in another. 29th, a few. April 2, many. In autumn only a few in the last of September; but on the 29th their song was heard everywhere. Great flocks October 17 and 18. The last in the Daily Beat, October 31 (1) and November 2 (2). South of the railway a single one November 3 and 4. In 1883, two seen April 2. Many the 3d. In autumn great flocks from October 15 to 19. *Sturnella magna neglecta* (Aud.) is a western form; but it was seen at Racine (Hoy), and it breeds in St. Croix county (King). Whether any of the specimens shot by me belong to this form, I cannot now determine.

98. **Icterus galbula** (Linn.). ×× M. (N.) ♂ L. 184. E. 289. W. 97. T. 75. ♀ L. 182. E. 277. W. 87. T. 72. In 1882 this bird bred in large numbers. At least eleven pairs had nests along the river between the house and Shiocton. In 1883 it was not so plenty. Most of the nests were found in large isolated trees which hung over the water. Many were also seen away from the river, but then generally in the neighborhood of dwellings. The birds seem to have regular places where they breed year after year, sometimes in the same tree. In an old elm that stood near the house and hung over Shioc River, there were nests many years in succession. Of fifteen nests, eleven hung over water. Eight were in soft maple, three in elm, three in poplar, one in a dead tree. Eight hung at a height of from twelve to twenty feet; four from twenty-four to thirty; two from thirty-six to forty; one about sixty feet. As most of the

nests were too high, I cannot say with certainty when the first eggs were laid, but it was hardly before — rather after — June 6. M. from three nests. L. 22–24. B. 16–17. Thread and yarn are often found in this bird's nicely woven nest. May 17, 1882, and following days, a bag hung out was unraveled for material for a nest. In 1882 several males seen May 4. Some few from 7th to 10th. None 11th and 12th; afterwards daily. First female the 16th; 17th many, partly in small companies of five or six. Many of these probably in migration. In autumn none seen after August 29. In 1883 several males, May 7; afterwards almost daily, but none from 10th to 12th and 14th. The first female the 15th.

Icterus spurius (Linn.) breeds regularly at Racine (Hoy) and was seen twice at De Pere by Willard. Not seen at Shiocton.

99. **Scolecophagus carolinus** (Müll.). ××× M. ♂ (5) L. 223–232. E. 342–371. W. 112–119. T. 84–93. ♀ L. 213. E. 323. W. 113. T. 75. One of the most abundant migrants at Shiocton. Never seen so abundant as in the autumn of 1881, when the water was very high. Everywhere that there was water there birds were abundant, and a hundred were found in a single tree. Most on October 20. None seen after November 4. In 1882 the first flocks seen March 29. Afterwards daily. Most abundant from April 18 to 24. Last flocks May 5. In autumn hardly seen before September 18, when small companies of five to eight appeared; 19th great flocks; 28th by thousands. October 15th still many; 16th almost none. Plenty from 24–26. Many November 6. A single one on the 15th. April 11, 1883, four seen in the morning, in the afternoon many, most on logs and brush in the rivers. Twelfth to 14th, quantities; most the 14th. Still many April 19. Seen till May 4. In autumn countless flocks October 18. Curiously enough, King has not met with this species in Wisconsin before October. Still more remarkable that Cooke has not noticed it at all in Jefferson county.

(100.) **Scolecophagus cyanocephalus** (Wagl.). September 25, 1882, many blackbirds were seen. One that kept by itself on a sand bar in Wolf River seemed to me much larger than the others. I shot it. It was a young male with brownish feather edges on the head and throat. Whether it belonged to this species I cannot say with certainty. There was no decided difference between the gloss on the head and the rest of the body. This was true also of another young male I shot October 4. It was in a flock in which the birds were apparently all of the same size. Besides those on the head and neck, it had the same brown-bordered feathers on the back. M. of 2. L. 244–245. W. 119–123. T. 91–93. B. 22–26. According to Coues these measurements appear too large for the foregoing species, but partly too small for the present. It is a western bird. It is met with however occasionally in Wisconsin. Shot in Green Lake county (King).

101. **Quiscalus quiscula æneus** (Ridgw.). ×× M. ♂ (4) L. 281–317. E. 417–455. W. 128–144. T. 126–133. ♀ L. 277. E. 404. W. 131. T. 113. Many have nests singly or in small colonies. The largest colony was found in a row of high poplars that stood around our neighbor's garden. Here upwards of 50 pairs built. The height from the ground is very different. In the poplars no nest was lower than 12 feet, the most about 30. At Wolf River I found one nest 10 feet above the water. Often nests are as high as 40 feet. It is bad for other birds to build in its vicinity. A single male whose nest was in an elm just west of the house and Shioc River, 32 feet from the ground, drove away from their nests in May, 1882, first a *Merula migratoria* and afterwards a *Sialia sialis* and a *Tyrannus tyrannus.* The fight with the robin that built in a little poplar near the house was begun April 29. The robin had adorned its nest with a red silk ribbon. This caught the blackbird's eye and he carried it off when the robin was absent. The latter, on his return, with angry cry pursued the robber, who dropped the ribbon in Shioc River. In 1882, flocks were seen March 29. Afterwards not many before April 2. In 1883, first male seen April 6. Several the day after. Afterwards daily.

Coccothraustes vespertina (Coop.). Western bird. Occasionally appears in winter in Wisconsin. Seen in Jefferson county March 1, 1883 (Cooke).

102. **Pinicola enucleator** (Linn.). ××× M. ♂ L. 239. W. 119. T. 91. B. 11. ♀ (2) L. 217–226. W. 110–114. T. 88–93.

B. 11. Was not noticed in the winter of 1881–82, but was very abundant in 1882–83. Seen by hundreds in Great Wood south of the railway, where I found the first Nov. 17, and flock of 15 of both sexes Dec. 18. From Jan. 8 until Feb. 18 seen in the Daily Beat often in great flocks. Most numerous from Jan. 8 to Feb. 3. Seen mostly in ash trees, whose seeds it ate.

103. **Carpodacus purpureus** (Gmel.). ×× M. ♂ (5) L. 144–158. E. 256–268. W. 82–92. T. 57–63. ♀ (8) L. 144–158. E. 226–259. W. 75–99. T. 54–59. Very abundant in migration. Not a few breed in the region, in the woods and gardens. There were most in 1883 when at least 3 pairs had nests in the woods between the house and Shiocton. May 29 I saw several pairing. June the 5th and the following days they flew with feathers for the nest. There was a nest on our neighbor's farm, twelve feet from the ground; but I did not have the opportunity to examine it. Cooke has not noticed this bird in summer in Jefferson County. March 4, 1882, I shot two females, March 17, a male. 25th the first flocks. Afterwards occasionally, sometimes in flocks of several hundreds. After April 13, almost daily. Most numerous April 18 to May 2. Flocks seen on the latter day probably consisting exclusively of females (or young birds). In autumn most numerous Aug. 24 to Sept. 1. In the Daily Beat, no flock after Oct. 7. A single one Nov. 3. The day after, a large flock in the the Great Wood south of the railway. In 1883 first male seen April 9, one the 12th, and two the 13th. Afterwards many. Most numerous 22nd to 30th. In flocks till May 13. In autumn perhaps the last on Oct. 19.

104. **Loxia curvirostra minor** (Brehm). M. ♂ L. 151. W. 89. T. 50. B. 17. ♀ L. 151. W. 88. T. 52. B. 17. Not noticed in the winter of 1881–82, but very numerous in 1882–83. How often I saw this species I am not prepared to say, since I had to see it near at hand to recognize it. The call note is quite different from that of the European form. The flocks of cross-bills I had the opportunity to examine consisted either of this or the following species. No mixed flocks. I think that *L. leucoptera* came first. November 3, I was in the Great Wood, south of the railway, looking after the cross-bills in the tall pine trees. I saw several flocks; but none seemed to con-

tain any *L. curvirostra.* I shot the first, November 7, when they were very abundant. The most cross-bills were seen in November, before the 18th. Single flocks occasionally throughout the winter; also in the Daily Beat. May 9 I saw a flock of over a hundred *L. curvirostra* in the Great Wood. It rained and all the birds were busy on the ground seeking pine seeds. The crop in the tree-tops was apparently exhausted. When a cone was found, the bird took it in its claws and carried it to a branch. Here it hung with one leg and held the cone with the other, pressing it against the branch and working with the bill to reach the seed. The birds were not at all shy. I could approach within four feet of them. I had therefore the opportunity to assure myself that however great a difference there was in color, there was not a single *L. leucoptera* among them. May 24 a cross-bill was seen still, but of which species I cannot say.

105. **Loxia leucoptera** Gmel. M. ♂ (2) L. 144 169. W. 84–93. T. 59–63. B. 16. ♀ L. 143. W. 83. T. 59. B. 14. Large flocks in the wood south of the railway November 3, 1882. May 8, 1883, I found a few in the Pine Wood. The male had a very shining brown-yellow color which I have not seen in any other cross-bills either here or in Europe. On the back many dark stripes. This species was hardly seen as often as the foregoing.

166. **Acanthis linaria** (Linn.). ××× M. of 15. L. 126–142. W. 68–75. T. 54–59. B. 6–8. Only seen in the winter of 1882–83, but was then present in immense multitudes. Probably seen flying by the middle of November, but was not shot before the 21st of November, when they appeared everywhere in woods and swamps, especially in thistles, alder bushes, and cedar trees, of whose berries they were very fond. Afterwards seen all winter and almost daily. Fewest in February. Few after April 13. The last shot April 23. *A. linaria rostrata* (Coues) and *A. hornemanni exilipes* (Coues) are said to occur in Wisconsin. I can, however, hardly believe that any individuals shot by me were to be referred to these forms.

107. **Spinus tristis** (Linn.). ×× M. ♂ (3) L. 122–129. W. 72–75. T. 54–59. B. 9. ♀ (2) L. 129–132. W. 72–79. T.

43–47. B. 9. Often seen in December, 1881. A few times in January, 1882; but not in February. March 6, I shot one near Shioc River. April 26 a small flock was seen in transitional plumage. 28th, great flock. May 14 males in summer plumage. Most abundant on May 19. For the rest, seen in flocks almost all summer. Rarely, however, between June 17 and September 16. Scarcely after November 13. In 1883 a large flock was seen on thistles near the house, January 18. None in the following months. A single flock May 8. More on the 10th and following days. Most on the 29th–31st. On the 29th a few large flocks consisting of females exclusively. After June 2, only in smaller companies. Many must breed in the woods and swamps. I found no nest, however. July 2, 1883, I saw a female with nest material in her bill. August 29, 1882, I saw the parents feeding the newly fledged young. Large young were fed October 6.

(108). **Spinus pinus** (Wils.). Was certainly seen in flocks April 7, 1883, and the following days. None shot. It is said to breed in Wisconsin as far south as Jefferson county (Cooke). Many were shot at De Pere in March, 1883 (Willard).

109. **Plectrophenax nivalis** (Linn.). ×××. In great flocks in winter. Appears for the most part just before or during a snow storm. In 1882, the first large flock was seen Jan. 9. Later occasionally. Almost daily in March. The last April 1. In autumn, a single one Nov. 9. First flock the 11th. On the 18th extremely numerous, especially on the outer edge of the ice formed during the night on the overflowed Shioc Meadows. Here the water had thrown up many kinds of seeds. In one flock there were surely over a thousand. Seen frequently in the course of November. Three times in December. Last time the 16th. In 1883, several flocks seen January 14. Seen three times in February. None in March. April 4–7, several. The last four the 14th. In autumn, the first two October 31. Singularly enough, some (for example T. Gentry in "Birds of Eastern Pennsylvania") deny that this bird has any call note. It has one nevertheless.

110. **Calcarius lapponicus** (Linn.). M. of young ♂ shot in Shioc Meadows, Oct. 29, 1883. L. 151. W. 86. T. 57. B. 9.

Middle toe 18. Hind toe 16. Not many noticed, but notwithstanding it may well be a regular visitor at Shiocton. *Calcarius pictus* (Swains.) is seen in winter in Wisconsin (King).

111. **Poocætes gramineus** (Gmel.). ×× M. of 6. L. 154–160. E. 258–270. W. 77–81. T. 56–68. A common field bird in summer. In 1882, not noticed before April 14. Most on the 20th. In autumn, most numerous about September 18, but many still October 7. Hardly seen after the 9th. In 1883, a single one shot April 9. More the 13th. Most on the 21st.

112. **Ammodramus sandwichensis savanna** (Wils.). ×× M. of 11. L. 129–148. E. 213–229. W. 64–72. T. 47–54. B. 9–11. In 1882 not noticed before May 10. May have been on hand before. Found many on that and the following day. Most on the 11th and 23d. In autumn most numerous on September 18th. The last perhaps, October 7. In 1883 I shot a male April 26, that was sitting on a stump in a grass field, singign. None seen again before May 9, when a single one was noticed. Most 18th to 26th. Nests in the edges of large swamps and on Shioc Meadows where the grass has been cut the previous year. During the incubation season the male is fond of sitting and singing on fences. King appears not to know of this bird's breeding in Wisconsin. At Shiocton it is common. *A. savannarum passerinus* (Wils.) is not uncommon in certain localities in Wisconsin (Hoy). *A. caudacutus nelsoni* Allen was shot in Jefferson county (King).

Chondestes grammacus (Say). Is found in many places in Wisconsin, as in Brown county (Willard), but *not* at Shiocton.

113. **Zonotrichia leucophrys** (Forst.). ××× M. of ♂. L. 176. E. 248. W. 81. T, 75. Two males May 13, 1882. Very abundant in autumn. Flocks September 28 to October 18. In 1883 three at the slaughter-house May 12, in company with the following species. Afterwards many. The last, May 19.

114. **Zonotrichia albicollis** (Gmel.). ×× M. ♂ (3) L. 164–173. E. 226–235. W. 72–77. T. 75. ♀ (2) L. 168–169. E. 235–239. W. 72–75. T. 72–75. King thinks that this bird does not breed north of Angelica in Shawano County, 18 miles north of Shiocton. A few, however, probably breed every year in the Daily Beat. In 1882 I could only say surely that they

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nested in the young wood near the German Farms on the edge of West Swamp, but in 1883 I knew several places where they nested. June 25, I saw in the Pine Wood both the parents and a little young one which could not fly. It sat in a bush. In 1883, three seen April 25. Two were females. Next day I shot a male. Most abundant April 30 to May 8. Migration ended about the 24th. In autumn most numerous Sept. 24 to Oct. 9. In 1883, five at the slaughter house April 22. Afterwards almost daily. May 9, unusually large flocks in the Great Wood south of the railway. Most abundant in the Daily Beat, 12th–16th.

115. **Spizella monticola** (Gmel.). ××× M. of 6. L. 144–160. E. 219–242. W. 72–77. T. 62–72. One of the most abundant sparrows in migration time. In 1882, four seen Feb. 24. None again before March 7, when five were seen in the morning and a flock in the evening. After that almost daily. Disappeared the 29th, but came again the 31st. Most numerous April 5–17. Not many after the 25th. The last, May 6. In autumn some few Oct. 17 and 18. The first flocks, the 19th. Most on the 26th. Few after Nov. 14. Last flock the 25th. In 1883 not noticed before April 11, when many were seen. More the day after. Afterwards constantly till May 5. The last the 8th. Not nearly so many as in 1882.

116. **Spizella socialis** (Wils.). ×× Breeds abundantly in woods and gardens, never over water. Of 10 nests, 6 were in four kinds of trees (3 in poplar, 1 in cherry, 1 in beech, 1 in spruce), at a height of from 6 to 10 feet from the ground. Three were placed in three kinds of bushes (currant, hazel, beech-sapling) from 2 to 4 feet from the ground. One was placed in a fence 2 feet from the ground. Of these 10 nests, 7 were in the vicinity of dwellings, 3 in the woods. This gives by no means, however, the true relation. The most are undoubtedly built in the woods. Number of eggs 2 to 4. June 7, 1882, the first nest was found with 3 eggs almost ready to hatch. In 1883 the first eggs were laid from May 27 to June 7. M. from 7 nests. L. 17–18. B. 13–14. Two broods. In 1882, not noticed before April 20. Afterwards daily. In flocks April 27 and next following days. In autumn most abundant about Sept. 16. Hardly later than Oct. 7. In 1883, heard near the house

on the morning of April 12. Afterwards daily. Most abundant about April 24.

Spizella pusilla (Wils.). Not known to have been seen at Shiocton. King calls it "not a very common summer resident." Willard writes from Brown Co., "Taken only a few times in 1882." Cooke writes from Jefferson Co., "Seems to be quite uncommon about here." *S. pallida* (Swains.) is possibly found at Shiocton. King has shot 13 specimens in Waushara, Green Lake and Jefferson Co's.

117. **Junco hyemalis** (Linn.). ××× . In 1882, first flock seen March 29. Afterwards almost daily. Probably most abundant 13th to 20th of April. Not many after May 10. A few the 15th. The last two the 19th. In autumn the first were seen Sept. 16. A few the 24th. Flocks the day after. Most about Oct. 11. Few after the 27th. In the Daily Beat not later than Nov. 7; but in the Great Wood south of the railway, very large flocks Nov. 17. None the 21st. In 1883, a few near the house April 7. Abundant the 9th and next following days. Very few the 19th to 24th. Flocks again the 26th. Last flock May 4. This sparrow is extremely abundant in migration time. *Junco hyemalis oregonus* (Towns.) is a western bird. Shot by Willard in Brown Co. Oct. 6, 1883. A pair were shot in Illinois (Coale).

118. **Melospiza fasciata** (Gmel.). ×× M. of 10. L. 151–163. E. 213–219. W. 63–68. T. 63–68. The most abundant breeding sparrow at Shiocton. I can hardly name a place where one would not expect to find its nest. Of 20 nests one was in a hollow in the ground in a field where the grass was cut. No trace of shelter. Nine were without any kind of cover, partly *in* the ground. Of these, 3 were in tussocks (of grass, moss and ferns), 1 at the side of a tussock, 5 under open bushes, 1 was completely concealed in a grass tussock, 2 were in the ground under a natural roof of dried grass that lay over a branch of a bush. May 23, 1883, I found a nest in the end of a rotten log. The hole had been tolerably large but was stopped up by the bird so that there was just room enough left for her to enter. The nest was one foot from ground. Six times I found the nest placed in bushes or trees, mostly over water. In all these cases it was the second or third time the

bird built. June 22, 1882, the first egg was laid in a willow bush, 1 foot over water. July 4, first egg in a maple, 9 feet over water. June 23, 1883, a nest with 5 eggs was found in a currant bush, 1½ feet from the ground (June 29, the young were hatched). June 26, first egg in a shoot at the root a plum tree, ½ foot from the ground. The number of eggs of the song sparrow is 5, rarely 4. They vary much in form and color. M. from 14 nests. L. 19–22. B. 14–16. In 1882, no nest found before May 28. It contained 4 slightly incubated eggs. In a nest with 5 eggs, young were hatched June 4. In 1883, first eggs laid May 10–13. June 5, a striped snake was seen under a willow bush swallowing the eggs in a song sparrow's nest. Both the old birds repeatedly flew down on the snake which was so irritated that it attacked my wife and struck at a stick. It had eaten up all the newly laid eggs but one. In 1882, the first song sparrow was seen in some brush March 12. It was a very peculiar male. It was larger than the ordinary form. L. 169. E. 225. W. 68. T. 75. No stripes on the head. Forehead plain brown. On the back of the head the color passed into gray. Stripes on the neck narrow and pale. Stripes on the back narrow and few. Tail very pale, the dark stripes narrow extremely narrow. After this male none was seen before the morning of March 29, when they were abundant everywhere. In autumn most before Oct. 10. Very few after the 22nd. The last Nov. 24. In 1883, a few April 6. Afterwards more numerous day by day.

119. **Melospiza lincolni** (Aud.). M. of ♂ shot in East Swamp, May 20, 1882. L. 137. E. 192. W. 59. T. 53. Shot only this one. Think I have seen several, however.

120. **Melospiza georgiana** (Lath.). ×× M. of 9. L. 139–144. E. 194–204. W. 56–63. T. 53–63. The most numerous sparrow breeding in swamps. Found several nests with young, a single one with eggs. Most nests I found in the grass, a part under a natural roof. I found a single one in a willow bush ¾ foot from the wet ground. May 30, 1883, I found a nest in which the young were just coming out of the eggs. The bird has at least two broods. M. of eggs from 1 nest. L. 20. B. 14. It is impossible for me to give

the time of this bird's arrival. In 1882 I shot several in East Swamp, April 18. In autumn, most Sept. 24 to Oct. 5. The greatest part disappeared in the course of October, but a straggler was shot Nov. 19. In 1883 it was most numerous in the swamps April 12.

121. **Passerella iliaca** (Merr.). ××× M. of ♂ (2) L. 179–185. E. 283–285. W. 85–87. T. 75. In 1882 not noticed before April 13, when three were seen in some bushes in the edge of a grass field. Next day a dozen in the Pine Wood, several near the slaughter house. In the autumn, one Oct. 9 in the above mentioned bushes. A few, 19th and 20th. Most abundant 26th–29th, when the last were seen in the Daily Beat. In the Great Wood south of the railway more abundant than ever Nov. 3 and 4. None Nov. 7. In 1883, two, April 9, in the above mentioned bushes. 16th, a single one. 24th, a few. 26th, one. May 3, one. In autumn most abundant about Oct. 15.

Passer domesticus (Linn.). This introduced species is as yet seen only occasionally at Shiocton. In 1882, a male seen at our house March 1. April 23, one in Shiocton. 29th, a female in our garden. None in the course of the summer. Oct. 27, a female at the house. Nov. 1, two. In 1883, none observed. Appears to have fast foothold in the larger neighboring towns, as Neenah, Appleton, De Pere, Green Bay and Waupaca. M. of ♀ L. 151. E. 223. W. 75. T. 56.

122. **Pipilo erythrophthalmus** (Linn.). ×× M. (N) ♂ (3) L. 201–213. E. 270–299. W. 88. T. 93. ♀ L. 198. E. 261. W. 83. T. 84. Breeds in great numbers in damp woods with dense bushes and brambles. Was most abundant, however, in 1882. Found no nests. Saw a female with food for young, June 9, 1882. Never seen in flocks. In 1882 not observed before April 26, when two males were seen. Afterwards almost daily, but slowly increasing in numbers. First female observed May 10. Most numerous the 17th. The last in autumn, Oct. 6. In 1883 one heard, April 26. Seen and heard daily thereafter.

Cardinalis cardinalis (Linn.) belongs to to the Carolinian fauna. Bred once, strangely enough, at Racine (Hoy).

123. **Habia ludoviciana** (Linn.). ×× M. (N) ♂ L. 201. E. 314. W. 107. T. 75 ♀ L. 201. E. 311. W. 97 T. 66. In

1882 a dozen pairs bred in the vicinity of the house. June 9, I found two nests in an alder grove, one 10 and the other 8 feet from the ground. The first was plundered, but the egg shells lay in the nest. The other contained 4 eggs nearly ready to hatch. M. L. 22. B. 16. In 1883 only a few bred. The alder grove near the German Farms was one of their breeding places. There the first male was seen in 1882, May 9. Several the day after. First female the 15th. Most about the 24th. In 1883, first male near the German Farms May 16. 18th, several of both sexes. That year, at no time common in the Daily Beat. In the Great Wood south of the railway a very large flock was seen May 22, mostly females. M. of one of these. L. 207. W. 101. T. 75. B. 17.

124. **Passerina cyanea** (Linn.). ×× M. (N) ♂ L. 132. E. 210. W. 67. T. 50. ♀ L. 129. E. 201. W. 66. T. 47. Not many breed at Shiocton. It is never seen in flocks. King writes that in Waupaca county it is "one of the most abundant species." In 1882 the first male seen near the German Farms May 18. June 12, two males on the road between the house and Shiocton, where there is a piece of open wood with many hazel bushes. Had the birds not been present in the meantime? I got an answer a few days after. I found a little nest June 8 in a hazel north of the German Farms. It was placed in a fork 2 feet from the ground and appeared to be finished. On June 14 I looked at it and found a female of this species sitting on much incubated eggs. On the road between the house and Shiocton there must have been at least three nests. June 19, first egg laid in a nest near Wolf River. It was placed in a hazel bush 3 feet from the ground. M. of eggs from two nests. L. 18–19. B. 14–15. In autumn not seen after Aug. 9. In 1883 the first male, May 22, south of the railway. Not seen again before July 9. After that day two males were seen constantly for a while on the road between the house and Shiocton.

Spiza americana (Gmel.) belongs especially to the Carolinian fauna, but appears also in the Alleghanian. I have not seen it stated that it is found in Wisconsin further north than in Green Lake county (King). At any rate it is *not* seen at Shiocton.

125. **Piranga rubra** (Linn.).[17] ×× M. ♂ (2) L. 173–176. E. 286–295. W. 93–97. T. 63–66. ♀ (3) L. 173–180. E. 265–277. W. 92–93. T. 63–68. (The largest shot May 22, 1882.) A few breed in damp woods. In 1883 I saw a nest on the road to Shiocton. It was placed in an elm on a horizontal branch 12 feet from the ground. In migration time many were seen. In 1882, first male May 10. Two, the 11th. Several, the 19th. First female, the 21st. 22nd, both sexes extremely numerous. The day after fewer. 24th, only a few. In 1883, first male, May 22; 26th, a host of both sexes. *Piranga ludoviciana* (Wils.) is a western bird. Is said to have bred in Jefferson county (King).

126. **Progne subis** (Linn.). ×× Only a few seen outside of Shiocton, where it builds in boxes put up for the purpose. In 1882 four males were seen in the town April 10 (there were none the 8th.) In autumn not seen after Aug. 19. In 1883 there were many in the town April 14. It was said that they arrived the day before.

127. **Petrochelidon lunifrons** (Say). ×× Builds under the eaves of most barns and several houses. Much more abundant than *Chelidon erythrogaster*, but not nearly so numerous as *Tachycineta bicolor*. In 1882, the first two were seen April 25. Many the 30th. One of these swallows was engaged in building under the eaves of our house May 29. The mason sat in the nest and it was remarkable that he had *two* assistants to bring him mud. When the mason was tired, one of the assistants took his place. In autumn this swallow was hardly seen later than Aug. 21. In 1883, several April 29. Many May 4.

128. **Chelidon erythrogaster** (Bodd.). ×× Builds singly at many farms but by no means at all of them. In 1882, the first were seen April 29. Scarcely seen after Sept. 4. In 1883, the first observed May 7.

129. **Tachycineta bicolor** (Vieill.). ×× The earliest and most abundant swallow at Shiocton. Breeds here and there, mostly in old woodpecker-holes in dead trees in the swamps and in Shioc Meadows. Height from the ground generally 14–50

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[17] *Piranga erythromelas* Vieill., not *Piranga rubra* of the A. O. U. Check-List.—Author *in litt.*

feet. In 1882, the first was seen over Wolf River March 29. Two, April 1. A few the following days. April 6, small companies of 4 or 5 in several places. The 7th, abundant everywhere. In autumn millions were seen flying over the rivers, most on July 22. Only a few in August. The last probably, Sept. 6. In 1883 the first, April 7. A few the day after. Many the 9th. In autumn most about July 20. This swallow was in the habit of building in our bird-boxes. In 1882, it appeared not to find them till late in May. Two pairs built. First egg June 10. In 1883, several visited the boxes at favorable times immediately after arrival. First egg May 27. In the boxes there were 4 and 5 eggs. M. from 2 nests L. 21–22. B. 14–15.

130. **Clivicola riparia** (Linn.). ×× M. of ♂ L. 130. E. 270. W. 101. T. 50. In 1882 none shot before May 12. No great number seen at any time. Several (nearly a score) built in a sand bank in one of the turns of Wolf River (in Sec. 8). It was plain by the many holes unused that the colony had formerly been much larger. But the river breaks down great pieces of the bank every year. In 1883 a single one of this swallow was seen late in May; but none bred. For want of suitable breeding places it must probably give up breeding in the Daily Beat.

131. **Stelgidopteryx serripennis** (Aud.). ×× M. of 2. (N) L. 135. E. 295. W. 110. T. 54. B. 6. Several bred on the rivers. In 1883 I knew seven places where they must have had nests. At least two pairs built in the vicinity of our house, where they were seen almost daily. May 17 and the following days they got feathers in our hen-yard. April 24, 1882, three were flying over Wolf River. One alighted on a dry branch and was shot. In 1883, none seen before May 4. King has met with this swallow only once in Green Lake Co. Cooke has not seen it in Jefferson Co.

132. **Ampelis cedrorum** (Vieill.). ×× Breeds in great numbers in woods and gardens, but oftenest in young trees in or near the water. Of 19 nests, 12 were over water. Though oftenest in a fork, a single one was found on a horizontal branch. Of 19 nests 18 were in trees, 1 in a beech bush 4½ feet from the ground. Ten nests were in maple, 5

in oak, 3 in other trees. Two were at a height of between $4\frac{1}{2}$ and 5 feet over water, 3 between 6 and 10 feet over water, 7 were at a height of between 12 and 14 feet (1 over water,) 5, 16–18 feet over water, one 22 feet over water. In 1882, 10 were seen in company May 19. Several the 22nd and the following days. Not abundant before June 2. Hardly in flocks after the 17th. First eggs June 18–25. On the 27th, however, a nest with five nearly hatched eggs. July 5 a nest near Wolf River 6 feet from the ground. It was plundered and almost destroyed. Only a few straws remained in the place of the nest; but as I approached, the bird came lamenting anxiously and sat on the straws. It did not fly till I almost touched it. In autumn the first flock seen on Sept. 26. The last Oct. 1. In 1883 two seen May 16. Small flocks the 25th. Many on the 26th–28th. Most abundant May 29 to June 3. June 13, large flocks still seen in the gardens where they devoured the green currants. At this time the birds of the region had mostly finished their nests. First eggs June 23–28. The 22nd I saw a bird sitting, but it does not follow that there were eggs. Number of eggs 3–5. M. from 7 nests L. $20\frac{1}{2}$–25. B. 16–17.

Ampelis garrulus (Linn.) belongs to the Hudsonian fauna, and appears in Wisconsin only occasionally in winter. Not seen at Shiocton.

133. **Lanius borealis** Vieill. ××× M. of 2. L. 239–252. W. 124–126. T. 113. In 1881 a pair —probably of this species— were seen Nov. 14. In 1882 I shot a male Jan. 23 in a large wood ten miles northeast of Shiocton. In the Daily Beat none before Feb. 24, when a male sat and sang in the top of an oak (shot). One again Feb. 26 (shot). Saw one—probably this species—March 1. In the autumn the butcher bird was seen Oct. 22 to Nov. 17. Most Oct. 28. Probably all of this species. One was shot Oct. 25. A single one seen Dec. 9. In 1883 hardly seen in the spring. In the autumn the first Oct. 23.

134. **Lanius ludovicianus excubitorides** (Swains.). ×× Extremely rare. May 17, 1882, I found a nest in the only large fruit garden in the Daily Beat (in Sec. 9). It was placed in a fork of the trunk of a young elm, 10 feet from the ground, and it

contained 6 eggs which a few days after where hatched. M. of eggs L. 22–24. B. 17. June 2, I shot one of the old ones that appeared to be the female. L. 219. E. 311. W. 97. T. 91. Must be referred to this form although only agreeing badly with the ordinary descriptions. It is to be especially noticed that the black stripes did not meet each other over the forehead (neither in the full grown young). The male fed the young. June 9 a little yellow-striped snake and two *Dendroica pensylvanica* were found impaled by the butcher-birds on a thorn of a wild plum-tree. The birds were so impaled that the thorns were driven in through the back of the neck (cervix) and came out on the throat (guttur). In 1883 I saw and heard this butcher-bird probably April 9 and 11. In the course of this and the next month I saw a single one but would not shoot it, vainly hoping that I might perhaps find a nest.

135. **Vireo olivaceus** (Linn.). ×× M. of 13. (N) L. 144–157. E. 230–263. W. 75–84. T. 50–57. B. 14. Builds about woods and swamps and is in Shiocton the commonest Vireo. Of 24 nests 10 were in trees over water (6 in maple, 3 in ash, 1 in oak). Over ground the nests hung partly in trees partly in bushes (3 in oak, 2 in elm, 4 in other trees, (linden, maple, larch), 2 in hazel, 1 in willow, 2 in other bushes). Lowest over ground hung, three 3 feet, five 4 feet, four from 6–8, one 9, and one 14 feet. Over water, one 5 feet, four 6 feet, three 10 feet, one 12 and one 15 feet. Number of eggs, 2–4, mostly 3. Very variable in form and color. In 1882, first eggs June 10–17. 1883, June 13–19. M. from 10 nests. L. 19–24. B. 14–16. In 1882, the first was seen May 11. Next, 17th. Later, more and more. Most, the 23d. The last in autumn, Oct. 1. In 1883, several May 18. Many, 19th. Most, 20th.

136. **Vireo philadelphicus** (Cass.). ××× M. of 8. L. 123–130. E. 194–205. W. 63–68. T. 43–47. B. 9. It has been said: "Almost indistinguishable from *V. gilvus*, except by absence of spurious quill." This is quite wrong so far as I have observed. 1. *V. gilvus* is larger. 2. In *V. philadelphicus* the second and third primaries are the longest and equally long. In a single specimen the second primary was longer than the third. In *V. gilvus* the third and fourth primaries are the

longest and equally long. 3. The color of the two species is different. *V. philadelphicus* is (in spring plumage) not "whitening on throat," but strong yellow on neck and breast. A distinct gray stripe runs from the bill through the eye. *V. gilvus* is white or dirty white on neck and breast, yellowish only on the sides under the wings. It has no distinct stripe through the eye. In 1882 I shot a male May 23. Probably there were more. In 1883, I learned by close study to recognize this species even in the tops of high trees. The first was shot May 19. Tolerably numerous and seen often in warbler-flocks from 24th–28th. King has not met this species in Wisconsin. Neither was it seen by Cooke in Jefferson Co., nor by Willard in Brown Co.

137. **Vireo gilvus** (Vieill.). XX M. of 10. L. 139–144. E. 213–230. W. 72–74. T. 50–54. B. 9–11. It is a question whether the Shiocton form is not a variety. The color is pale, especially the yellow, which sometimes is wanting even on the sides under the wings. Upper mandible almost wholly black. 2nd primary usually 2 mm. $<$ 6th and $3\frac{1}{2}$ mm. $>$ 7th. This Vireo builds in many places, but generally on the margins of rivers and always in very high trees. I saw a great many nests but examined only two on the banks of the Shioc River, not far from the house. The one, June 13, 1883, contained 3 new-laid eggs. Placed in an elm 32 feet over the water. The other, June 14, 3 slightly incubated eggs. Placed in a maple 30 feet over the water. M. from these nests (6 eggs) L. $19\frac{1}{2}$–$20\frac{1}{2}$. B. $14\frac{1}{2}$. In 1882 the first was shot May 9. Not plenty before the 18th. In 1883 several were seen May 8. Afterwards often in warbler-flocks. Most about May 17.

138. **Vireo flavifrons** (Vieill.). XX M. of 9. L. 133–148. E. 223-245. W. 74–82. T. 50. B. 13. In migration time much commoner than *V. gilvus*, but not nearly so abundant in breeding season. I saw only a few in June, mostly near the rivers, and I was not so fortunate as to find any nest. In 1882 the first was shot in a flock of warblers May 8. Very plenty about May 14. Still more the 18th. Migration ended the 23d. In 1883 the first was shot in a flock of warblers May 5. Afterwards only a few before May 12, when several were seen. Most

numerous May 15 and the following days. Migration ended the 24th.

139. **Vireo solitarius** (Wils.). ××× M. of ♂ L. 135. W. 74. T. 54. B. 9. Small primary 13. Was overlooked or did not appear in 1882. Several were seen in a large warbler-flock May 7, 1883. I shot two males. According to Cooke this Vireo breeds in Jefferson county. In migration time in 1883 he saw it from May 10 to 19.

Vireo noveboracensis (Gmel.) belongs to the Carolinian fauna, but also appears in the Alleghanian. It is said to be common in Wisconsin (Brewer), but was not met with by King. From Jefferson county Cooke writes: "Certainly occurs, but not identified."

140. **Mniotilta varia** (Linn.).[18] ×× M. ♂ (3) L. 115–118. E. 194–208. W. 66–71. T. 47. ♀ L. 123. E. 201. W. 66. T. 47. In 1882 two males May 1. Afterwards daily, but mostly singly in flocks of warblers. From May 4 also in company with titmice, kinglets and woodpeckers. First female May 10, when the birds were most numerous. Migration ended the 27th. In 1883, May 6, six in a flock of *Dendroica coronata*. Next day several in all warblers-flocks. In one very large flock this species was nearly as numerous as *Dendroica coronata*. After May 7 scattered about, but mostly singly. Fewest 9th–13th. Many in a few flocks May 14 and 19. Migration ended 26th. Not a few may breed in damp woods and in the edge of East Swamp. I saw females several times in breeding season, but without being able to find any nest.

141. **Protonotaria citrea** (Bodd.). M. of ♂ shot in flock of warblers near Shioc River in the evening of May 4, 1882. L. 135. E. 219. W. 72. T. 52. B. (measured on the side) 15½. This bird is not mentioned at all by King. Cooke does not think it is found in Jefferson Co. It will probably be found that it breeds in several places in Wisconsin, at any rate near the Mississippi. I have found it breeding in large numbers as far north as Sabula (Jackson Co., Iowa) near that river (about 30

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[18] [A short account of the vernal migration of warblers at Shiocton in 1882 was published by the author in Bull. Nuttall Orn. Club, viii. 65–72, April, 1883.—TRANSLATOR.]

miles from the Wisconsin boundary). I have not yet had the opportunity to trace it further north.

Helmitherus vermivorus (Gmel.) belongs to the Carolinian fauna, but is met with breeding at Racine (Hoy). *Helminthophila pinus* (Linn.) is likewise a southern bird; but Cooke thinks that he has seen it in Jefferson Co. Might it not very likely have been *Protonotaria citrea?*

142. **Helminthophila chrysoptera** (Linn.). ×× M. ♂ (5) L. 119–126. E. 183–201. W. 63–66. T. 43–47. B. (measured on the side) 11–14. In 1882 two males were seen May 15. A single one the 18th. The next two days singly in several flocks of warblers. On the 21st both sexes extremely numerous. Only exceeded in number by *Dendroica striata, Helminthophila peregrina* and *Dendroica maculosa.* Migration ended the 27th. In 1883, a single male May 18 and 20. Two the 21st. The day after, several of both sexes. Not nearly so many as the previous year but there were probably more that bred. At any rate this species was noticed oftener in breeding time in 1883 than in the previous year. Not a few breed in open damp woods and thickets, especially hazel. But I could not find a nest. Strangely enough this bird was not seen by Cooke in Jefferson Co. It appears also not to have been met with by King. At Racine two nests were found (Hoy).

143. **Helminthophila ruficapilla** (Wils.). ×× M. of 12. L. 109–117. 175–185. W. 59–63. T. 41–43. On May 24, 1883, I shot a female without crown-patch. In 1882 this species was seen the 4th of May singly in several warbler-flocks. Five in company in some bushes near Wolf River. May very likely have been in the swamp before. May 5, several. 6th, the most numerous warblers in the bushes west of Wolf River. From 7th to 9th only a few. 10th, tolerably plenty everywhere. Increased in number till May 12, when it was only exceeded by *Setophaga ruticilla.* After this it was scarce near the river. Migration ended the 23d. In 1883 several were seen in a large warbler-flock May 7. Two, May 10. First female, 18th. Many males in a flock the 30th. A few the following day. 24th, a number of both sexes, but very few in comparison with the previous year. In 1882 several pairs must have bred in East Swamp where they

were frequently seen in June. In 1883 I met none although I searched the place with great care. Possibly their breeding here in 1882 was exceptional. King appears to think that it breeds at Waupaca. He has only twice met with this warbler, so common at Shiocton at least in migration.

144. **Helminthophila celata** (Say). ××× M. of 4. L. 123–126. E. 185–194. W. 61–63. T. 47–50. B. (measured on side) 11. This species has been described as equal in size to the foregoing (*H. ruficapilla*). It will be seen that this does not agree with my experience; neither does the statement that *H. celata* is "never ashy about the head." In 1882 I shot a female April 30, in company with *Dendroica coronata*. It might well have been present earlier. After May 1 both sexes appeared tolerably common in warbler-flocks, at any rate the 2nd and 5th. Not shot after May 6. In 1883 I met with only a single one May 1 in a flock of *Dendroica coronata*. This species is not noticed either by King, Cooke or Willard. The last has here, as in several places, unfortunately mingled his own and my observations.

145. **Helminthophila peregrina** (Wils.). ××× M. ♂ (9) L. 117–123. E. 185–201. W. 63–68. T. 38–43. B. 9–11. ♀ (4) L. 114–119. E. 184–189. W. 59–66. T. 39–41. B. 9. In 1882 a single male May 19. 21st, both sexes in great numbers, vying with *Dendroica striata*. Later somewhat fewer, but many till May 27. Day after, none. In 1883 two males in a warbler-flock, May 22. On the 24th in the morning only very few, in the afternoon many; 25th great flock of this species alone; 26th more numerous than all the other warblers together; 28th last flock.

146. **Compsothlypis americana** (Linn.). ×× M. ♂ (2) L. 110–119. E. 174–177. W. 63–64. T. 38–43. ♀ (4) L. 97–114. E. 176. W. 57–59. T. 38–47. B. 9. In 1882 two females shot in a large flock of warblers the evening of May 3. Next morning several of both sexes. Many in the afternoon. Later also in flocks of its kind, and, like *Mniotilta varia*, in company with titmice and kinglets. Migration ended May 23. In 1883 a few in warbler-flocks May 7. None 9th–11th. Many 14th–17th. Most 18th–21st. Migration ended 28th. As a migrant this species

is extremely numerous, and many breed at Shiocton. In 1882 I saw, however, only a few nests which were built in the top of the high maples where it was quite impossible to reach them. On the 23d of June I shot for the sake of identification a female on a nest in a maple near Shioc River 42 feet over the water. The shot tore the nest, and remnants of new laid eggs fell down. In 1883 I saw many nests, mostly near the rivers, but also in the Pine Wood. It is almost inconceivable that King should have met this bird only once. Cooke has seen a few in Jefferson county.

147. **Dendroica tigrina** (Gmel.). ××× M. of ♂ (7) L. 117–125. E. 180–207. W. 64–68. T. 43–50. B. 11–12. ♀ (10) L. 117–130. E. 189–201. W. 61–68. T. 41–47. B. 9–12. May 8, 1882, I shot two males, on May 7, 1883, one with white spots on four pairs of tail feathers. May 21, 1883, I shot a female with white spots on only two pairs of tail feathers. The same female was very different from the others. *No yellow.* Back nearly as in *Helminthophila peregrina.* King has only seen this species four times. Cooke has not noticed it in Jefferson county. At Shiocton it is abundant. In 1882 many males in the warbler-flocks, May 8. The day after, nearly as numerous as *Setophaga ruticilla;* first female. Continued to be plenty during the following days. On the 12th outnumbered by *Setophaga ruticilla, Dendroica pensylvanica,* and *Helminthophila ruficapilla* only. 13th, only a few. 14th, many. Afterwards only a few, mostly females. None on the 17th and 18th. The last on May 25. In 1883 first male in a large warbler flock May 7. A single one the 8th. 21st and 22nd, a few females. 24th, several of both sexes. 26th and 27th, many, most the first day. In all not half so many as in 1882.

148. **Dendroica æstiva** (Gmel.). ×× M. ♂ (2) L. 119–123 E. 192–194. W. 63. T. 43–46. ♀ (4) L. 119–123. E. 176–185 W. 57–63. T. 38–43. May 12, 1881 I shot a male which not only was unusually strongly striped with red on throat and breast, but had an almost uniform cap of that color (brown-red). It was larger than usual. L. 126. E. 198. W. 66. T. 43. This warbler is, after *Setophaga ruticilla,* the most numerous breeding species at Shiocton. In nesting time it is spread over

the whole country but prefers to build in bushes near the water. I once found a nest nest placed *between* a slender willow branch and the stem of a young poplar. All other times in the fork of a branch. Of 16 nests only one was over water. Six were in willow, 4 in hazel, 5 in different bushes (1 in a quite small rose bush). 3 nests were 1½ feet, 6, 2–3 feet, 6, 4–5 feet, 1, 8 feet from ground. Number of eggs mostly 4. In two cases 2, in one 5. The 3d of June 1882 I found an egg on which the spots were collected at the *small* end (and I have found such later at Clinton, Iowa). June 10, 1883, a set of 3 eggs nearly without spots. On one there were only two. In 1882, first eggs laid May 31 to June 4. In 1883, June 1–8. M. of eggs from 13 nests. L. 14–19. B. 12½–13½. In 1882 first male seen May 3. The day after, in many warbler-flocks. May 5, the commonest warbler in bushes west of Wolf River. May 14, uncommonly plenty everywhere only exceeded by *Setophaga ruticilla* and *Dendroica pensylvanica*. Migration ended May 26. In 1883 a few males May 7. Afterwards daily except 9th and 11th. Most numerous the 18th, but by no means in great numbers. Not half so many as in 1882. Migration ended May 27.

149. **Dendroica cærulescens** (Gmel.). ×××. M. ♂ (4) L. 123–124. E. 194–201. W. 64–67. T. 50. B. 11. ♀ (2) L. 119–126. E. 163–192. W. 61–63. T. 50. B. 11. It will be seen that the statement that this bird is the same size as *D. virens* does not agree with my experience. In 1882, several males May 8. Number increased till May 11 when I saw the first females. None the 12th and 16th–18th, but daily with these exceptions; more or less numerous till the 23d. A single male was seen singing in a windfall May 31. In 1883, one male May 12. Many in a large warbler-flock the 14th, 18th, two females. The 22d two males. Few compared with the previous year.

150. **Dendroica coronata** (Linn.). ××× M. ♂ (5) L. 133–151. E. 204–233. W. 72–77. T. 57–63. B. 11. ♀ (3) L. 133–139. E. 214–226. W. 67–72. T. 54. B. 11. In migration time the most numerous warbler. In 1882, first male April 5. A single one 10th, 12th, 14th and 18th. April 21, the first large flock. Afterwards more numerous each day. April 30, other kinds of warblers in the flocks for the first time.

Females perhaps not seen before that day. May 5, in the afternoon, this species was not so numerous as the other warblers together. May 8, the number not remarkable. May 14, a lot were seen, only singly on 9th–20th. In autumn noticed Sept. 26 to Oct. 26. Most Oct. 4–8. In 1883, a single male was seen on April 12. First flock the 14th. Many after the 18th. The first female appeared the 22nd. Few 28th—30th. The 29th, I saw in all only 3. Flocks again after May 1. Many large flocks the 4th–6th, when other warblers also appeared. On the 7th and 8th they were in only few flocks, more numerous than all the other species together. 9th and 11th, none seen. From 10th to 15th in most flocks more numerous than any other kind of warbler. Afterwards only few. The four last, May 18.

151. **Dendroica maculosa** (Gmel.). ××× M. ♂ (5) L. 110–126. E. 183–192. W. 58–63. T. 47–50. B. 9. ♀ (2) L. 113–129. E. 183–184. W. 57–59. T. 47. B. 9. In 1882, the first male seen May 3. The 5th, singly in four flocks of other warblers. Two males that I shot that day differed from those I shot May 9 and later in that the black stripe through the eye did not join the black of the back, but was sharply bounded by clear ash. Both males were much brighter in color. L. 121–124. E. 190. W. 60–63. T. 15. B. (measured on the side) 11. The 6th, a male. 9th, several. None 13th to 17th. 19th, more numerous than any of the other warblers. Continued to be plenty till the 24th. The last the 25th. In 1883 the first male was seen in a large warbler-flock May 14. The 17th, more numerous than any other warbler. The 18th, several in the morning, only a few in the afternoon. 20th, one. 24th, a lot in the morning, in the afternoon many of both sexes. Many still the 26th.

Dendroica cærulea (Wils.) belongs to the Carolinian fauna. A few breed in Wisconsin (Hoy).

152. **Dendroica pensylvanica** (Linn.). ×× M. ♂ (3) L. 128–130. E. 194–198. W. 59–68. H. 43–50. B. 8. Breeds about woods but not in great numbers. The nest is placed in a forked branch in a low bush. Five nests were at a height of ½–2 feet from the ground. Number of eggs 4, in one case 5. In 1882, first eggs laid June 3 and 4. In 1883, the first egg June 7, in

the same raspberry bush where there was a nest in 1882. M. of eggs from 4 nests. L. 15½–17. B. 12½–14. In 1882 a small flock was seen May 3. Not seen again till the 8th, when several appeared. The 12th, they were next to *Setophaga ruticilla* in abundance. The 14th, more numerous than the latter, except in bushes over water. Afterwards fewer. Migration poobably ended 26th. In 1883, two males May 8 and 9. The 12th, one. 13th, several. 14th, in an immense warbler-flock, second to *D. coronata* in numbers. 15th, none. 16th, two. 17th, many. 18th, in some flocks most numerous next to *Setophaga ruticilla*, in others more numerous than that species. 20th, and 21st, more numerous than any other warbler. Migration ended about the 26th.

153. **Dendroica castanea** (Wils.). ××× M. ♂ (3) L. 126–135. E. 214–220. W. 68–75. T. 47–49. B. 9. ♀ (2) L. 133–140. E. 214–215. W. 68–72. T. 47–59. B. 9. In 1882, five males of this species in a large flock of warblers May 18. Numbers increased the following days. The 23d, the most numerous after *D. striata*. 25th, the most numerous of any warbler. Disappeared the day after. First female the 25th. In 1883, first male in a warbler-flock May 20. Several the next two days. None after that before the 26th, when a large flock appeared. 27th, several of both sexes. 29th, one female. This bird strangely enough was not noticed by Cooke in Jefferson Co.

154. **Dendroica striata** (Forst.). ××× M. ♂ (8) L. 126–139. E. 220–226. W. 75–82. T. 50–57. B. 9–11. ♀ (3) L. 133–135. E. 214–216. W. 68–72. T. 57–50. B. 9. In 1882, the first males May 10. After that none till the 18th. A few during the next two days. 21st, tolerably common. 22nd–24th, more numerous than any other warbler. 25th, not so plenty as *D. castanea*, but still in great numbers on that and the following days. 27th, a few. A single male singing in a fir June 5. The first female was seen May 21. In 1883, two males in a warbler-flock May 18. Several, 20th and 21st. 22nd, one male. 24th, many of both sexes. 26th and 27th, a lot. 29th, a single male. First female May 20. King thinks that this warbler is not nearly so abundant as the foregoing. At Shioc-

ton *D. striata* was many times more numerous than *D. castanea.*

155. **Dendroica blackburniæ** (Gmel.). ×× M. ♂ (3) L. 117–119. E. 198. W. 61–68. T. 43–50. B. 9. ♀ (4) L. 119–125. E. 196–198. W. 63–66. T. 43–47. B. 9–11. Cooke has seen this warbler in Jefferson county only in migration time, and it seems to have escaped King's observation that it breeds in Wisconsin. In 1882 I did not examine its breeding ground in nesting time. In 1883 I found that it must have nests in several places in thick damp woods. It was seen mostly flying in the tops of high larch trees. On June 9 I saw a male and female about to pair in the Great Wood south of the railway. I saw most in the Pine Wood. June 14, I saw one, June 25, three males, so there must have been at least three nests. In 1883, first male seen May 3. A few during the three following days. None on the 7th. The day after, so many that no other one species of warbler could compare with it in numbers. None May 9. Afterward daily, except 16th and 17th. The 18th, probably the first female. Migration ended 23d. In 1883 four males were seen in a warbler flock the morning of May 7. In the afternoon in a great flock, most numerous next to *D. coronata.* None 8th–14th. A few occasionally from 15th to 21st. The 20th, first female. 22nd, many of both sexes; more numerous than any other species in a large warbler-flock. None the 23d. Many the 24th. Next again on the 27th, when they predominated in a smaller warbler-flock. Herewith the migration ended.

Dendroica dominica albilora Baird is a southern bird, which was met with once, however, at Racine (Hoy).

156. **Dendroica virens** (Gmel.). ××× M. ♂ (5) L. 113–119. E. 182–194. W. 63–66. T. 47–63. B. 9. ♀ L. 117. E. 183. W. 61. T. 43. B. 9. In 1882, several males May 4. Afterwards occasionally; not after 22nd. None 7th, 9th and 13th–18th. Plenty only May 8. In 1883 two males in large warbler-flock, May 7. None 8th–23d. 24th, several of both sexes. None 25th. Many 26th. A few may breed in Wisconsin, but in Shiocton none were noticed in breeding time.

Dendroica kirtlandi Baird is said to occur in Wisconsin (C L.), but was not seen at Shiocton.

157. **Dendroica vigorsii** (Aud.). ××× M. ♂ (3) L. 126–133. E. 208–223. W. 68–72. T. 47–55. B. 11. ♀ L. 125–126. E. 201–205. W. 63–67. T. 47–50. B. 11. These measurements are less than those generally given. The 4th of May, 1882, I shot a male with white spots on three pairs of tail feathers. May 12, I shot a strange looking female. Only the upper tail coverts were olive color, back and head quite gray. No trace of eye-line. Underneath dirty white. L. 125. W. 67. T. 50. In 1882 I shot a female in a flock of *D. coronata*, May 3. The next succeeding days in many warbler-flocks, but sometimes by themselves in small companies of 4 and 5. After May 6 only a few. The last, May 12. In 1883 only a single male was seen in the Daily Beat in a flock of *D. coronata*, April 24. In the Great Wood south of the railway a male May 9. That was all. King has not met this bird more than once. In Jefferson county a lot were seen in 1883.

158. **Dendroica palmarum** (Gmel.). ××× M. of 13. L. 118–133. E. 192–201. W. 61–67. T. 46–55. B. 9–11. Young bird shot Oct. 4, 1882, had white on three pairs of tail feathers. This species is seldom found in company with its congeners. Appeared only a few times in warbler-flocks near the river. Was mostly seen on high ground in grass and bushes. Was not carefully observed. In 1882 the first was seen May 1. Most numerous 8th–12th. Last one seen the 16th. In the autumn in great quantities. Seen Sept. 14 to Oct. 15. In 1883 not observed before May 7; then a male was shot in a warbler-flock. Most numerous 16th and 17th. Last seen 26th.

Dendroica discolor (Vieill.) is said to belong to the Alleghanian fauna but is especially a prairie bird.[19] Is found at Racine (Hoy), but does not appear at Shiocton.

159. **Seiurus aurocapillus** (Linn.). ×× M of 3. L. 144–157. E. 230–242. W. 74–75. T. 50–57. Breeds in no small

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[19] [Our author has fallen into error here, probably misled by the inappropriate English name of *Dendroica discolor* — "Prairie Warbler."—TRANSLATOR.

numbers. Is seen throughout summer in woods. In 1882 not noticed before May 9. Most on the 17th. In 1883 extremely numerous May 9 in the Great Wood south of the railway. In the Daily Beat not observed before the 15th.

160. **Seiurus noveboracensis** (Gmel.). ×× M. of 4. L. 148–151. E. 244–264. W. 72–84. T. 54–57. King has not met with this bird in breeding season in Wisconsin. At Shiocton it nests in considerable numbers along the rivers and lesser streams. In the breeding season the male often sings in the tops of tall trees. On June 23, 1882, two newly hatched young sat on a trunk in Wolf River. They fell into the water when they tried to fly. May 31, 1883, I found a nest near a ditch in the Pine Wood. It was built in a hollow in the north bank. The entrance was made small by the birds which had also protected the nest by a roof. In contained 5 fresh eggs. L. 20–20½. B. 16½–17½. In 1882 a pair was seen April 26. Many the 28th. In 1883 the first April 30. The next day everywhere where there was running water. Afterwards fewer.

161. **Geothlypis trichas** (Linn.). ×× M. of ♂ (5) L. 119–133. E. 173–185. W. 55–59. T. 43–54. ♀ (2) L. 123. E. 160–167. W. 50–52. T. 41–47. It cannot now be decided whether the Shiocton bird is *G. trichas occidentalis* Brewst. (a form that was then unknown to me). It is the commonest breeding warbler in swamps. But I found only two nests. June 8, 1883, one with 4 eggs. The day after there were 5. The nest was built in grass an inch from the wet ground under a natural roof composed of a dried tuft of grass held up by a twig. June 14, a quite open nest in a mossy place in the Pine Wood. Contained 5 much incubated eggs. M. from these two nests. L. 17½–19. B. 13½–14. In 1882, not observed before May 10. But may well have been in the swamp before. In warbler-flocks near the river not very numerous before May 18, when the first females appeared. In autumn one of the most abundant warblers. Great flocks Sept. 21–27. The last Sept. 30. In 1883 a large number were seen in East Swamp May 10. *G. formosa* (Wils.) which belongs to the Carolinian fauna has been found once at Racine (Hoy). *G. agilis* (Wils.) which be-

longs to Canadian fauna, is in migration time common in Wisconsin. King has not met with it; but Cooke has seen it in Jefferson Co., May 26–29. I cannot deny that it may be found at Shiocton, especially as it belongs to the latest migrating warblers. *G. philadelphia* (Wils.) is said to belong to the Canadian fauna, but Cooke gives it as breeding in Jefferson Co. It seems remarkable that it was not seen at Shiocton. Moreover it was not met with by King either.

Icteria virens (Linn.) belongs to the Carolinian fauna. It breeds in Jefferson county (Cooke), but is not found at Shiocton.

Sylvania mitrata (Gmel.) belongs to the Carolinian fauna, but was met with at Racine (Hoy).

162. **Sylvania pusilla** (Wils.). ××× M. ♂ (5) L. 113–126. E. 164–173. W. 52–63. T. 29–49. B. 8–9. This species was seen very rarely, and always singly, either by itself or in warbler-flocks. No female was observed. King has met this species only once, but Cooke saw flocks in Jefferson county May 12–29, 1883. In 1882 I saw males of this warbler May 12, 14, 18, 22–25, and 28. The largest number seen in one day was four, which were found May 23 in four separate places. In 1883 seen May 18, 19 and 20. The last day two were seen, on the other days one.

163. **Sylvania canadensis** (Linn.). ××× M. ♂ (4) L. 126–133. E. 189–198. W. 63–66. T. 54–57. B. 11. ♀ L. 130. E. 189. W. 6. T. 50. B. 11. In 1882, first male seen May 10, two on the 11th and two on the 18th. The 19th, very numerous, hardly exceeded by *Dendroica maculosa.* The 20th, more numerous than any other warblers. Tolerably plenty the next three days. The last two seen May 31. First female probably the 21st. In 1883, first male in a large warbler-flock May 18. None the day after. 20th, in the morning three males in a warbler-flock. In the evening several. More, 21st and 22nd. None, 23d. Some of both sexes, 24th and 26th. One male the 27th.

164. **Setophaga ruticilla** (Linn.). ×× It is undoubtedly the most numerous breeding warbler in the region. Nests both in swamps and woods, but generally prefers the vicinity of the rivers. Of 38 nests, 23 were placed over the water and were

there, as a rule, lower down then elsewhere. Over water the nests were placed at a height of 2–32 ft. (4, 2–3, 3, 6–7, 3, 8–9, 8, 11–13, 4, 14–18, 1 just 32 ft.). Over the ground at a height of 4–15 ft. (3, 4–5, 2, 6–7, 4, 8–10, 6, 12–15 ft.). The nest is usually built in a fork in a young tree. 10 in maple, 7 in elm, 6 in ash, 5 in oak, 4 in willow, 2 in alder, 4 in other trees. 3 nests were built in dead trees. Two of these were placed on a *horizontal* branch. In 1882 many built twice. This was not the case in 1883. Number of eggs almost always 4. Of 30 nests four contained 3 eggs. One, 2 (incubated). In 1882, first eggs laid 2nd to 11th of June, in most nests 3d to 5th. June 11, I found a nest in a windfall 2½ ft. from the wet ground. It contained 4 eggs and the bird was sitting. The nest had lost its support on one side and hung down, so that it was almost impossible for the bird to sit. With the help of a pin I fixed the nest in its former position. The bird came, sat first on the edge of the nest examining carefully what had happened and then sat quite contentedly. In 1883 the first eggs laid June 4–13. M. of eggs from 11 nests. L. 14–17. B. 12–13. In 1882 a female was seen May 3 in a large warbler-flock. May 5, a male and a female. 8th, three males in different flocks. 9th, very numerous but no females. 10th–15th, more numerous than any other warbler. 10th, females also appeared. Migration ended about May 25. In 1883 two males May 7. Several the following days, but singly. 10th to 11th, only three. Afterwards more numerous day by day. 14th, first female. 18th, more numerous than any other warbler. Migration ended about May 24.

165. **Anthus pensilvanicus** (Lath.). ××× M. of 3. L. 164–167. E. 252–258. W. 79–88. T. 63–68. This bird seems not to have been observed often in Wisconsin. Cooke does not mention it at all. King has seen a single flock. On May 20, 1882, at 5 o'clock in the afternoon during a violent shower a large flock alighted in the field just east of the house. Several were shot. Oct. 17, I saw two on a fence near a barn. Shot one. May 17, 1883, I think I saw two flocks fly over the above mentioned field low down over the ground. The day after, several.

Mimus polyglottos (Linn.) belongs to the Carolinian fauna. Has bred at Racine, but could hardly be expected at Shiocton.

166. **Galeoscoptes carolinensis** (Linn.). ×× Breeds in great numbers. In 1883, however, it was not nearly so abundant as in the previous year. Breeds mostly in bushes in or near the water. On uplands it appears to prefer thorns and brambles. When the nest is over water it is as a rule placed lower than at other times. The same is true of most other birds. Generally the nest is placed in the fork of a branch. Of 23 nests, 9 were in bushes over water (7 in willow), 7 at a height 2 feet, two 3 feet. 14 were over the ground. Of these 9 were in bushes (3 in willow), 4 in thorns and thorny trees, 1 in brush. 1 in a broken plum tree was only 1½ feet from the ground. 8, about 3 feet; 5, 4–5 feet. Number of eggs 3–5; in 1882 oftenest 4, in 1883, 3. 5 eggs in only one case. In 1882 first eggs laid May 28 to June 2. In 1883, June 3 and 4. A nest was found, however, in the Great Wood south of the railway June 9 with 1 egg and 3 young. M. of eggs from 13 nests. L. 22–25. B. 17–19.

167. **Harporhynchus rufus** (Linn.). ×× Seen also in migration time, only in certain places. A few bred in young woods with thick bushes. June 15, 1882, I found two nests near Wolf River. One in a hazel bush 2 feet from the ground. Contained 4 much incubated eggs. The other in a vine on an ash 7 feet from the ground. Contained 2 new-laid eggs. M. from these two nests. L. 25–27. B. 18–21. In 1882 not observed before May 7. Only singly till May 12. Seldom in larger companies than 4 or 5. In 1883 not so numerous as in 1882. A pair seen May 2. Thought I heard the male's song as early as April 26.

Thryothorus ludovicianus (Lath.) belongs to the Carolinian fauna. Is found occasionally in Wisconsin (King.).

Thryothorus bewickii (Aud.) must surely be found at Shiocton, but was not observed.

168. **Troglodytes aëdon** Vieill. ×× M. of 2. L. 119–123. E. 164–169. W. 51–54. T. 43–47. Is present in large numbers, but breeds almost exclusively in the swamps. In 1882, none seen before May 5. June 5, observed the first at our house.

It examined the bird-houses, carried dry sticks into two and built in a third. *It had, however, no mate.* Not seen in autumn later than Sept. 30. In 1883 there were a pair at our house May 7. Two pairs built in the bird-boxes, where the first egg was laid June 2. M. of eggs from two nests (one in a bird-box at a farm north of our house). L. 17. B. 14.

169. **Troglodytes hyemalis** Vieill. ×× M. of 5. L. 97–110. E. 148–160. W. 47–50. T. 29–32. This northern bird does not breed in Jefferson county (Cooke), but must be considered as breeding at least occasionally at Shiocton. June 4, 1883, and the following days I saw one in the Pine Wood. It was in the habit of sitting and singing on the topmost branch in the dead tops of the tallest larch trees. The nest, however. I did not find. In 1882 the first was seen March 31. Afterwards occasionally, but always singly. Most, April 1 to May 6. In the autumn till Oct. 16. In 1883, the first seen April 9. Most, April 16 to May 10.

170. **Cistothorus stellaris** (Licht.). ×× M. of 3. L. 104–117. E. 139–151. W. 42–47. T. 36–41. Does not breed at Shiocton in nearly so great numbers as the following species, but is found, however, in many places on the edges of woods along Shioc Meadows and in the swamps. The greatest number of nests I found in the vicinity of each other was 5, but the nests are very hard to find. They are built oftenest in the fine dry last year grass, as a rule only a few inches from the ground. Generally the nest is placed at the roots of a bush, where the grass is wrapped round the lower branches. During the summer, however, I have met with three nests among grass in bushes as much as a foot from the ground. In these cases the nests were easy to find. Like the following species this one builds in dry or green grass as circumstances require. In 1883 most nests were built after June 8. I found a single one building, July 2. This must not be regarded as testimony that the bird has two broods. When this and the following build late, it is certainly only because they have deserted their earlier nest. The nests are deserted, even when there are eggs, at the slightest disturbance. I cannot say with certainty when the first eggs are laid. June 2, 1883, I found 3 nests in one place. Two were

yet empty, the third contained 6 fresh eggs. M. of these. L. $15\frac{1}{2}$–$15\frac{3}{4}$. B. 12–$12\frac{1}{2}$. In 1882, none shot before May 20. In 1883, the first observed May 10.

171. **Cistothorus palustris** (Wils.). ×× Breeds apparently only in Shioc Meadows; but is found there by thousands. Almost always many nests are found in the vicinity of each other. In some places one sees large colonies. The nests are placed in the top of the long coarse last year's grass. Later in the summer also in the new. In 1883, May 28, 21 nests were found. There were eggs in only one (3). June 3 there were eggs in 5 of 28 nests. Most were built after June 5. Number of eggs 6, sometimes 5. First egg laid in 1883, May 26. M. of eggs from 5 nests. L. 16–17. B. $12\frac{1}{2}$–14. In 1882 I saw none before May 30. Had probably long been present in Shioc Meadows. In autumn they are seen scattered about, most in September. Shot one as late as Nov. 7. In 1883 abundant in Shioc Meadows May 17.

172. **Certhia familiaris americana** (Bonap.). ×× M. ♂ L. 144. E. 201. W. 66. T. 63. Not given as breeding in Jefferson Co. (Cooke), but that a few breed at Shiocton is quite certain. June 7, 1883, I followed one from tree to tree, but did not find the nest. In 1882, the first seen March 26. More after 28th. Most numerous April 24–26. Migration over about May 2. In autumn, most Oct. 7–11. Last seen Dec. 16. In 1883 saw a single one Jan. 8. Afterwards not before March 20. Seems as if it must have gone away in the coldest part of the winter. A few, March 26. More after April 9. Most, May 6. Migration hardly ended before the 14th.

173. **Sitta carolinensis** Lath. × Most abundant in summer. Very common. Breeds in holes in trees, 10 feet or more from the ground. May 16, 1882, young were in a nest.

174. **Sitta canadensis** Linn. ××× M. ♂ L. 104. E. 198. W. 66. T. 34. Only very few seen in the Daily Beat. In 1882 one each day from May 21 to 23, and one Sept. 26. When I went to the Great Wood south of the railway Nov. 3, I saw many. Nov. 4, I counted over 50. On the 17th there were still a few. On the 21st none. In 1883 it was not observed. This bird is said to breed in several places in Wisconsin.

175. **Parus atricapillus** Linn. × Most numerous in winter when it is seen in small companies. Many breed in swamps and damp woods. May 20, 1882, I saw one in East Swamp flying with a tuft of sheep's wool. June 4, 1883 I found a nest full of young ones. It was placed in a hollow in the stump of a young birch, 12 feet from the ground. *Parus hudsonicus* Forst., which belongs to the Canadian fauna, is said to be a winter visitor in Wisconsin.

176. **Regulus satrapa** Licht. ××× M. ♀ L. 93. E. 155. W. 52. T. 34. Appears to arrive mostly in separate flocks, not as the following species in company with titimice and warblers. King is certainly right when he says that the migration of this species takes place earlier than that of the other. In 1882 none were shot before April 9. Many days it was not observed. Most abundant April 24 to May 1. In autumn seen mostly Oct. 5–9. In 1883, first flock of this species April 9. Afterward only a few.

177. **Regulus calendula** (Linn.). ××× M. ♂ L. 104. E. 176. W. 57. T. 43. ♀ (4) L. 106–112. E. 173–181. W. 57–59. T. 41–43. In 1882 a few flocks of kinglets were seen from April 3. This species was not shot before the 10th. Not abundant before the 18th. Most abundant April 30 to May 12. The last seen May 15. In autumn a single one of this species was seen Sept. 30. Kinglets seen in flocks Oct. 4–22. In 1883 flocks of kinglets — probably this species — seen from April 11. First shot the 15th. Most, April 25 to May 6. Last seen May 17.

Polioptila cœrulea (Linn.) is ascribed to the Carolinian fauna but often appears to breed in Wisconsin. Was not seen, however, by King, Cooke or Willard.

178. **Turdus mustelinus** Gmel. ××× Two seen in company with other thrushes May 22, 1882. Hardly breeds at Shiocton. Was found on a single occasion breeding at De Pere (Willard), and is said to be common in Jefferson county (Cooke).

179. **Turdus fuscescens** Steph. × ×. M. ♂ L. 183. E. 352. W. 101. T. 75. ♀ L. 176. E. 277. W. 93. T. 69. Cooke has not found this species breeding in Jefferson Co. In the Daily Beat it breeds in several places in damp woods. But it does not appear to be very abundant. Most observed in the

Pine Wood, where in 1883 at least five pairs had nests. In sitting time the male sings very beautifully. The song, which recalls organ tones, can be heard far around. In 1882 they were very abundant in migration time. A few seen May 10. More the day after. Most abundant the 19th and next following days. Migration ended about the 25th. In the autumn only a few seen. Last flock, Oct. 15. In 1883 almost no through migration observed. Flocks only, May 22.

180. **Turdus ustulatus swainsonii** (Cab.). ××× M. of 5. L. 173–201. E. 277–330. W. 93–110. T. 63–75. This bird is said to breed in northern Illinois (Nelson) and must in that case also without doubt nest in Wisconsin. Yet I do not know that I have seen it at Shiocton in summer. In migration it is much more abundant than the foregoing species, which it often accompanies. In 1882, saw several singly May 10 and the following days. May 16, in small companies of 5 or 6. On the 18th, by hundreds, and still more the following days. Constantly seen in flocks till the 31st (but not the 28th). The last, June 3. In 1883 not very numerous. The first seen May 12. Next the 18th. Singly the following days. In the Great Wood south of the railway extremely abundant May 22. In the Daily Beat most numerous 24th–27th. The last the 30th. *Turdus aliciæ* Baird was shot in Brown Co. (Willard) and is found probably at Shiocton, but was not observed by me.

181. **Turdus aonalaschkæ pallasii** (Cab.). ××× M. of 6. L. 167–182. E. 284–293. W. 79–94. T. 63–75. King thinks that this species breeds in Wisconsin, at Waupaca for instance, about 30 miles from Shiocton. Not observed by me in summer time. In migration it is very numerous, but is seen mostly singly near running water. In 1882 a single one April 10. Several the 12th. After that almost daily till May 14th. Large flocks May 1. In autumn Oct. 5–15. Probably the most abundant the last named day. In 1883 the first April 22. Very abundant the 24th. Afterwards a few till May 2. The last, the 9th. In the autumn the last, probably Oct. 23.

182. **Merula migratoria** (Linn.). ×× M. ♂ (N) L. 252. E. 456. W. 135. T. 101. ♀ (N) L. 252. E. 386. W. 129. T. 101. There is scarcely a garden where one or more pairs do

not nest. The bird also builds, however, deep in the woods, but there generally near running water. The nest is usually placed in a fork of the trunk or of a branch. Of 27 nests 20 were near dwellings, 7 in woods (6 over water). 18 were in trees, 6 of these in woods over water, from 4 to 36 feet (3 in willow, 3 in maple). 12 on upland (7 in poplar, 4 in fruit trees, 1 in oak), from 4 to 30 feet, (3 from 4–6, 5 from 8–10, 3 from 12–16, 1, 30 feet). 3 were in bushes 3 feet from ground. 6 under cover of roofs from 2 to 5 feet from ground. 4 of these were in fences, 1 in a wood-pile, 1 in a pile of boards. Number of eggs 4, sometimes 3. At least two broods. In 1882 I found the first egg in a nest May 1, but the birds most certainly have had eggs earlier in other nests than those examined by me. In 1883, first eggs April 26 to 30. M. of eggs from nine nests. L. 28–32. B. 19–22. In 1882 a single one was seen near the house Feb. 26. One in the same place the 28th. None again before March 29, when many appeared. April 19, two were occupied in building near the house. Large flocks were still seen the day after. In autumn the first large flock Sept. 24. Quantities Sept. 30 to Oct. 9. Most on the last and foregoing day. Oct. 10, a cold northwest wind blew and none were seen. Considerable many Oct. 22 to Nov. 1. The last Nov. 6. In 1883, a single one near the house March 22. One again April 2. Two the day after. More and more the following days.

183. **Sialia sialis** (Linn.). ×× Breeds in great numbers, mostly in holes in trees, particularly such as have been used by woodpeckers. The nests I saw were 6–30 feet above the ground or water. 12 nests examined. The bird begins to build late in April or early in May, but I cannot say when the first eggs were laid. Two pairs built in our bird-boxes near the house. April 28, 1882, one was engaged in building. May 6, 1883, there was a nest nearly finished in one of our bird-boxes. It was destroyed. May 24, found a nest with 4 somewhat incubated eggs. Number of eggs 3–4. Two broods. In 1882 first eggs laid in the boxes May 31. In 1883 first egg in same place June 1. June 19, when there were 4 eggs in one of the boxes, a squirrel got two by thrusting his paw into the hole. The third was pushed to one

side. The fourth was broken. M. of eggs from 4 nests. L. 21–22. B. 16–17. In 1882 a pair was seen March 3. Afterward none till the 26th. Several the 29th, and more on the following days. The last in autumn, Oct. 20. In 1883 the first March 29. Next, April 2. Several on the following day. Numerous after the 4th.

Clinton, Iowa.

EXPLANATION OF NAMES ON THE MAP.

Skov = woods.
Sump = swamp.
Eng meadow.
Floder og gamle Flodsenge = rivers and old river-beds.
Veje = roads.
Huse og Gaarde = houses and farms.
Gamle Wolf Flod = Old Wolf River.
Shioc Enge = Shioc meadow.
Stribede Hus = Striped House.
Tyske Gaarde = German Farm.
Shioc Floden = Shioc River.
Østersumpen = East Swamp.
Wolf Flod = Wolf River.
Slagterhus = Slaughter-house.
Gröft = ditch.
Naaleskoven = Pine Wood.
Jærnbane = railway.
Storskoven = Great Wood.

HISTORY OF EARLY BANKING IN WISCONSIN.

CLARENCE BERNARD HADDEN, B. L.

INTRODUCTION.

During the early part of this century, trading, in the section of the country now known as Wisconsin, was carried on by means of barter, small coin, town scrip, tickets "good for one shave" or a "pound of tea," and an ever-changing, unreliable currency.

What is now the state of Wisconsin was, previous to 1836, a portion of the Territory of Michigan. Among the very few first banks incorporated in the Territory were the banks of Macomb and Calhoun counties, the bank of Raisin, and a bank at Detroit.[1] These banks had a capital of $50,000 each; were not to issue notes in excess of their capital; and the loans, discounts, and endorsements of each were not to exceed one-fourth of the circulation.

But in those back-woods days it was easy and profitable to flood the neighboring country with notes entirely unsecured and frequently either irredeemable or nominally convertible at a bank whose location was unknown. The term "wild-cat," which characterized the currency of that period, was originally applied to the notes of a Michigan bank upon which there was engraved the picture of a panther.

To show the extent to which the circulation was inflated and the currency thereby depreciated in some parts of the Union, Comptroller Knox says:[2] "In 1814, 37 banks went into operation in Pennsylvania, with an aggregate capital of less than $17000,000, of which only one-fifth was paid in. Many had but a nominal capital, consisting chiefly of notes given by the stockholders for the amount of their shares. * * * Of these 37 banks, fifteen failed within four years from the date of their organization. * * * The amount of currency issued was fre-

[1] Green Bay *Intelligencer*, April 5, 1834.

[2] Finance Report, 1876, *Compt. Rep't*, p. 147 et seq.

quently twice and in many instances three times the amount of nominal capital of such banks."

Mr. Gallatin says: "From the first of January, 1811, to the first of January, 1815, not less than 120 new banks went into operation, adding nearly $30,000,000 to the banking capital of the country." In 1816 the issue of notes was $68,000,000. From 1816 to 1820 there was a general suspension of specie payments, accompanied by a large number of commercial failures and the evil results of a depreciated currency. The banks contracted their issues until in 1820, there was in circulation only $44,863,344 of bank notes. Discounts and loans were decreased; debts were contracted under this depreciated paper regimè, which, after 1820, became payable at par. One hundred and sixty-five banks failed between January first, 1811, and July first, 1830. On a total bank capital of $140,000,000, the failures amounted to $30,000,000, or more than one-fifth of the whole. Mr. Knox ascribes the distress and failures to "the excessive number of state banks and their improvident issues."

Below are appended two tables giving the number and condition of the state banks in the United States from 1774 to 1840:

Year.	No. of banks.	Metallic medium, millions.	Paper currency, millions.	Capital, millions.
1774		4		
1784	3	10	2	2.1
1790	4	9	2.5	2.5
1791	6	16	9	12.9
1792	16	18	11.5	17.1
1793	17	20	11	18
1794	17	21.5	11.6	18
1795	23	19	11	19
1796	24	16.5	10.5	19.2
1797	25	16	10	19.2
1798	25	14	9	19.2
1799	26	17	10	21.2
1800	28	17.5	10.5	21.3
1801	31	17	11	22.4
1802	32	16.5	10	22.6
1803	36	16	11	26
1804[3]	59	17.5	14	39.5

[3] Table from 1744 to 1804, taken from Blodgett's *Economica*, 1806.

Year.	No. banks.	Capital.	Loans.	Deposits.	Circulation.	Specie.
1811	88	$52,601,601	....	....	$28,100,000	$15,400,000
1815	208	82,259,590	....	....	45,500,000	17,000,000
1816	246	89,822,422	....	....	68,000,000	19,000,000
1820	307	137,110,611	....	35,950,470	44,863,344	19,820,240
1830	329	145,192,268	$200,451,214	55,559,928	61,323,898	22,114,917
1834	506	200,005,944	324,119,499	75,666,986	94,839,570	....
1835	704	231,250,337	365,163,834	83,081,365	103,692,495	43,937,625
1836	713	251,875,292	457,506,080	115,104,440	140,301,038	40,019,594
1837	788	290,772,091	525,115,702	127,397,185	149,185,890	37,915,340
1838	829	317,636,778	485,631,687	84,691,184	116,138,910	35,184,112
1839	840	329,133,512	492,278,015	90,240,146	135,170,995	45,132,673
1840 [4]	901	358,442,692	462,896,523	75,696,857	106,968,572	33,105,155

The following is a table showing the condition of the State Banks in the U. S. from 1840 to 1861:[5]

Year.	No. Banks.	Capital.	Loans.	Deposit.	Circulation	Specie.
1840	901	358,442,692	462,896,523	75,696,857	106,968,572	33,105,155
1841	784	313,608,959	386,487,662	64,890,101	107,290,214	34,813,958
1842	692	260,171,797	323,957,569	62,408,870	83,734,011	28,440,423
1843	691	228,861,948	254,544,937	56,168,623	58,563,608	33,515,806
1844	696	210,872,056	264,905,814	84,550,785	75,167,646	49,898,269
1845	707	206,045,969	288,617,131	88,020,646	89,608,711	44,241,242
1846	707	196,894,309	312 114,404	96,913,070	105,552,427	42,012,095
1847	715	203,070,622	310,282,945	91,792,533	105,519,766	35,132,516
1848	751	204,838,175	344,476,582	103,226,177	128,506,091	46,369,765
1849	782	207,309,361	332,323,195	91,178,623	114,743,415	43,619,368
1850	824	217,317,211	364,204,078	109,586,585	131,366,526	45,379,345
1851	879	227,807,553	413,756,799	128,957,712	155,165,251	48,671,048

[4] Table from 1804 to 1840, taken from Sec. Crawford's Report to Congress, Feb. 20, 1820, p. 158, *Compt. Rep't*, 1876.

[5] Fed. Financ Rep., 1876, *Compt. Rep't*, p. 159.

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Year.	No. banks.	Capital.	Loans.	Deposit.	Circulation	Specie.
1853	750	$207,908,519	$408,943,758	$145,553,876	$146,072,780	$47,138,592
1854	1,208	301,376,071	557,397,779	188,188,744	204,689,207	59,410,253
1855	1,307	332,177,288	576,144,758	190,400,342	186,952,223	53,944,546
1856	1,398	343,874,272	634,183,280	212,705,662	195,747,950	59,314,063
1857	1,416	370,834,686	684,456,887	230,351,352	214,778,822	58,349,838
1858	1,422	394,622,799	583,165,242	185,932,049	155,208 344	74,412,832
1859	1,476	401,976,242	657,183,799	259,568,278	193,306,818	104,537,818
1860	1,562	421,880,095	691,945,580	253,802,129	207,102,477	83,594,537
1861	1,601	429,592,713	696,778,421	257,229,562	202,005,767	87,674,507

First Banks in Wisconsin.

By an act of the legislative council of Michigan dated January 23, 1835, a bank was incorporated at Green Bay, to be known as "the President, Directors, and Company of the bank of Wisconsin." [6] This was the first bank organized west of Lake Michigan. The charter was to run until 1858. Its main provisions were these: A capital of $100,000 divided into two thousand shares; total liabilities, including bond, bill, note, and contract not to exceed three times the capital actually paid in; loans and discounts to equal one-fourth the amount of its circulation, until the capital stock should reach $50,000, but such discounts not to exceed $50,000; its shareholders to be personally liable for the debts of the bank after all bank assets have been used in payment of its liabilities; if the bank at any time fail to redeem its notes on demand, it is to be dissolved. The bank of Wisconsin was organized and in operation on November 12, 1835, about a year before Wisconsin became a separate territory, which occurred in December, 1836.

On December 2, 1836, another act was approved, incorporating the Bank of Mineral Point. Some minor differences between the provisions of this charter and those of the bank of Wisconsin are to be noted: its capital was $200,000; 7 per cent. was legal interest and no notes were to be issued until $40,000 of the

[6] Green Bay *Intelligencer*, April 5, 1834

capital had been paid in. This bank commenced operations on December 30, 1837, but issued no notes until later. The Miner's Bank of Dubuque and the Bank of Milwaukee were also chartered and in operation about this same time. No more inauspicious period could have been chosen for launching these four institutions into the business world, for scarcely were they in operation, when they were struck by the panic of 1837, and together with scores of older and stronger banks in other states were overwhelmed in financial ruin.

On June 9, 1837 the Wisconsin *Democrat* of Green Bay contained the following: "Most of the banks of the United States have suspended specie payment. The present state of affairs is the natural effect of over issues of bank paper, over trading and speculation. The Bank of Wisconsin in common with other banks has suspended specie payment for the present."

The banks of Lexington, Kentucky, suspended on May 19, "as a matter of policy rather than necessity, "for it is to be remarked that perhaps specie was never more abundant in the banks and with the farmers than at this time."[7] The Wisconsin *Democrat*, above quoted, also contains an interesting account of the incidents connected with the suspension of the western banks. Eastern banks, suspending in May, dispatched runners to the west with quantities of western bank bills to be exchanged for specie. But the western banks, seeing the approaching storm, suspended a few days before the runners arrived, and the result was that the latter carried back with them in exchange for western notes not gold and silver as they had expected but instead only eastern currency.

All the New York banks, including the deposit banks, had suspended specie payments on May 10, 1837, for one year without violation of their charter. There was a convention called on February 28, 1838, and the bankers decided to resume specie payments on or before May 10, 1838. The Pennsylvania banks did not resume before January 16, 1841.

From 1837 to 1841 there was terrible distress throughout the country, particularly in the well settled eastern states. Prices

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[7] Milwaukee *Sentinel*, June 27, 1837.

were abnormally high. · Flour rose from $5.00 in 1834 to $11.00 per barrel in 1837; corn, from 53 cents to $1.50 per bushel. Bread riots broke out in New York;[8] inflated land values collapsed and the currency depreciated. In March and April, 1837, the failures in New York and New Orleans amounted to about one hundred and fifty million dollars.[9]

In the territory of Wisconsin the winter of 1838–9 was especially severe. The settlers themselves had a hard time to get money or to sell their produce, and the distress in the neighboring states checked immigration considerably.

During the year 1838, the Miners' Bank at Dubuque having failed, there were only two banks in active operation—the Bank of Wisconsin in Green Bay, and the Bank of Mineral Point. A committee was appointed at the December session of the legislature to investigate the condition of both banks. The officials of the Bank of Wisconsin refused to open their books to the committee for inspection and as this was a direct violation of its charter, the attorney general was authorized by a legislative act to wind up its affairs.

The committee appointed to investigate the affairs of the bank at Mineral Point reported it in a safe and solvent condition. On August 11, 1838, this notice appeared in the New York *Morning Courier and Inquirer*: "Notes of Bank of Mineral Point redeemed at par by Jas. S. Hunt, 27 Wall Street."

A charter had also been granted to a Bank of Milwaukee, but as two different boards of directors claimed the franchise and could not agree upon the management, the legislature on November 30, 1836, repealed its charter and its affairs were in liquidation for two years.

It is interesting to note that at this same session of the legislature in 1836, an act was passed establishing the The State Bank of Wisconsin with a million dollars capital. The governor on behalf of the territory was to subscribe *over* one-half, i. e., a majority of the capital stock and to pay for it in the bonds of the territory bearing 7 per cent. interest payable in 1863. It

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[8] *Epochs of American History Series*—Wilson's *Division and Reunion*, p. 93.

[9] Ridpath's *History of the United States*, p. 437.

was to consist of a central bank and five branches. The approval of congress, however, was necessary to ratify this act, and as this approval was never given, the State Bank of Wisconsin died before it was born.[10] It may be said that had congress given approval to this act, a monopoly of banking might have been established during the period from 1840–50 in the hands of the territorial government of Wisconsin, instead of in the hands of a private corporation, namely, the Wisconsin Marine and Fire Insurance Company, which took advantage of a much disputed clause in its charter in order to assume banking privileges. The exigencies of the time called for a strong and secured bank of issue and, as so often happened with industrial enterprises in the west in the early stages of development, the state of Wisconsin relinquished control over banking herself only to transfer unwittingly this fruitful charge upon a single corporation during the years of her greatest development.

Although business throughout the country revived slightly in 1838–9, the weak and crippled condition of the state banks in general made them easy victims to the after panic of 1839, which was occasioned immediately by the failure of the United States Bank of Pennsylvania. This was closed on October 10th and it dragged with it nearly all the banks in the South and West. Of 850 banks, 343 were closed entirely and 62 in part.[11]

The only legally authorized bank existing in Wisconsin in 1839 was the Bank of Mineral Point, and this was again reported by a committee in a sound and solvent condition,[12] although Governor Dodge, in his annual message of that year, called attention to its issue of so-called "post notes"—notes payable at an unspecified future date—which issues he characterized as "a violation of all judicious banking." Suspicion was soon aroused, however, and it was found that the affairs of the bank were being badly managed.

Meanwhile a bill was introduced into the legislature to adopt *in toto* the NewYork free banking law, which had been in operation

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[10] Strong, *History of the Territory of Wisconsin*, p. 285.

[11] Von Holst, *History of the United States*, p. 216, cites note to W. G. Sumner, *History American Currency*, p. 152.

[12] Strong, *History Wisconsin Territory*, p. 314.

in New York since 1838. This law obliged all banks to deposit ample funds with the state treasurer as security for their issues, in addition to other stringent regulations. It may be remarked in anticipation that the main feature of this New York law were copied in the Wisconsin General Banking Law of 1852, of which mention will be made later on.

This bill was opposed by all the influence which the Bank of Mineral Point could bring to bear. The bill passed the house by a vote of 16 to 10; but in the minor amendments which were proposed by the council, the house refused to concur; the council refused to recede and the bill was defeated.[13] Thus was the opportunity lost of establishing a free banking system on a secure basis, which undoubtedly would have been a more judicious system than that of a state or a single corporation banking monopoly.

The hostility toward the Mineral Point bank, occasioned by its suspicious dealings, led to the appointment of another committee of investigation, which reported on March 23, 1841, as follows: Liabilities (not including stock) $250,295.34; resources $246,132.95. Paper "which is not considered immediately available but which may be deemed ultimately good" $86,877.69. Real estate $17,723.46. Stock paid in $100,000. Total liabilities $346,132.95. Total assets $350,734.10. Its own note circulation was $208,820, which showed an abnormal increase of $118,515 since September 25, 1840—scarcely six months.

In August, 1841, receivers were finally appointed. Upon examination the vaults of the bank were found to be empty. $26,507.25 of the specie had been removed. The cashier, his brother, and the teller of the bank had all absconded, taking with them all the currency and portable assets. They were overtaken, however, at Rockford, Illinois, and relieved of $15,000 of Illinois bank notes, together with $70,000 worth of certificates of deposit and drafts, and bills of lading for 12,901 pigs of lead. Very little, if anything, was realized on these securities, for the parties on whom the drafts were drawn interposed all manner of defenses and offsets. The injury to the community from the failure of this, "the only legal banking institution" in Wis-

[13] Strong, *History of Wisconsin Territory*, p. 328.

consin, is estimated to have been over $200,000. The total loss to the residents of Wisconsin during the thirties and the forties, resulting from a demoralized banking system and a depreciated currency, can not be estimated with any exactness; for while there was only one bank in the territory in 1839, the bulk of the currency came from banks in other states and we know how these banks—the mushroom growth of a night—deluged the country with their worthless paper. From 1830 to 1837 the banks of the country increased from 329 to 788; their capital just doubled—$145,192,268 to $290,772,091; while their liabilities (deposits) leaped from $55,559,928 to $127,397,185—more than doubled—and their note issues rose from $61,323,898 to $149,185,890; their specie reserve on the other hand increased only from $22,114,917 to $37,915,340.[14]

Even during the panic of 1837–8, although the bank credits (loans) were contracted from $525,115,702 to 485,631,687, and although the currency was contracted about $33,000,000, the number of banks increased from 788 to 829 and their capital from $290,772,091 to $317,636,778.

The *North American Review* for January, 1844,[15] describes the condition subsequent to the panic of 1837 and 1839 thus: "In some of the new states it was difficult even for the wealthy to obtain money for the daily use of life. We have heard of farmers owning large and well-stocked farms who could hardly get money enough to pay the postage on a letter. They had scarcely any currency, and most of that which they had was bad." This applies with considerable force to the condition of Wisconsin settlers. Another way of estimating the losses, from the standpoint of the period itself, may be found in a dialogue between Plowshare and Counter,[16] which illustrates, in some degree, the injury of a depreciated currency upon a farming community: Plowshare tells Counter that the notes of the Bank of Clinton have been refused at any price, while the notes of the Bank of Wisconsin and the banks of Calhoun and Ma-

[14] See table page 161, above.

[15] *No. Am. Rev.*, Jan., 1844, p. 121.

[16] Wisconsin *Democrat*, Sept. 22, 1838.

comb Counties are not worth over $66\frac{2}{3}$ cents on the dollar in New York. Now he estimates the loss in this way:

"In our county $43,500 in New York bank notes have been paid out by the government agents to farmers for their produce, to Indians as annuities, to soldiers, traders and men employed on the public works in the community. This good money is turned over in exchange for goods to the merchants, who send it back to New York; but since it takes $3 to pay for every $2 worth of goods, and since Wisconsin notes are interchangeable with gold and New York notes, the merchants will give only $29,000 worth of goods for the $43,500; in other words," says Plowshare, "we have given $14,500 for the privilege of using a depreciated currency, and we have paid to the merchants the difference in the value of the money as a bonus for having a bank established in this town."

The loss from counterfeiting was also consideralble. Nearly every Wisconsin paper of the period contains a warning notice like the following: "Look out for counterfeit $3 notes of the Weybosset Bank at Providence," or "of the Farmers' Bank at Catskill," etc. Banks collapsed with such alarming and yet amusing rapidity that at length witticisms like the following were heard on every hand:

"Have you heard that the Boston banks have broke?"

"How can that be; they suspended last May!"

"Yes, but they broke again."

"How?"

"Why, you fool, they run out of paper."

The Wisconsin Marine and Fire Insurance Company.

Legislative Controversy.

At the December session of the Legislature of 1838, the "Wisconsin Marine and Fire Insurance Company" of Milwaukee was incorporated and the act of incorporation was approved the 28th of February, 1839.

The charter contained this provision: "This corporation may likewise receive money on deposit and loan the same on bottomry, respondentia, or *other satisfactory security*,—may employ such capital as may belong to or accrue to said company in the purchase of public or other stock, or *in any other moneyed transactions or operations for the sole benefit of said company—provided nothing herein contained shall give the said company banking privileges*." It was customary to add this latter proviso to the charter of church societies, insurance companies and other organizations incorporated under the state, to guard against any unwarranted assumption of banking powers; it was probably added in this case as in many others as a matter of form, the passage above being understood as in no way contravening this proviso.

On May 6 and 7, $101,300 capital was subscribed; on the 1st of August 1839, $10 on each share was paid in and the Company began business on the 13th. George Smith, the originator of the company, was made president and Alexander Mitchell, a young Scotchman of 22 years, was made secretary. This was the beginning of that career which ultimately made Alexander Mitchell the greatest financier in the northwest, and one of the foremost bankers this country has produced.

On August 20, 1839, this notice appeared in the Milwaukee *Sentinel:* "The Wisconsin Marine and Fire Insurance Company,—Contracts of Insurance at low rates of premium; the company will also receive money on deposit, and transact other moneyed operations in which by their charter they are allowed to engage. Three per cent. allowed on all deposits." On January 14, 1840, this statement was added: "Drafts granted on New York, Detroit and Chicago; also drafts available in any part of Great Britain or Ireland." Thus there was not the slightest doubt of the intention of the company to carry on a general banking business. It began the issue of certificates of deposits, $4,819 worth being issued by March, 1840, and steadily increased them until on the 10th of January, 1842, the number outstanding was $34,028. They were issued in one, three, and five dollar certificates, in the similitude of bank bills. Its sworn assets at this time were $229,893.31—its liabilities (including currency) $75,418.31. In April, 1843, its outstanding certificates had increased to $52,000.

As soon as it was discovered that the company was issuing certificates, making loans and discounts, and doing a general banking business, the legislature began to question the legality of its proceedings. No action however was taken until April, 1843, when a committee was appointed to investigate the affairs of the company. The report of this committee recommended the repeal of its charter because the issue of notes was held to be a violation of the provision, "*nothing herein contained shall give the company banking privileges.*" Meanwhile Mr. Mitchell, the able young secretary of the company, submitted a communication to the legislature in which he maintained that the "legislature has no power to determine its (the corporation's) rights while acting in the three-fold capacity of party interested, a jury, and a court. * * * To the decree of the proper legal tribunal the company will cheerfully submit." Furthermore he positively denied (and continued to deny up to the day of his death), that the company had in the least violated its charter.

A majority of the committee (three out of five) in their report declared "that a court of law is the proper place to determine the question whether or not the company has violated its charter. * * * They (the committee) are not satisfied that it would at this time be expedient to commence any new Territorial suits."

The legislature was not so sure of its ground as to carry the matter into the courts. The assembly was almost evenly divided upon the question. The greater part of the session was taken up with the debates. Discussion waxed hot on both sides. Alexander Mitchell and George Smith exerted all the influence they possessed to prevent any hostile legislation, and at length they were successful. A joint resolution to vacate the charter was amended and finally laid upon the table until July 4th, 1845, by the close vote of thirteen to eleven. No question was raised during the entire discussion in regard to the solvency or management of the institution, as it was well known and often asserted that its condition was beyond reproach, its circulation as "good as gold," and its management by Alexander Mitchell abler than that of any bank in the northwest. The only point over which so much of the time of the legislature was wasted from 1840 to 1852 was the question whether or not the company was authorized to do a banking business.

In 1845 a committee report was unanimous in the opinion that the "Wisconsin Marine and Fire Insurance Company have forfeited their charter" but was also unanimous that the "Legislature has no power to repeal it." The committee recommended: "That the Attorney General of this Territory be requested to institute legal proceedings against the company, that the act incorporating them, may be, as it ought to be, declared void; and that this 'soulless being' be brought to a 'lively sense' of its duties and behold its enormous iniquities." [17]

The report was accompanied by a joint resolution authorizing such proceedings to be instituted; but after much discussion this resolution was laid on the table. A bill was then introduced to suppress unauthorized circulation, imposing fines and penalties; but the Legislature adjourned before this was acted upon. Thus ended the legislation of 1845.

In 1846 however, there was a decided majority in each house opposed to any further issues. Three measures were introduced into the house. Only one passed both houses. This was an act repealing the charter of the Insurance Company. The vote stood 18 to 8 for repeal in the house, and 9 to 4 in the council. Thus after five years of hesitation, the legislature in January 1846 decided that the Wisconsin Marine and Fire Insurance Company was no longer a legal institution.

Bills were introduced at frequent intervals from 1846 to 1852, now placing a five dollar fine upon every note issued or received, now declaring the notes illegal and subjecting the issuers to imprisonment; but none of these bills became law and even if they had, could not have been enforced.

History.

The Insurance Company did not, however, close up its business in 1846 as had been expected. Instead Alexander Mitchell issued a manifesto in which he declared his business was not in the least affected by this repeal act; that as the charter did not expire until 1868, and as his Company had in no manner tran-

[17] Strong, *History of Wisconsin Territory*, p. 468.

scended its provisions, the charter could not be repealed by th legislature; "that the company would maintain the even tenor of its ways as it was not incumbent upon him—dividing a hair twixt south and south-west side" to reconcile the contradictory clauses, if they existed.

From this time on, therefore, its growth kept pace with every hostile legislative enactment and it was more than ever evident that "Mitchell's Bank" had back of it a mighty force of public opinion.

Soon after its organization in 1839 the banking had dried up the insurance branch of the institution. Only one life insurance policy was granted during the entire history of the company. It seems a customer of Geo. Smith, the president of the company, wished to borrow $200 at 6 per cent. interest. Smith insisted that if he wished to borrow, he must take a life policy in the company for the same time and rate. The arrangement was carried out, and the story goes that this was the only life risk taken, for the customer died before the maturity of the note, and thereafter the "life department" was discontinued.[18]

A portion of its business also was connected with the Federal land office and its public agents. The company bought public lands, advancing to the government their value in gold and silver according to requirement, and gave a contract to deed them to the farmers at the end of four years at an advance on the government price.[19] As early as 1841, the government agents, after vainly seeking loans in Missouri and Illinois, borrowed $16,873.01 of this company at 10 per cent. interest. Nowhere else in the West could they have secured such good money on such easy terms. For ten years, besides the government dealings, the company carried on the entire deposit, discount, and exchange business of the territory and state, and for thirty years carried, on its books and in its vaults, one third of all the Milwaukee deposits.[20] Its certificates of deposit increased during the decade as follows:[21]

[18] Camp, *Western Banking*, in Bank. and Curr. Pamph., vol. 19, p. 9, 1879.

[19] Flower, *History of Milwaukee*, p. 1083.

[20] *Wisconsin Historical Collections*, vol. XI, Butler on Alexander Mitchell.

[21] Flower, *History of Milwaukee*, p. 440.

1840,	March	$4,819
1840,	September	......
1842,	January	34,028
1843,	April	52,000
1843,	December	100,000
1845,	November	250,000
1847,	July	300,000
1848,	November	600,000
1849,	October	1,000,000
1851,	December	1,470,225 [22]

These notes were redeemable at Chicago, Galena, St. Louis and Cincinnati.

Several times during the decade runs were made upon the bank with the avowed intention to break it if possible. The greatest run was inaugurated the day after Thanksgiving, 1849. For several weeks before, the Chicago and Detroit bankers had collected "Mitchell notes." A report was then circulated that George Smith, president of the "Mitchell Bank" had suspended specie payments in his branch house at Chicago. The great quantity of notes was dispatched post-haste by agents and was presented in a lump for redemption the day after Thanksgiving. Depositors from all over the city and neighboring country hastened to withdraw their deposits. As soon as the news reached Mr. Mitchell, he sent a courier to Chicago to request that $100,000 in specie be sent by land and water. Meanwhile, however, he kept his tellers and cashiers busy redeeming the notes not only till banking hours were over but even till bed time. So great was the confidence reposed in Mr. Mitchell's integrity, by the prominent citizens of Milwaukee, that they not only scraped together all the cash they could find; but in many instances returned to the bank the withdrawn deposits of specie placed in their hands by their fearful friends for safe-keeping. The supply of coin seemed inexhaustible; every note was redeemed and the run was successfully met even before the $100,000 in specie arrived from Chicago. The confidence reposed in the institution had been almost perfect and it was only increased by these numerous runs, and it was a noticeable fact that expansion was always greater after than before these sudden disturbances. The statement is made that

[22] Horace White, *An Elastic Currency*, p. 52.

the notes of the Mitchell Bank never failed to be redeemed in specie upon presentation "and that this was more than could be said for any bank-notes that had ever been put forth either in Wisconsin or in the neighboring states, or by any bank in New York except the Chemical." [23]

Undoubtedly the decade between 1840–50 was that of the most rapid development of business and material interests in the history of Wisconsin. The increase in population is noteworthy.[24]

1836	11,683[25]
1840	30,945[25]
1846	155,277
1850	305,391
1855	552,109

This shows an increase of population of over 800 per cent. in ten years, a rate probably not surpassed by any state in the Union except Minnesota from 1850 to 1860.[26]

Mines were unearthed; canals dug; the Wisconsin and Fox rivers widened and deepened; railroads were projected and built; agriculture was fostered; many towns established. During this fruitful period of immigration, settlement, rapid growth, and marvelous development of the resources of this great commonwealth, the Wisconsin Marine and Fire Insurance Company was able, in spite of a dubious charter and hostile legislation, to supply all the channels of money circulation in the Northwest and in the valley of the Mississippi with a constantly increasing stream of currency, the integrity of which remained to the last absolutely unquestioned.

Rejection and Ratification of the State Constitution.

On October 5th, 1846, at a convention called for the purpose of framing a state constitution, one of the articles adopted was on banks and banking with these important sections:

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[23] *Wis. Hist. Col.*, Thwaites, Vol. XI, p. 439.

[24] *Gov. Mess. and Accompanying Docs.*, 1857, Vol. I, p. 21.

[25] Probably not accurate, Census of 1838 (first) showed population of 41,008.

[26] *Wis. Hist. Coll*, Vol. XI, p. 442.

Sec. I. There shall be no bank of issue in this state.

Sec. III. It shall not be lawful for any corporation, institution, person or persons within the state, under any pretense or authority to make or issue any paper money, note, bill or certificate, or other evidence of debt whatsoever, intended to circulate as money.

Another section prohibited the legislature from conferring banking privileges upon any corporation whatsoever.

Four-fifths of the convention were in favor of these sections, and they reflected public sentiment. There was among the people a universal opposition to the issue of notes by any legally-authorized corporation, but at the same time there was a prevailing sentiment in favor of granting the privileges of deposit, discount and exchange to individuals or private corporations.[27]

There were many reasons for this state of the public conviction. The currency of the country was in a deplorable condition. Many banks in the Western and Southern states had suspended specie payments, and bank notes of whatever kind were regarded with great distrust. In he southwestern portion of Wisconsin Territory the circulating medium was nearly all gold and silver, mostly foreign coin. English sovereigns were paid out and received at $4.90, and French five-francs at $.95. In the eastern part of the Territory a heterogeneous currency existed, consisting partly of New York and New England bank notes, Mitchell certificates, and a large quantity of counterfeit and broken bank bills, bills issued by a foreign government, and city or county orders — "with here and there the honest face of a sterling bank bill from some of the Whig states down east." The Milwaukee *Sentinel* for January 6, 1848, says: "Thousands of dollars are lost to this community annually. The banks of Canada enjoy about one-half our present currency, and as it is not received by our brokers at par in payment of notes, those who have it on hand submit to a shave of 3 and 4 per cent."

Except the Mitchell notes, it was difficult to tell anything about the value or the extent of the depreciation of the cur-

[27] Strong, *Hist. of Wis. Terr.*, p. 518.

rency. The experience of the past decade had also been sufficient to prejudice the people against banks of issue in any form.

When the first state constitution, drawn up on December 16th, 1846, was submitted to a popular vote in April, 1847, the opposition led by the Whigs, was concentrated not only against the prohibition of issues by any bank or corporation but also against the provision which was aimed to prevent the adoption of any free banking law in the future and to prohibit the legislature from conferring any banking privileges whatever upon individuals. This provision, the Whigs and the banks claimed, was a constitutional departure and its advocates, while admitting it claimed that stringent measures were necessary and that the experience of the past demanded that the entire prohibtion of free banking should be tried. This article on banking was the main cause of the rejection of the first state constitution of Wisconsin. The vote resulted in a majority of 6,112 against adoption.

The second constitution prohibited the legislature from conferring banking privileges except upon condition that the law conferring the franchise should, after its passage, be submitted to the people and approved by a majority vote. This constitution was ratified March 13, 1848, and Wisconsin was formally admitted as a state on May 29.

After the constitution had been in operation three years there was a strong sentiment manifested in favor of the adoption of some state banking system, partly arising from an ever growing hostility to the monopoly held by the Mitchell Bank. This sentiment crystallized in a session of the legislature held in 1851, when an act was passed proposing to submit the question of banking to the will of the people "at the next general election."

Accordingly in 1852, the question of "banks or no banks" was submitted and a majority vote was polled in favor of "banks." Thereupon at the next session a law was framed entitled, "An Act to Authorize Banking," which, being in turn submitted to a referendum vote in accordance with a constitutional provision was ratified in November 1852.

The General Banking Law of 1852.

This law[28] was modeled upon the best features of the New York free banking law of 1838. Its main provisions were intended to furnish full security for the issue of notes by the state banks.

Section 5 provides that United States or any state stocks on which full interest is paid must be assigned and transferred in trust to the state treasurer, whereupon the Bank Comptroller must issue "an amount of such circulating notes of different denominations, registered and countersigned, equal to, and not exceeding, the amount of stock aforesaid. Such stocks must be taken at their current market value in the city of New York at the time of deposit; provided, that if, in the opinion of the Bank Comptroller and Governor, any stocks offered shall be deemed insecure they shall not be received."

Sections 8 and 9 provide that railroad bonds may be received at a rate not higher than eighty cents on every dollar of actual and current value, as security for not over half the bills and notes issued.

Section 16 provides for a semi-annual tax of three fourths of one per cent. on the capital stock.

Section 17 provides for the deposit of bonds by the directors and stockholders of a bank, as additional security, to the amount of one fourth of the notes issued.

Section 18. The aggregate of the capital stock shall not be less than $25,000 nor more than $500,000.

Section 25 declares, that, if the current market value of the securities falls below their value at the time of deposit and continues below that point for ninety days, the difference must be made up upon call of the Comptroller.

Section 41 provides that every bank must make and transmit a report twice a year to the Comptroller, containing a sworn statement of its true condition. The Comptroller shall publish the report in some paper in Madison, with a summary of the items of capital, circulation, deposits, specie, cash items, public and private securities.

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[28] *Laws of Wis.*, 1852, p. 706, *et seq.*

Section 43. Banks may demand and receive for loans on real or personal securities, or for notes, bills, or other evidences of debt discounted, at a rate of interest not exceeding 10 per cent. per annum, until the first day of January, 1860, and not exceeding 7 per cent. thereafter.

Section 48 declares that the referendum must be used for all amendments, and a majority vote necessary for adoption.

The first bank organized under this new law was the "State Bank" at Madison, which deposited securities on January 25th, 1853.

The Wisconsin Marine and Fire Insurance Company about the same time called in its certificates, redeemed them, dollar for dollar, and reorganized as a state institution, adding the word bank to its title. This ended the long controversy over the legality of its existence. The history of this Company from 1839 to 1852 is one of the most striking instances of the futility of restrictive legislation upon the powers of a corporation when such corporation is supported by the force of a strong public opinion.

Later in the same year (1853), the "State Bank of Wisconsin" and the "Farmers' and Millers' Bank" were established; followed in January, 1854, by the "Bank of Milwaukee."[29]

The table on the following page shows the development of the state bank ing system in Wisconsin from 1852 to 1864; and from 1865, when the state bank circulation was taxed out of existence, to January 1, 1894.

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[29] Article, "Banking," in *Wisconsin Historical Atlas.* Snyder, Van Vechten & Co.

	No.	Capital.	Circulation.	Deposits.	Loans & Dis.	Specie.	Cash items.	Public securities.	Private securities.	U. S. currency
July 4, 1853	8	$530,000 00	$301,748 00	$397,201 42	$636,758 00	$174,986 92	$42,531 51	$398,957 07	$751,300 30	...
July 2, 1854	19	1,250,000 00	786,216 00	1,211,111 33	1,673,729 00	240,909 73	103,184 27	974,308 33	1,861,043 66	...
Jan. 2, 1855	23	1,400,000 00	740,764 00	1,481,866 74	1,755,079 00	334,383 74	95,459 07	998,485 19	1,897,555 56	...
July 2, 1855	27	1,536,000 00	930,320 00	2,026,818 01	2,405,401 00	358,127 53	70,487 15	1,033,000 00	[30] 2,618,494 52	...
Jan. 7, 1856	32	1,870,000 00	1,060,165 00	2,806,341 61	3,667,196 00	531,713 64	57,218 89	1,170,422 93	3,936,043 14	...
July 7, 1856	35	2,210,000 00	1,312,845 00	2,863,122 59	4,215,511 00	463,478 61	53,024 86	1,454,128 51	4,494,094 37	...
Jan. 5, 1857	49	2,955,000 00	1,702,570 00	3,365,562 55	4,929,095 00	542,938 81	73,222 03	1,933,018 51	5,327,472 77	...
Jan. 4, 1858	66	5,515,000 00	2,913,071 00	2,077,862 00	6,230,861 00	576,543 00	67,439 00	3,626,468 00	...	...
Jan. 4, 1859	98	7,995,000 00	4,695,170 00	3,022,384 00	9,262,457 00	706,009 00	83,893 00	5,114,415 00	...	...
Jan. 2, 1860	108	7,620,000 00	4,429,855 00	3,085,813 00	7,592,361 00	419,947 00	64,430 00	5,031,504 00	...	...
Jan. 7, 1861	110	6,782,000 00	4,310,175 00	4,083,131 00	7,723,387 00	372,518 00	...	4,949,686 00	...	...
July 1861	107	4,607,000 00	2,317,907 00	3,265,069 00	...	304,478 00	...	...	...	...
Jan. 1862	60	3,807,000 00	1,419,422 00	2,341,112 00	4,573,512 00	265,548 00	61,448 00	1,850,516 00	...	...
July 1862	64	3,055,000 00	1,643,200 00	3,318,007 00	3,924,584 00	...	112,187 00	1,914,117 00	...	...
July 1864	66	8,147,000 00	2,461,728 00	5,483,215 00	...	...	...	...	...	...
July 3, 1865	26	1,087,000 00	192,322 00	2,284,210 75	...	70,581 87	55,951 88	212,292 00	...	...
July 2, 1866	19	650,000 00	48,108 00	2,916,552 23	...	47,946 33	318,934 95	52,060 00	...	...
July 1, 1867	15	500,000 00	15,759 00	2,748,891 78	...	30,933 22	226,423 15	19,178 00	...	...
July 6, 1868	16	525,000 00	15,247 00	3,355,495 07	...	18,640 68	192,169 25	17,634 00	...	...
July 5, 1869	13	425,000 00	14,576 00	2,878,112 12	...	18,752 83	190,297 43	16,606 00	...	...
July 4, 1870	14	525,000 00	13,396 00	3,254,990 44	...	65,999 03	172,781 19	13,396 00	...	...
July 3, 1871	15	565,000 00	5,809 00	4,057,016 24	...	24,598 88	307,363 31	5,801 00	...	...
July 1, 1872	18	656,450 00	4,544 00	5,410,666 29	...	31,488 18	280,007 06	4,544 00	...	...
July 7, 1873	16	715,000 00	1,404 00	6,200,547 34	...	26,798 71	173,567 99	1,409 00	...	...
July 6, 1874	18	862,688 17	1,404 00	6,618,781 42	...	21,606 27	276,615 01	1,409 00	...	...
July 5, 1875	23	1,113,231 33	1.404 00	6,909,214 80	...	28,322 00	186,262 13	1,409 00	...	...
July 3, 1876	25	1,328,633 98	1,404 00	7,098,149 20	...	40,471 34	629,143 40	1,404 00	...	...
July 2, 1877	26	1,288,231 33	1,403 00	6,662,973 77	...	62,548 86	219,477 38	1,403 00	...	...
July 1, 1878	28	1,420,281 33	1,403 00	6,977,549 92	...	78,450 52	316,249 00	1,403 00	...	...
July 7, 1879	30	1,496,031 00	1,403 00	7,618,941 10	...	61,701 44	157,689 52	1,403 00	...	...
July 5, 1880	29	1,404,431 33	223 00	9,830,008 56	...	120,192 26	233,897 93	...	...	$996,739,15
Jan. 3, 1881	32	1,549,431 33	223 00	11,775,944 55	...	196,417 30	201,163 63	...	...	1,128,850 18
Jan. 2, 1882	34	1,499,431 33	223 00	13,667,843 68	...	357,424 59	357,100 55	...	...	1,156,535 85
July 7, 1884	43	2,203,200 00	223 00	15,411,481 18	...	443,010 89	294,672 41	...	...	1,393,281 60
July 6, 1886	52	2,592,200 00	...	17,260,198 46	...	423,156 94	348,840 86	...	...	1,325,596 78
July 2, 1888	65	3,821,100 00	...	22,429,490 46	...	874,729 37	527,610 51	...	...	1,652,494 06
July 7, 1890	80	4,509,300 00	...	30,648,161 78	...	817,243 79	798,515 39	...	...	2,090,719,03
July 4, 1892	110	6,286,900 00	...	41,659,713 00	...	1,675,513 64	900,989 14	...	...	1,866,820 34
July 3, 1893	118	6,806,900 00	...	37,826,559 82	...	1,783,577 17	784,678 45	...	...	3,564,732 64
Jan. 1, 1894	116	6,036,900 00	...	23,767,410 19	...	1,646,819 01	392,503 36	...	...	2,519,785 13

[30] Excluding securities of Oshkosh City Bank.

Condition of Wisconsin Banks from 1852 to Suspension of Specie Payments, April 17, 1861.

On January 31, 1854, the securities deposited with the State Treasurer amounted to $608,000 distributed among the several states as follows:

Wisconsin 8's	$40,000
Wisconsin 7's	50,000
Georgia 6's	27,000
Missouri 6's	158,000
Tennessee 6's	62,000
Virginia 6's	204,000
Kentucky 6's	67,000
Total	$608,000

In just a year the securities had increased to $1,033,000, the stocks of the Southern states being largely increased; they were divided as follows on January 1, 1855:

Virginia 6's	$279,000
Missouri 6's	230,000
Tennessee 6's	175,000
North Carolina 6's	83,000
Kentucky 6's	62,000
Louisiana 6's	36,000
Michigan 6's	18,000
Wisconsin 7's	50,000
Wisconsin 8's	40,000
Georgia 6's	42,000
Georgia 7's	20,000
Total	$1,033,000

There was only one failure in 1855. The bill holders of the Oshkosh City Bank, however, were amply secured. Its circulation was $49,900; its securities at their market value in New York were worth $46,000, which, with the interest, $1,500, in the comptroller's hands, made $47,500. This deficiency of 5 per cent. was more than made up by bonds of $12,500 deposited by directors and stockholders.

The Governor commenting upon the condition of the banks in Wisconsin for 1855, says:[31] "It is a gratifying fact * * * that thus far (two years) the practical workings of our banking system gives evidence of its superiorty over all those adopted by

[31] *Gov. Mess. and Accom. Docs.*, 1885, p. 12 et seq.

other states. * * * Notwithstanding the numerous failures of banking institutions in other states and the money panic, which of late has so generally prevailed, but one of our institutions is reported to have failed to redeem its notes," and this occasioned (as we have seen above) no loss to the community.

While from the foregoing it is evident that Wisconsin's banking system was eminently satisfactory to the people, and while the notes of its banks were at all times redeemable, yet the latter formed only a fourth part of the currency needed in the state, and as the banking systems in the other states of the Union were unreliable, Wisconsin's channels of trade were filled with a cheap currency and her bankers were forced to accept and redeem the depreciated notes of the banks of other states on a par with their own good currency. Mr. Knox in his admirable report on State Banks,[32] says: "In other states the best features of the New York law were omitted. The shareholders were not made personally liable; the security required was not sufficient; the notes were issued in proportion to the stocks and bonds deposited, and not in proportion to the cash capital; no provision was made for the prompt redemption of the notes at any commercial center, and a majority of the directors and stockholders were frequently non-residents. . . . The speculator nominally locates his bank in a community where it is difficult to reach, and then circulates his notes in distant parts of the Union as legal money, assured that little of it will be presented for redemption." The operators of such schemes were prepared to flood Wisconsin with this paper in 1853.[33]

The Wisconsin Bank Comptroller made this suggestion:[34] "The business of this state requires a currency of $4,000,000; less than one fourth is furnished by the banks of this state; and it rests with our legislature to determine whether it is proper for our channels of circulation to be filled with the doubtful and depreciated currency of far-distant states, whose currency is neither secured by the pledge of public stocks or anything else,

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[32] Finance Report, Com. Rep't, 1876, p. 149.

[33] N. Y. *Jour. of Commrce*, June, 1853.

[4] Compt. Rep't in *Gov. Mess. and Accom. Docs.*, 1855.

and whose banks pay no taxes toward the support of our government."

Upon the same point the Governor recommends in his message of 1855[35] that foreign circulation, "which is not secured in a manner like our own," be prohibited altogether, or else "require as far as practicable such bankers as may issue foreign notes to treat them in all respects as their own currency, subject to the same legal requirements."

This recommendation, however, was not followed, because on the one hand foreign currency could not be prevented from entering the state, and on the other hand, no banker would treat it the same as his own currency; would not pay a tax on a note already depreciated, nor deposit any stocks to protect a swindler in some other state.

In the months of October, November and December, 1854, the southern stocks began to depreciate and the New York money market was soon more depressed than at any other previous time within twelve years.[36] The stocks of the largest and most reliable states fell several points. In view of this depreciation in state securities, the Comptroller requested of all the banks an additional deposit of 10 per cent. in state stocks or an equivalent reduction of 10 per cent. in their currency. No additional security was required for Wisconsin stocks, as they were at par. This call was promptly responded to by all the banks.

Five thousand dollars of the first mortgage bonds of the Milwaukie and Wisconsin Railroad Company were for a short time deposited, but on account of the discount in value of twenty cents on the dollar, and the limited amount of currency allowed to be issued upon them, they were soon withdrawn and state stocks substituted.

It is interesting to note that before any panic or civil war cloud cast its shadow on the horizon, the Comptroller hinted at the greatest defect in the Banking Law of 1852. He said: "Since the constitution limits the Wisconsin public debt to $100,000, other state bonds must form the basis of the greater

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[35] *Gov. Mess. and Accom. Docs.*, 1855, p. 13.

[36] Comptroller's Rept. in *Gov. Mess. and Accom. Docs.*, 1855.

part of the Wisconsin currency. In times of universal prosperity this may be well enough; but when commercial and financial revolutions occur, *as occur they must*, it would seem that the greatest degree of power ought to be held by our own government, consistent with its general financial policy, over the security of the currency authorized by its laws."

To have saved all the trouble of future years the limit should have been removed from the Wisconsin public debt; the banking law should have been amended so that only United States and Wisconsin state stocks could be received as sufficient security for note issues; then with a careful discrimination of foreign circulation on the part of the Wisconsin banks, there is no reason why the crisis of 1857, the depression of subsequent years and the Civil War might not have been weathered with only a minimum loss to the community.

But as the stocks of any state were sufficient security, the stocks of the Southern and Southwestern states continued to increase.

On the first Monday in January 1856 the securities were listed as follows:

Virginia 6's	$277,500
Missouri 6's	363,000
Tennessee 6's	205 000
North Carolina 6's	77,000
Kentucky 6's	77,000
Louisiana 6's	31,500
Michigan 6's	11,000
Wisconsin 7's	50,000
Wisconsin 8's	50,000
Georgia 6's	25,000
Georgia 7's	20,000
California 6's	33,000
Gold	26,898 75
Total	$1,246,898 75

Two banks (including the Oshkosh City Bank mentioned above) had failed since the beginning of the banking system; but there was no loss accompanying the failure of the Germania Bank of Milwaukee, as there was not in the case of the Oshkosh City Bank.

On the first Monday in January, 1857, the state stocks were distributed as follows (including the stocks of six banks winding up):

Wisconsin 8's	$50,000
Wisconsin 7's	50,000
Indiana 5's	55,000
Missouri 6's	889,000
Michigan 6's	41,000
Virginia 6's	297,000
Tennessee 6's	255,000
Kentucky 6's	78,000
Kentucky 5's	14,000
Georgia 6's	35,000
Georgia 7's	20,000
Louisiana 6's	39,500
California 7's	165,000
Ohio 6's	30,000
North Carolina 6's	101,000
Pennsylvania 5's	14,000
Milwaukee and Watertown R. R. bonds, 8's	26,009
Specie	48,476
Total	$2,208,476

The value of these stocks on the New York market on January 1856, and on January 1857, together with the public debt of each of these states is appended:

	Jan. '56	*Jan.* '57	*State Debt.*
Ohio 6's due 1860	103½	101	$14,000,000
Ohio 6's due 1886	103½	107	....
Pennsylvania 5's due 1862	84	87	41,000,000
Pennsylvania 5's due 1877	86¼	87	....
Kentucky 6's	103	104	6,000,000
Kentucky 5's	86	87	....
Lousiana 6's	92¼	90	13,000,000
Indiana 5's	81¼	82	9,000,000
Tennessee 6's.	95¾	93½	9,000,000
Virginia 6's	96	94¼	34,000,000
Missouri 6's	88½	89	17,000,000
North Carolina 6's	95	96	3,000,000
Georgia 6's	96	98	3,000,000
Georgia 7's	103	104	....
California 7's	87	78½	5,000,000
Michigan 6's	100	100	....
Wisconsin 7's. . None in New York market			100,000
Wisconsin 8's. . . None in New York market			....

On January, 1857, the Comptroller gave the following statement in his report.[37] "The banks organized under our general

[73] Gov. Message and Acc. Docs., 1857, p. 12.

banking law have, during the year just closed, done a safe, profitable and legitimate business. The amount of capital invested has yielded fair returns. Their entire currency is well secured by the deposit of state stocks, and their *reports show an unusual amount of specie in their vaults.* Public confidence in their currency is perfect, and the integrity of their management is shown by the large amount of individual deposits."

When the financial panic of 1857 struck the Wisconsin banks along in October they were accordingly in splendid condition, and with few exceptions met their runs with great ability. There were twenty failures during the year, however, due partly to the decline in the market value of the Southern State bonds and partly due to the lack of actual working capital of banks established in distant and inaccessible points in the North for the purpose of merely issuing notes. The loss was not severe, however, and the panic of 1857 was not felt as sharply in the following year in Wisconsin as in most of the other states.

The Comptroller makes the following interesting statement in his report for January, 1858:

"The past year has been signalized as one of unprecedented financial disaster, extending throughout the United States and Europe. While it has been one of severe trial to banks and banking associations, it must be gratifying to the friends of our system to reflect that with but few exceptions, the banks of Wisconsin were able to conduct their business without a suspension of specie payments. No circulating notes have been returned to this office, protested. * * * I believe that the banks of Wisconsin are in as sound and healthy condition as those of any state in the Union."

The returns of 1857 show a withdrawal of deposits during the year to the extent of $1,287,000; whereas the year before the deposits were increased by $559,221. But while there was a lack of public confidence, the banks were able and willing to increase their loans and discounts to the amount of $1,050,000 over the previous year.

In July and August, 1858, Milwaukee bankers refused some of the currency issued by certain Illinois banks of doubtful character. In return the bankers of Chicaco refused to receive the issues of 27 Wisconsin banks, which had the name of some winter lumber camping place, high up on the tributaries of the Wisconsin or Chippewa rivers, owned by non-residents, and officered by straw men. Among these banks, however, were three at least, which were owned wholly by bankers and brokers of Chicago, who thus attempted to discredit their own paper with the evident design of buying it in at a discount.

On December 26, 1857, Thompson's Bank Note Reporter quoted Wisconsin notes at a discount in New York city of 6½ per cent. and on October 3, at 10 per cent.

In may be added that so great were the fluctuations in the value of all State Bank notes, that the merchant in his store, or the peddler on the prairies, would as soon think of doing business without scales, measure, or yard-stick, as without "Thompson's" or some other Bank Note Reporter, of recent date, and a coin chart of all known coins of the world.[38]

As there was no provision in the banking law against issuing notes to any persons or corporations depositing the requisite amount of security, the Bank Comptroller, during the previous year, had issued notes to any person or persons who had deposited the proper securities. Taking advantage of this provision the State Treasurer and other officials purchased Missouri stocks at a discount and depositing these received about $95,000 of notes for $75,000 of stocks, which however, were accepted at the market value in New York, which was considerably higher. Then with these notes they purchased more Missouri stock and the exchanges were continued and much money made out of the speculation.

The Governor, commenting upon this action of the banking department, says:[39] "At this time the stocks or collateral deposited, is made to represent bank capital itself; and very large issues of bills have been credited and put into circulation on this hypothesis. In numerous instances too, the banks thus started, with no other known capital than their collateral security, are located at places or at points without population, either unknown to the people of the state or the maps, or inaccessible

[38] *Western Banking*; H. H. Camp. Vol. XIX Bank. and Cur. Pamph. 1879.

[39] *Governor's Message and Accompanying Documents*, 1858, p. 15.

and beyond the reach of bill-holders, even when known; and not infrequently the bills appear to be signed by fictitious names as officers, by minors, or by persons pecuniarily irresponsible. It needs little sagacity to foresee that if such banking is to be tolerated or if the legislature at this session, shall fail to provide stringent remedies for the evil, that all legitimate banking is ended for the present, and widespread financial ruin must soon overtake the people and the state."

In accordance with these suggestions, which were emphasized by the first Bankers' Convention called in the latter part of 1857, the legislature adopted, and the people ratified the following amendments to the Banking Law:

First. No bank shall be located in a township containing less than two hundred inhabitants.

Second. The Comptroller shall uot issue circulating notes excepts to banks doing a regular discount, deposit, and exchange business in some inhabited village, town or city.

In January 1858 the total outstanding circulation of all the Wisconsin State Banks was $2,913,071. Missouri stocks were the chief securities, listed at $2,004,000. Their market vlaue in New York was not over 80 cents on the dollar [40] and it was firmly believed that, were the demand created for banking in Illinois and Wisconsin to cease, they would sink far below the rates at which they were then being received on deposit as collateral security. Furthermore the public debt of Missouri, Virginia, Louisiana, and one or two Northern States had passed the bounds of prudence and they were having a hard struggle to pay the semi-annual interest on their bonds. For these reasons from this time on, the Bank Comptroller refused to accept any longer the stocks of doubtful Southern States as security. In January, 1859 the currency stood at the highest point ever reached, $4,882,442 [41].

On December 30, 1859—nine months from above—the circulation had decreased over $200,000; the Southern State securities had decreased in proportion.

The year 1859–60 was a severe year on the Wisconsin banks.

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[40] *Governor's Message and Accopanying Documents*, 1858, p. 21.

[41] Compt. Rep. in *Gov. Mess. and Acc. Doc.*, 1870, p. 5.

There were many failures. Loans and discounts of the banks were diminished from $9,262,457 to $7,592,361; whereas the year before there had been an increase of over $3,000,000. Such a drain was made on the specie by the runs of the year that there was a decrease from $706,009 to $419,947, whereas the year before had shown an increase of $230,000. The crisis was severe; heavy demands were made upon the banks, and when the loans were refused, commercial houses of long standing went under. The cancellation of notes by the Comptroller this year was larger than ever before; the Southern State stocks were depreciating very rapidly on account of the election of Lincoln. Every indication foreboded a storm.

Twenty banks had failed during the year and the securities were scarcely sufficient to indemnify the bill-holders. During 1860 when the country was in suspense waiting the threatened outbreak, continuous demands were made upon the Wisconsin banks. The securities were slightly diminished by sale, but the Comptroller did not dare to overburden the already weak and falling market with such quantities as $1,974,000 of Missouri stock and $738,000 of Tennessee stock. There was a contraction in the currency during the year of $119,680 and a decrease of $47,429 in the specie reserve; at the same time there was a slight increase of loans and discounts—$121,026 and just a million dollars increase in the deposits, indicating a slight revival of business and a considerable restoration of confidence.

The securities on deposit October 1, 1860, were $5,000,009.50. The Bank Department had discouraged, and finally opposed, any further deposits of Missouri stock, on account of her large debt and undeveloped resources; so Missouri stock decreased during the year from $2,049,000 to $1,408,000. The Comptroller also limited the amount of Virginia and Tennessee bonds which he would receive, leaving for future purchase and deposit only North Carolina, Louisiana and California bonds.

On October 15, 1860, the Comptroller issued a call of 2 per cent on Missouri stock from all the banks in the state on account of depreciation; and again, on November 25, he made another demand for 6 per cent. on Virginia bonds on deposit. As the sharp decline in southern stock values continued, another call was about to be made in February, 1861, when the legislature passed a joint resolution, prohibiting any more deficiency levies.

In comment on this action, the Comptroller says:[42] "The measure seemed wise and timely; many well-informed citizens had declared that a general failure, involving three fourths of all the banks, was imminent, unless relief in some shape was granted; and there is scarcely any reason to doubt that at least 80 out of the 109 then existing banks would have failed, entailing an immense loss on the currency, and probably on the deposits of the people of this state. No sale could have taken place before the latter part of April, when the principal southern bonds held by the department had dropped down to a point[43] considerably lower than the market prices at the present time. More than three millions of southern bonds (Mo., N. C., Tenn. and Vir.), forced on a weak and sensitive market, would have caused a stock panic unprecedented even during the last disastrous twelve months." Missouri bonds had depreciated from 63 on April 5, 1861, to 39½ on April 20.

Suspension of Specie Payments.

On the 17th of April, 1861, after the firing on Fort Sumter had threatened destruction to the banking interests of the state by a compulsory winding-up of all the Wisconsin banks and an enforced sale of southern state securities at panic prices, the legislature passed "an act to protect the holders of notes of authorized banks of the state of Wisconsin."

This act provided:

First, that the Bank Comptroller should suspend all action (such as sale of securities, liquidation, etc.) toward all banks failing to redeem their circulation.

Second, that notaries public should not protest bills of such banks until after December 1, 1861.

Third, that the banks might have until December 1, 1861, to answer all complaints in any proceedings to compel specie payments of circulating notes.

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[42] *Compt. Rep.*, 1862, p. 5.

[43] N. Y. Market, April 20, 1861; Mo. 6's, 39¾; Vir. 6's, 36½; Tenn. 6's, 41.

The Banking Law was also amended at this same session, the principal amendments being as follows:

Chapter 242, laws of 1861.[44] Section V reads: Provided further that from December 1, 1861, the Bank Comptroller shall not receive as security for circulating bank notes any other public stocks than those issued by the state of Wisconsin and the United States.

Section XIII. No bank shall receive upon deposit of bonds, circulating notes exceeding three times its bona fide cash capital actually paid in.

Section XIV. Every bank must have a bona fide cash capital paid in of $15,000. The Bank Comptroller is to satisfy himself as to the amount of the capital.

Section XV. No bill or note of foreign or other state banks shall be circulated, unless it has been for six months redeemable in New York City at a rate of discount not exceeding three-fourths of one per cent. The decision of the Bank Comptroller is conclusive.

Section IV. Every bank outside of Madison and Milwaukee shall appoint an agent, who shall keep an office in either of those cities to redeem any notes of its issue presented.

Suspension of specie payments was therefore legally authorized from April 17th to December 1, 1861.

On April 12th, when the Confederate batteries opened fire on Fort Sumter, there were 110 banks of undoubted credit in the state; on the 25th of the same month, twenty-two had been discredited and a general feeling of uncertainty overshadowed the rest.

Banks were winding up. The securities of the Bank of Eau Claire were sold on February 25, 1861, and they only paid 84 cents on the dollar to the bill holders.

The Koshkonong bank failed and on May 10th, its securities being sold, they only netted 54¾ cents on the dollar.

On June 3d, a final call of eight per cent. was made, but it was useless. Fifty-eight banks failed to respond and forty did not even acknowledge the receipt of the notice of the call.

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[44] *Revised Statutes*, 1878, p. 596, *et seq.*

Meanwhile on April 25 a bankers' convention was called and 18 banks were abandoned as unsound. The bankers in convention published a list of seventy banks which agreed to receive and pay out their issues until December 1st, 1861.[45]

Some banks which had not sent representatives to the convention refused to be bound by this list. They discriminated between the good and the bad currency, paying out the poorest and hoarding the best. Railroad corporations were also making their deposits in the worst currency. The combined issues of all the Milwaukee banks was only $65,475 while their aggregate capital was $1,425,000 and as it was a season of least country demand for currency, they could not afford to permit their deposits to accumulate suspiciously while their vaults were rapidly being loaded down with the worst currency. So on Friday, June 21st, 1861, without any concert of action, ten of the Milwaukee banks were thrown out of the "current list" and their issues were to be received thereafter only on "special deposit."

Other banks, to protect themselves, began the process of elimination, and soon the people, not knowing where the process was going to stop, protested violently and hurled charges of bad faith against the banks. The bank riots of June 24th, 1861, in Milwaukee were the result. Saturday night the workingmen received their wages in notes part of which were issued by the ten rejected banks. Meetings were called Saturday night and Sunday, and Monday morning a mob of several hundred people with a band of music marched down to the corner of Michigan and East Water streets, where stood the Wisconsin Marine and Fire Insurance Company's bank on one corner and the State bank of Wisconsin on the other. Alexander Mitchell, after locking up all the books, currency, and valuables, attempted to address the crowd; but it only hooted and yelled; then a volley of stones was hurled against the windows, demolishing nearly all the panes of glass in the front of the buildings. This so delighted the mob, that, now under the control of the worst rioters, it made a rush for the offices; attacked the bank officials and employees; tried to break open the safes and vaults, and

[45] Flower, *History of Milwaukee*, p. 1083.

finally, piling up all the broken furniture in the several offices, applied the torch. At this juncture, however, the city fire brigade arrived; put out the fire and then assisted the Milwaukee Zouaves in dispersing the mob. The damage was not great, amounting to about $5,000, but the laborers' notes on the ten rejected banks were, during the next week, redeemed in gold and silver, much to their satisfaction. Threatened riots kept the city in alarm for some days after; state troops were called to Milwaukee, and the disturbance conclusively showed that the issues of all banks that could not be put in shape to meet specie payments in December must be retired from circulation.

The bankers met again in convention and with the aid of the Merchants' Association of Milwaukee arranged to raise $1,000,000 to assist the crippled banks.

Meanwhile Wisconsin had issued $800,000 of war bonds: these however could not be sold in New York for over sixty cents on the dollar. So it was agreed among the bankers that their depreciated Southern State bonds on deposit as security, should be sold in New York for what they would bring in coin; and that Wisconsin war bonds should be substituted, the latter to be purchased at nominal par value; i. e., 70 per cent. in cash, 30 per cent. to be paid in semi-annual installments, under individual bank obligations, 60 per cent. of the 70 per cent. cash to be paid in coin.

By this means the weak banks were enabled to make good their securities. By the 19th of July, six of the ten rejected banks were restored. The other four were wound up.

Of the total number of banks which failed to respond to the call of June 3d, twenty-two exchanged their southern securities for Wisconsin war bonds. It appears by the semi-annual statement of the condition of the banks of Wisconsin for July 1, 1861, that at that time thirty banks failed to send in the report of their actual condition. As every one of these banks had allowed its circulation to become discredited and depreciated, had disregarded the call of the bank competroller, and as most of them had hopelessly failed, it was under these extraordinary circumstances deemed most prudent by the bank department not to commence any suits for payment of fines under the statute, it being almost certain that the department would lose every cent on the outlay necessary to conduct the suits and that nothing would be realized by such legal proceedings.

Before the last of August, by means of the exchange of southern for Wisconsin war bonds, the value of the securities of all the banks was brought up to their circulation as shown by the Comptroller's report. At the time of the bank riots, Wisconsin currency was at a discount of 15 per cent. on the New York market, as compared with gold or New York exchange. By the middle of July, the discount fell to 12 and 10 per cent., and early in August a Wisconsin note was only 5 per cent below par.

During this year the current rate for collections was formally changed by the Milwaukee banks over 30 times, the rates being rarely under 3 per cent.—generally 5 to 8 per cent.; and in April 10 to 15 per cent., and in one instance 20 per cent.[46]

No southern state stocks were accepted as security in 1861 The comptroller remarks in regard to the condition of the securities as follows:[47] "After the severe losses suffered by the people, it is gratifying to find that our banking securities have been largely improved. One year ago they consisted for more than two thirds in securities of southern states, while the department now holds only a little over one fourth of this class of bonds, which proportion will be considerably improved after the sale of the stocks of the discredited and defunct banks in November and after December next."

The Comptroller in his report for 1862, says:[48] "The 'Bankers' Association' of this state has exerted a conservative and salutary influence in restraining the soaring propensities of wild cat speculators, and they are entitled to the thanks of the people of the state for aiding to carry through the financial storm, *with much less loss* than our sister states experienced, and placing on a sound, substantial basis, our present banks."

Again the next year the Comptroller said: "Wisconsin is

[46] Camp, *Hist. of Western Banking*, Bank. and Curr. Pamph., Vol. XIX, p. 11.

[47] Compt. Report in *Gov. Mess. and Acc. Doc.*, 1862, p. 11.

[48] *Gov. Mess. and Acc. Doc.*, 1863, Compt. Rep., p. 212.

under deep obligations to our bankers for the alacrity with which they in 1861 advanced money to enable the state to furnish her quota of men armed and equipped for the national defense. If the bonds which they received therefor, had at that time been offered in Wall street they could have been negotiated only at a heavy discount. They not only relieved the immediate and pressing wants of the state treasury, but also manifested their confidence in the credit of the state."

When December 1st, 1861 came, the sound banks were ready to redeem their issues. On this date only $1,500,000 of current Wisconsin bank notes were outstanding. The runs were large, but the banks met the runs with ease, and confidence was partly restored.

During 1861 fifty banks went out of existence; bank capital was decreased $2,900,000; loans and discounts shrank $3,200,000 as compared with the year before; public securities were reduced $3,100,000; the specie reserve fell to the extent of $68,000; while the circulation was contracted from $4,310,175 to $1,419,423, or a little less than $3,000,000 in one year.

The war management of the Wisconsin banks is a fine example of public and private co-operation; the splendid financiering from April to December, 1861, on the one hand, saved the credit of the state, and on the other warded off a commercial, financial and stock panic which might have cost the business world untold failures, noteholders a loss of millions of dollars, and might have overwhelmed the entire Wisconsin state banking system in ruin.

Subsequent History and Conclusion.

From December 1, 1861, public confidence was somewhat restored and the banks continued to increase their business until the national banking law of 1863 was passed, providing for the organization of state banks under the national banking system.

The securities on deposit now consisted almost entirely of Wisconsin and U. S. bonds. The people knew that Wisconsin could pay all her indebtedness in one year without being seriously burdened with taxation, if necessary, and they had implicit confidence in the national bonds in spite of the heavy public debt which the government had contracted during the war. So the state banks were very slow in taking advantage of the privileges offered by the new national system.

In fact there was considerable preference manifested for the state free banking system as opposed to the national system which was looked upon as an untried experiment, monopolistic in its tendencies.[49]

On March 3, 1865, a tax of 10 per cent. was laid upon all state issues. After July 1, 1866, and during the next year, the number and circulation of the State Banks in Wisconsin began to diminish. In April the State Treasurer was required to receive Wisconsin bank notes, not only for taxes and debts due the state, but also on deposit, in return for which he was to issue certificates of deposit bearing 7 per cent. interest. In June, 1864, the National Bank Act was revised and state banks were given greater inducement to change over to the national system. By these means the state currency was rapidly withdrawn from circulation and in July, 1865, there remained only 26 State Banks with $1,087,000 capital, with deposits of $2,284,210 and a circulation reduced to $192,323.

In 1867, after it was settled that the national system had obtained a permanent foothold and that it was as free as the state system, and much more strongly secured in its issues, the Wisconsin legislature passed a joint resolution, which was ratified by the people, authorizing the State Banks to wind up their circulation without surrendering their charters, or in any manner interfering with their general banking business. By July, 1873, only $1,404 of currency was reported as outstanding. On January 1, 1870, the office of bank comptroller was abolished and the records and duties of the banking department were transferred to the state treasury. Semi-annual reports of the condition of the Wisconsin state and private banks have been issued by the treasurer from 1870 up to the present time.

By a semi-annual tax of $\frac{3}{4}$ of 1 per cent. on the capital stock of all the state banks, the state received quite a large annual sum, as is shown in the following table:

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[49] See J. M. Rusk, *Gov. Mess. & Acc. Doc.*, 1870. Comp't Rep. p. s.

For 1853	$7,097 92
For 1854	18,165 63
For 1855	23,970 83
For 1856	37,564 09
For 1857	70,298 02
For 1858	106,974 73
For 1859	60,604 65
For 1860	106,155 43
For 1861	92,697 12
For 1862	63,590 70
For 1863	52,208 49
For 1864	52,016 56
For 1865	40,658 72
For 1866	9,703 80
For 1867	4,582 50

In the panic of 1873, only a few State Banks went under, though all were severely tried. In 1880 the circulation was merely nominal — $223; the number of state banks, however, has rapidly increased.

On July 3, 1893, there were 118 State Banks in Wisconsin with a capital of $6,806,900. Their deposits amounted to $37,826,559.82. The prevailing commercial and financial crisis, probably the worst in our history, has checked the growth of the number of state banks and by reason of the shrinkage in the volume of business transactions and a lack of public confidence during this last year the deposits of the Wisconsin state banks have fallen $14,059,149.63 in just six months. There has been no outstanding circulation reported since 1884.

The able management of the Wisconsin State Banking system undoubtedly places it among the very few best State Banking systems in vogue in this country before and during the civil war. That great emergency, however, taught the people of the United States a lesson in the principles of banking which probably they will never forget.

It taught them that the federal government is stronger than any state goverment; that therefore national bonds are more secure and less liable to depreciation than any state securities; that the currency of the United States must be uniform, for otherwise a note at par in one state will be below par in another; that the circulation of this country must have immediate as well as ultimate security of redemption, and that immediate security can be obtained only by means of the federal government holding itself ready to redeem every bill or note issued, no matter how many banks may become insolvent, or fail to retain the confidence of the community.

For these and other reasons, the National Banking System has susperseded the old State Banking régime in its various forms. The recent defeat of the Brawley Bill in the house of representatives (which aimed to repeal the 10 per cent. tax on state issues) by a vote of 172 to 102 is a sure indication that the banking experience of the twenty years before the war has left an impression upon the minds of the American people, which will last forever.

While I believe that the Federal System of National Banking, far from being perfect, is open to great improvement in many particulars, e. g. more united cooperation, better redemption facilties, amendment of the limit of the reserve, and a more efficient management of the reserve in times of crisis, together with a greater elasticity of the currency, e. g., at the time of movement of the crops, —yet, notwithstanding these needed changes, I feel certain that the study of even as good a State Banking system as that of Wisconsin will convince any fairminded person that, in the process of evolution, from less to more secured forms of banking, our present system is much better adapted to meet the business needs of our great commonwealth, than any other form which has yet been devised.

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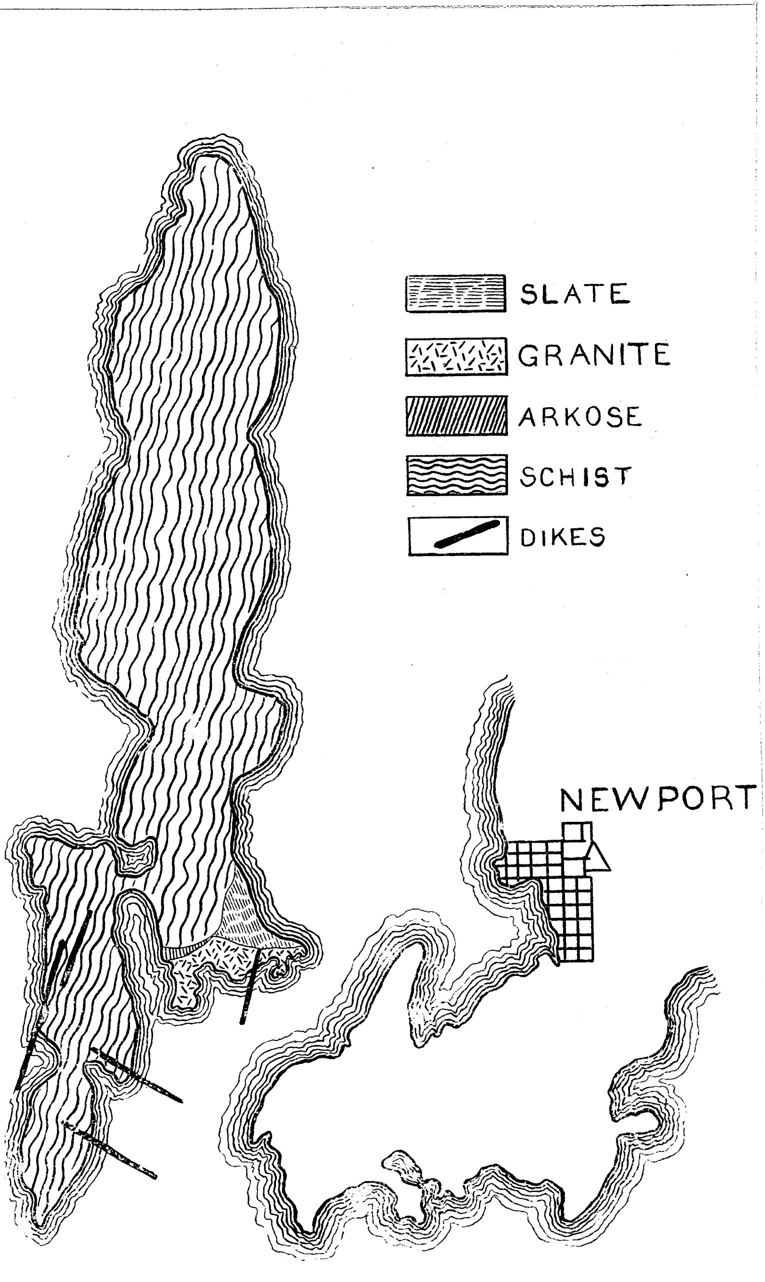

COLLIE ON GEOLOGY OF CONANICUT ISLAND, R. I.

THE GEOLOGY OF CONANICUT ISLAND, R. I.

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WITH PLATE IV.

The island of Conanicut is situated in the southern part of the area known to geologists as the "Narragansett Basin." It lies midway between the city of Newport on the east and the mainland on the west.

The territory comprised within this area has been the seat of profound dynamic metamorphism and this island situated as it is in the very heart of the basin has been the centre of the varied activities and forces affecting the region as a whole The island is nine miles long and averages less than one mile in width.

The surface features though modified by glacial action are controlled by the character of the underlying rocks very largely.

The topography belongs to two distinct types. The one is a smooth rolling surface unbroken save by a few prominences and ridges. This kind of topography is characteristic of the northern portion of the island and the western portion locally known as Beaver Head and Beaver Tail. The underlying rocks are mainly soft easily eroded schists, a rock which constitutes the chief formation of the island, the slopes of the hills frequently coincide with the dips of the rocks, or with the planes of schistosity. The whole topography of the region is gently sloping. The ridges and prominences which break the smooth outlines of this topography are either local outcrops of siliceous conglomerate or dikes which have better withstood erosive action than the schists themselves. The other topographical type is a broken and rugged one. Long ridges with cliff-like sides, or bare, irregular dome-shaped hills, locally denominated "dumplings," characterize this second type. The underlying rocks of this area are coarse granite rocks and compact flinty slates. The hard resistant rocks give rise to the rough, knobby topography found in the southern part of Conanicut, which exhibits so striking a contrast to the smooth surface features of the other parts of the island.

STRATIGRAPHY.

The indurated formations of the island resemble in character and in order of superposition those found about Newport and the small islands scattered through Narragansett Bay. In many respects the stratigraphy is closely allied to that found farther north in this same basin. There are four formations which are as follows in order of age: 1st. A compact non-fossiliferous slate. 2d. A coarse grained porphyritic granite. 3d. An extensive series of schists, interbedded with beds of grit and fine conglomerate. In the lower portion of this series carboniferous plants have been found, but as a whole these beds are non-fossiliferous. 4th. A series of dikes which cut both granite and schists. In all of these formations innumerable veins of quartz, calcite, pegmatite and chlorite are found, occupying every joint, fissure and crevice.

Metamorphism aside, the geology of the island is extremely simple. The more unaltered slates and schists indicate this. The original lithological constitutents were few, the conditions attending deposition were simple. Metamorphism, however, has altered all of this primal simplicity. This agency working hand in hand with secondary change has greatly increased the number of minerals, and since each of these minerals combines into masses by itself very frequently, the result is a great increase in the number and variety of the formations. The original sedimentary rocks contained grains of quartz and feldspar, and more rarely flakes of iron oxide, graphite, and ferro-magnesian silicates. These ingredients made up the rocks. Metamorphism has introduced as additional minerals sericite, ottrelite, staurolite, chlorite, tourmaline and andalusite. The sericite and ottrelite are sufficiently abundant to form distinct strata and formations; the great mass of the schists are sericites chists; imbedded in these are found ottrelite schists; and these two distinct formations have resulted simply from metamorphic action. Most of the schists are still further complicated by the presence of secondary quartz, calcite and epidote. The physical character of the rocks has also been greatly altered by folding, faulting and the production of schistosity. The original grains of quartz and feldspar have been crushed and drawn out into augen or even well nigh obliterated by the long continued and powerful pressure. All portions of the island have suffered metamorphic action, but there is some diversity in the amount and degree of the alteration. The slates and schists on the east side of Conanicut are least altered; there is a decided increase in the complexity of the metamorphism toward the west, though there is no uniformity in this progressive change. There are limited areas on the east side which exhibit as extreme cases of folding, crushing or of superinduced schistosity as any area on the west shore, but the former areas are less extensive and less abundant.

FIELD RELATIONS AND DESCRIPTION OF THE FORMATIONS.

The oldest rock on the island is the compact, flinty slate already mentioned. It is homogeneous in structure, dark green in color and very much jointed. It shows few traces of cleavage and schistose structure; it is unfossiliferous. The green color is not normal but is due to the secondary development of chlorite and epidote. The slate is unconformable both with the schists and the granite. Its strike is N. E.; its dip averages about 45° to the S. W. The strike carries the slate directly into the granitic mass to the south of it, the contact between the two being very clearly displayed in the southern part of the island. The actual contact between the slate and the schists has not been observed, but the transition from the soft sericite schists to the slate is very abrupt, taking place within the space of two or three rods. There is no agreement in dip or strike between the two formations; unconformity certainly exists between the two. This unconformable relationship should be enough to refute the common belief among geologists, who have investigated this area, that the slate is merely the schist metamorphosed by the eruption of the granite through it.

At the contact between the granite and the slate there is but little evidence to show that the granite is eruptive through the slate; it is extremely difficult to determine the exact relationship between these diverse occurrences. The contact is nearly vertical; the slate abuts directly against the granite, the two being firmly welded together. It is always possible to obtain hand specimens with both rocks present and the contact clearly shown.

The evidences of the granitic eruption are briefly as follows: 1st. Fragments of slate occur in the granite, but only in small quantities and at rare intervals. 2d. The slate has been baked at the contact with the granite. The effect of the heat is noticeable only in a narrow zone a few inches wide. 3d. Apophyses of granite occur in the slate, these are limited in number. Veins of pegmatite, which are later in origin than the granite, have been frequently mistaken for apophyses. The granite of the apophyses in no case resembles that of the parent stock, but is much coarser, and contains only limited amounts of mica or hornblende. It is more properly an aplite, frequently taking on a pegmatitic structure. These evidences of intrusion are confined wholly to the contact between the slate and the granite, on the east shore. There are no such evidences on the west shore where the slate is wanting, and where the schist immediately follows the granite.

The paucity of fragments of slate in the granite at the contact, and the absence of any very marked contact phenomena in the slate indicate that the eruption was a feeble one, devoid of a portion of its heat, so that its effects were not pronounced. That the flow was semi-pasty is indicated by the large and abundant porphyritic crystals of orthoclase which occur everywhere in the granitic area. The relationship between the two terranes having been briefly indicated, a more detailed description of each will now be given.

THE SLATE.

The macroscopic features have already been sufficiently indicated. Microscopically the slate is an aggregation of interlocking quartz and feldspar grains, in which sericite, chlorite and epidote have been secondarily developed. Some of the larger grains of feldspar and quartz lie with their longest diameters parallel to the schistosity which is sometimes feebly developed in these rocks. Infrequently fragments of hornblende and biotite occur; magnetite is an ingredient especially within the flakes of hornblende. Chlorite and epidote replace the hornblende, following the lines of cleavage and finally by their development separating the original crystal into a number of separate fragments, all however perfectly oriented. Secondary muscovite is also an important constituent of the rock. At the immediate contact with the granite, the slate has been metamorphosed to some degree by heat, this is indicated by the baking of the slate and also by the presence of small bodies or aggregations which resemble the knoten in the knotenschiefer of Rosenbusch.

These bodies occurring only in the neighborhood of the granite are regarded as true contact phenomena. The knoten in the slate are aggregations of quartz, muscovite, magnetite, graphite, chlorite and sometimes tourmaline with rather less mica than the average of the rock, and thus polarizing lower. They are small and usually irregular accumulations of the pigments of the slate into more or less definite masses. In some cases the knoten are of sufficient size to be recognized by the unaided eye. There is a difference in the definiteness and regularity of occurrence of these bodies. The most perfect and well defined knoten occur in the fragments of slate which are included within the granite or else at the very contact. In these localities the coloring matter is massed together into oval knoten, with clearly defined limits, there is no gradual shading off into the mass of the rock, but the demarcation is distinct and sharp, outside of the knoten there is comparatively little pigment, it is largely gathered into the knoten. A few feet from the contact, the knoten are more irregular, the pigment is not accumulated into definite masses, but is scattered irregularly through the rock, though at intervals it is massed into irregular bodies which lack, however, the definite boundaries of the knoten at the contact. There is a gradual thinning out of accumulation into the body of the rock, it is impossible to say where the knoten end and the ordinary rock structure begins, as there is no sharp line of demarcation. The slate is so decayed that careful study does not reveal this structure so fully as is desirable. Secondary minerals, especially chlorite have almost wholly replaced the original constituents and the original character of the rock is not revealed in its entirety. The presence of these knoten-like bodies at the contact, the gradually increasing definiteness of these masses as the contact is approached, indicate beyond doubt that they are true contact phenomena.

In certain localities the slate is conglomeratic in structure, it consists of brecciated material, a part of this material is slate closely resembling the country rock, the other part is a rock felsitic in its appearance, clearly pyroclastic in origin. It is made up of lath-like crystals of feldspar, often oriented and indicating flow structure. In this ground mass occur porphyritic crystals of plagioclase and of ferro-magnesian minerals now so altered that they cannot be recognized. The presence of this porphyritic rock in the slate has lead some geologists to regard the slate as igneous in origin and it has been called a melaphyre. The field occurrence of the rock disproves such a conclusion, the breccia is clastic in its present form though some of its constituents are certainly volcanic in origin. The breccia is bound together by a coarse cement consisting of fragments of slate and volcanic rock, it resembles volcanic ash in part, consisting of broken fragments of rocks and broken fragments of crystals. The brecciated material is exposed so rarely and in such limited areas that nothing definite regarding its origin has been obtainable. The field occurrence of the slate resembles that of other slates in the Narragansett Basin known to be of Cambrian age. No fossils are found in the slate and therefore no attempt has been made to fix its geological horizon, other than to call attention to the similarity of its field relations with the slates farther north in this same area.

THE GRANITE.

Through the slate a coarsely textured, porphyritic granite has been erupted. It varies in macroscopic appearance and structure. Normally it is dark red in color, and evenly textured. In the western portion of the area, where metamorphism has been most extreme, it is light green in color, through the chloritization of the feldspars, and gneissic in structure. The granite is all more or less jointed, slickensided surfaces frequently occur and the porphyritic constituents are often crushed to a mosaic or drawn out into augen. These evidences of movement and pressure are most abundant on the west shore. The joints are filled with quartz, the veins thus formed sometimes reach a width of two feet. In approaching the island from the sea, they form a striking contrast with the dark red granitic cliff for a back ground. A large number of pegmatite veins intersect the granite, with rare exceptions they do not exceed three or four inches in width. They closely resemble dikes in appearance. Their width is uniform throughout their length, they have sharply defined walls, there is no gradual transition from the granite to the pegmatite, but the contact is a sharp and clearly defined one. The small veins of pegmatite have not been observed outside of the granite, the structure is invariably fine in the small veins, but is much coarser in the larger ones.

MICROSCOPIC FEATURES.

The granite contains a large proportion of quartz, the biotite is irregularly distributed and is comparatively rare, it is usually altered to chlorite. The feldspar is usually much fissured and weathered, especially in the western area, and here the fine fissures are filled with chlorite, more rarely with epidote and calcite. It is stained a dull reddish brown color by the iron oxide which is abundant in these rocks. The extent to which metamorphism has gone on can be fairly well judged by the microscopic appearance. The deeper the green color of the rock, the greater the metamorphism, and vice versa. The feldspar occurs in rather coarse holocrystalline grains, and also as large phenocrysts in the granitic ground mass. Orthoclase and plagioclase occur both as ground mass and porphyritic crystals, but the orthoclase predominates. The quartz is a very large constituent of the granite and occurs in coarse grains, which are filled with numerous liquid inclusions, often to such an extent that they give the mineral a dark blue color. The mineral is not clear and pellucid, but is dark and quite opaque. This is partly due to the inclusions, partly due to the fracturing of the mineral All fissures are filled with iron oxide and chlorite, thus rendering the mineral dark or semi-transparent. The quartz grains are very uniform in size and they rarely show porphyritic development. The orthoclase is usually fresh in appearance, not having been so greatly altered as the plagioclase; it often changes to muscovite, but rarely to chlorite. The cleavage parallel to P and M is frequently well shown. The lamellar intergrowth with albite is very common, and in disturbed areas especially, crystals of microcline are included within the orthoclase. Wherever the orthoclase is fractured, as it frequently is in the gneissoid granite, calcite fills the fractures. Twinning is comparatively rare and none but Carlsbad twins have been observed. In the more disturbed areas there are evidences of deformation of the crystals. This is shown by the bending of the cleavage lines and by the wavy extinction. There are many small cavities lined with flakes of iron oxide, whose presence darken the feldspar. This occurrence is probably due to infiltration of iron into cavities formed by liquid inclusions, the fissuring of the mineral having permitted the escape of the liquid which originally filled these cavities. As a whole the orthoclase retains its original form better than any other constituent of the granite. It is less altered by dynamic action than the other minerals. The porphyritic crystals of orthoclase are not so well developed as the plagioclase phenocrysts, the crystals frequently lack faces and angles, and appear to be only much enlarged grains, rather than true porphyritic crystals.

The plagioclase like the orthoclase occurs both in the ground mass and in porphyritic crystals. The mineral is abundantly developed for a granite. It occurs in angular grains, which are on the whole much smaller than those of the quartz and orthoclase.

Albite is the most common mineral of the plagioclase group present in the granite, other forms that are found belong to the acid end of the series. The plagioclase is usually much altered both by deformation and secondary alteration. The porphyritic crystals especially exhibit every stage of mechanical deformation from slight bendings of cleavage planes to a complete breaking down of the crystal into mosaic structure or lenticular augen. Peripheral granulation is the most common type of change. Sericite is developed wherever shearing has taken place, though when the feldspar is broken up without shearing, muscovite usually takes the place of sericite. Chlorite is rare; in many instances titanite occurs abundantly, in the feldspar especially, though it is found in other minerals as well. The biotite, which occurs very sparingly, is almost invariably altered to chlorite. When unchanged it is a green color, the pleochroism parallel to *a* is yellowish green, parallel to *b* a deep green. The mineral occurs in irregular fragments without crystal faces or angles; it is very rich in apatite inclusions, which in turn rarely present crystalline development but occur as round grains. The cleavage planes of the biotite are filled with iron oxide, which stains the mineral a rusty yellow, and makes careful study difficult.

In addition to the three principal minerals mentioned, there are a number of accessory minerals, magnetite, ilmenite, titanite, rutile, zircon and garnets. The two latter are rare, when the garnet does occur, it is usually quite perfectly crystalline, showing sections of the dodecahedron; it occurs in the disturbed areas of the granite and is clearly of secondary origin. Rutile in fine needlelike crystals occurs very abundantly, some sections are so filled with it that they have a cloudy appearance. The remaining minerals occur only at rare intervals and are not sufficiently prominent to require special description.

SUMMARY OF THE GRANITIC STRUCTURE.

The granite as a whole is a holocrystalline granular aggregate of quartz, feldspar and biotite, with some secondary muscovite, and a number of accessory minerals. The granite is porphyritic, plagioclase usually occurring in this form. The ground mass consists of quartz and feldspar of medium sized grains; these in part interlock, in part are cataclastic in origin, arising from the granulation and breaking up either of the porphyritic crystals or the larger grains of the ground mass. The size of the grains varies greatly, portions of the ground mass are micro-granitic, but usually it is coarse in character. The granite possessing a porphyritic facies, resembles granite porphyry, its mode of occurrence, however, is intrusive.

Zircon, apatite and the titaniferous minerals belong to the earliest stages of crystal development, the micas follow, quartz and feldspar forming last. The feldspars precede the quartz, the plagioclase always crystallizing before the quartz. In the crushed granites quartz is frequently enclosed in feldspar, but this quartz is almost invariably of secondary origin. Another feature of the granite that needs mention is the large number of rock inclusions within it. The rock thus included is a fine porphyritic rock. Microscopic examination shows it to consist of a very fine ground mass almost wholly chloritized, within which occur porphyritic crystals of quartz and feldspar. These crystals vary in size and shape. Commonly they lack crystal faces and angles, and are round or sub-angular. The porphyritic crystals are largely quartz. Its structure and character indicate that it is a quartz porphyry. No trace of such a rock can be found in situ, fragments of it are abundant in the slate as well as in the granite. It doubtless belongs to a terrane which antedated the slate, from which the slate obtained a portion of its materials, and through which the granite was intruded, bearing fragments of it upward.

THE ARKOSE.

Adjoining the granite and overlying it, on the west side of Conanicut proper, is a bed of arkose one hundred and ten feet thick. This bed consists of small rounded blue quartz grains imbedded in an argillaceous cement. The quartz of the arkose is identical with that of the granite, both in color and in the character of the inclusions. The cement is detrital feldspar containing a considerable percentage of muscovite.

In passing from the granite to the arkose a gradual transition is noticeable, the former at first firm and compact, becomes more and more disintegrated until finally it is loose incoherent arkose. The mode of occurrence is such as to leave no doubt that the arkose is a mantle of detritus arising from the secular decay of the granite. The outcrop of arkose at the shore is not a local exposure. It is everywhere present, lying between the granite and the overlying schist. Well diggers state that in all parts of the island they invariably come upon a layer of "rotten granite" before the hard granite is reached.

It has been affirmed by some investigators that the arkose is fault breccia or possibly debris resulting from shearing movements in the granite itself. This view is not a tenable one, for the arkose is found only at the granite-schist contact, it follows all of the irregularities of this contact, it lies in the hollows and on top of the ridges of the granitic surface. It is inconceivable that faulting or shearing could occur upon so uneven a surface as that afforded by the granite and at the same time the fault plane or the shear plane invariably lie between the contact of the schist and granite. Faulting and shearing is a common feature in the granite area, but nowhere is it accompanied by large quantities of breccia, nor is the breccia of the nature of arkose. The former consists of broken fragments of granite, the latter of quartz imbedded in detrital feldspar.

The arkose is absent from the granite-slate contact. This circumstance when considered in connection with other contact features proves the priority of the slate. The presence of this decayed mantle at the granite-schist contact also proves the latter to be the later formation. The relationship of the granite with the two clastic formations immediately joining is clearly proven even if other proofs were wanting by the arkose alone. The granite is younger than the slate, it is older than the schist. The relationship here indicated ought also to disprove the repeated assertion that the hard compact slate is a metamorphosed state of the schist, the metamorphism having been produced by the granite intrusion. The occurrence of the arkose alone disproves such a view.

THE SCHISTS.

Immediately overlying the arkose on the west shore and the slate on the east shore is a series of schists which constitute the principal formation of the island. These schists are carboniferous in age; this is indicated in a twofold way. First, plant remains of carboniferous age are found occasionally in the lower beds of the series; second, the trend of the rocks carries them into the coal bearing series of rocks a few miles to the northeast. The schists are of two types; the first is a light gray rock tinged with green and possessing a bright micaceous lustre, when wet it is greasy to the touch and readily crumbles, but normally it is hard and brittle, its schistosity is developed in an extreme manner and the rock readily splits along the schistose planes. The second type is a dark colored rock, containing a large percentage of graphite and other forms of carbonaceous materials. It is essentially like the light schist in structure, the chief difference being the larger amount of carbonaceous matter present. The schists are usually made up of finely comminuted materials, though more or less grit and even fine conglomerate occurs interbedded with the schist series. The schists immediately north of the granite are of the first named variety, they extend for a mile or more before being replaced by the darker variety, though occasional bands of dark schist are interbedded between the beds of light schist. The strike of the schist immediately north of the granite, in common with the mass of this formation on the island is N. N. E., S. S. W., with the dip generally S. E. The dip of the schistosity varies greatly, out it is frequently to the N. W. and S. E. It often accords with the dip of the rocks.

The bedding is frequently very obscure and it is difficult at all times to determine it, hence the relationship of schistosity and bedding is not at all times traceable. In contrast to the majority of the schists, the light gray schist of this neighborhood contains few inclusions. Those that occur are largely iderite or pyrite, fine flakes of carbonaceous matter are disseminated through the rock, and where this matter increases in amount, a darker hue is given to the rock. Chlorite and muscovite occur abundantly. The major portion of the rock consists of feldspar, finely grained and distinctly clastic in character, dull in appearance even when most unaltered. It is kaolinized to some extent, often altered to chlorite or muscovite, but the larger portion of the feldspar has been altered to sericite, this change, as the structure of the rock indicates, having been accomplished by dynamic metamorphism.

It is the presence of this mineral that gives rise to the silvery lustre of these schists. Clastic grains of quartz are found in small quantities, but the feldspar altered and unaltered makes up the main part of the rock. In all portions of the schist rutile is very abundant. It occurs in fine needles and in the well known genal twin form. At times this mineral is so abundant that it resembles masses of felt. The inclusions of iron oxide and siderite are surrounded by broad zones of light yellow color arising from the oxidation and hydration of the original mineral. The schists in the immediate neighborhood of the granite are nearly vertical, but reach a gentler dip toward the head of Mackerel Cove, the dip is E. or slightly N. of E., frequently the rocks are overturned and dip west, but this is a local phenomenon. The strike is north and south nearly, bearing slightly northeast and southwest. Schistosity is so well developed that it obliterates the bedding and renders accurate observations impossible. Double schistosity is of frequent occurrence, one set of planes dipping N. W. the other northeast, the latter being better developed. North of Mackerel Cove to Round Swamp the dip of the rocks continues to be east and that of the schistosity mainly W. N. W.

These schists are quite uniformly graphitic but do not differ essentially from the light schist in any other respect. The same structure and the same features are present in both. The transition from white to dark and vice versa is usually an abrupt one, it is rare to find gradual transitions. So abrupt is the change and so frequent are the alternations of black and white that sometimes the schists have a banded appearance. This banding is uniform for long distances, in one case it can be traced from Freebody's Hill diagonally across the island to Lion's Head, a distance of four miles. This banding, which is due to alternations of sedimentation in the original rock, is of great service in determining the strike of the rocks, bedding planes are usually obliterated and their position difficult to determine, the banded schists are a means of determining the attitude and trend of the rocks where otherwise it is well nigh impossible to do so.

The strike is slightly E. of N. and W. of S. for the rocks as a whole, as indicated by the banded schists, though there are many local divergences from these directions. On the east shore the light schists extend from the slate to Freebody's Hill, though the dark members of the series are not wholly wanting, north of Freebody's Hill the black schist predominates.

At certain centres the schistosity and bedding have no uniform dip; there is confusion and complication in their arrangement. The schistosity constantly changes the direction of its dip, the strata are overturned and faulted. One of these centres of confused stratigraphy is Freebody's Hill. The dynamic forces producing folding and schistosity, acting from several directions, seem to have met in these centres as foci, maximum effects of pressure made by forces acting N. E. to S. W. and N. W. to S. E. have crossed each other at these foci and have here therefore produced a maximum result. The two forces meeting at these focal points combine to make it an area of greatest disturbance. These points are regions of very marked disturbance in contrast to the surrounding areas which are much less disturbed. In the less disturbed region this same phenomenon can be observed on a much smaller scale. A few closely appressed folds will be found, followed by an area in which disturbances are scarcely noticeable, then a closely folded area, then another comparatively undisturbed. This sequence of disturbed and undisturbed regions on large and small scales is observable in all parts of the island. The effects of pressure are cumulative, not evenly distributed, just as in wave action, where waves cross each other diagonally, there are certain points or foci in which there is a culmination of effects, so in the folding and disturbance of the earth's crust there are points of greatest disturbance, because at these points the forces acting from different directions have met and have by mutual interaction added to the dynamic efiect that each separately possessed.

In Conanicut these forces did not act at the same time, but at different periods, possibly widely separated in time. The force coming from the N. W., acted first, producing certain dynamic results, the N. E. force acted subsequently and added to the first results certain others, especially where the greatest stress of the later force coincided with the greatest stress of the earlier force. Where maximum forces combine, there would occur the greatest dynamic disturbance. These centres of foci would occur only at intervals, the intervening areas being comparatively undisturbed. Regions of very marked disturbance occur in Conanicut; these regions are widely scattered and do not occur in any definite order, the most noticeable points are Freebody's Hill, Beaver Head and Lion's Head. The surfaces of the rocks in these areas show slickensided surfaces, caused by the sliding of blocks along the planes of schistosity, the smooth sericite schists especially affording easy movement along such surfaces. There has been comparatively little true faulting, most of the movements have been along the gliding planes caused by schistosity. In addition to the slickenslides another interesting feature is noticeable. The schistose planes are often wrinkled by minute folds, rarely over 2 or 3 inches across and usually much smaller, the strike of these folds is quite uniform in the same locality and is approximately N. E. to S. W.

The schistose planes are frequently much contorted and disturbed on a small scale by the dynamic force which produced this folding. This force must have acted after the principal schistosity of the rocks was developed, in many cases this force was sufficiently powerful to develop schistosity of its own. Where this is the case, there occurs the double schistosity already mentioned. The schists in their present condition indicate at least three orographic movements: First, the movement which produced the principal folds of the island and tilted the rocks into their present position. This movement acted approximately in an easterly direction, the strike of the folds and of the rocks in the aggregate is nearly north and south. In many cases the schistosity, which has been developed to so remarkable a degree in these rocks coincides with the dip of the bedding, it may be presumed that this schistosity was developed pari passu with the tilting of the rocks, and that both processes were due to dynamic pressure. In many instances, however, there is discordance between the two. The banded schists already mentioned stand vertically while the schistosity is horizontal, the schistosity often dips N. E. or S. W., while the bedding dips E. or W., in such cases it is probable that the schists were tilted before schistosity was developed, and that later movements have caused this discordant schistosity. At least it is necessary to suppose that tilting had gone on for some time before the dynamic pressure was sufficient to develop schistose planes and hence there is no agreement between the bedding and the schistosity. This seems to be the most probable explanation of the relation of bedding and schistosity in the banded schists, the rocks had reached a vertical position before schistosity began to be developed. These schists were in the center of folds, where they were closely appressed and where the folding process would be resisted by the weight of the superincumbent rocks thus producing vertical pressure, which would produce horizontal schistosity. Frequent but small faults occur in the banded schists indicating that pressure was also relieved by faulting, as well as by the production of schistosity. Second, the changes in the direction of the dips of the schistose planes from their normal E. or W. dip seems to be caused by a second force which bent or warped the schistose planes. The dip gradually changes from E. to N. E. and vice versa, or from W. to S. W., it is an appressing of the schistose planes on a large scale, causing them to frequently change their direction of dip. Third, as already indicated the schistosity is folded and puckered on a minute scale by a third but relatively feeble force, which judging from the direction of the minute folds, acted from the N. W.

Thus far the schists have been described up to Round Swamp and Freebody's Hill. A line connecting these two points separates in bulk the black and white schists. North of this line they are predominatingly dark colored. The dip and strike agrees with that of the more southern schists. The schistosity is not as perfect as in the light schist. The rocks are softer and more unctuous to the feel, and when wet are easily crumbled and form a saponaceous pasty mass. The black schist vary in character. This is due largely to the greater or less admixture of grit and conglomerate. The rocks of the series vary from coarse quartzose conglomerate to a fine grained schist. The lower portion of the series is coarser, containing a large proportion of fine conglomerate and grit interbedded with finer clastic rocks. In the upper portions the rocks are prevailingly fine-grained. The coarse materials occur frequently in lenticular masses which may extend several hundred yards, and finally give place to a different rock. The finer rocks are all schistose. Those which contain a large proportion of grit are not, although the grains of sand and the small pebbles which make up the bed are usually flattened parallel to the schistosity in the finer rocks. The black schists are made up primarily of feldspar, with a large percentage of quartz at times; also flakes of iron oxide, mica, hornblende, chlorite, etc.

MICROSCOPIC DESCRIPTIONS OF THE SCHISTS.

The dark schists.—Microscopically the schists are found to be made up principally of quartz and feldspar in fine grains, the latter generally altered to sericite and chlorite. Flakes of biotite magnetite and ilmenite are common, metamorphic minerals especially garnet and andalusite occur frequently. The biotite shows secondary change often, due to the leaching out of the coloring matter. Numerous patches of yellow iron oxide, containing yet unaltered cores of magnetite. The most noticeable feature of these rocks is the abundance of graphite, it occurs heaped together in masses, not uniformly distributed, portions of the section are without this coloring matter except as it occurs in scattered flakes. In this respect the arrangement resembles knotenschiefer, but the knots of graphite are not well defined, they are irregular in shape and possess no sharp boundary line. The proportion of quartz to feldspar is generally small in the finer schists, the grains of which the schist is composed are small averaging 0.1 mm. They occur interlocked closely as a rule, though sometimes in juxtaposition.

Frequent alternation of fine clastic material and coarser grit are found even in microscopical sections, giving the section a banded appearance. By the increasing admixture of quartz grains the rock passes into a grit, which frequently becomes sufficiently coarse to be denominated a conglomerate.

In all cases the coarser grains are either flattened out or else crushed to a mosaic. All stages of the process of breaking down are represented, from the slight fracturing of the grain, through the stage of peripheral granulation to complete crushing. The constituent grains are stretched out parallel to the pressure, and where they cross the apexes of folds are bent or broken. Ilmenite plates and sericite flakes are bent and twisted about the broken grains of quartz and feldspar.

Andalusite occurs in large crystals sometimes 7 or 8 inches in length. Garnets are very abundant in the dark schists, they are usually changed in whole or in part to chlorite. They are almost invariably more or less crushed tailing out at each side and forming typical augen structure. About these lenticular bodies, the sericite is arranged in curves which are determined by the form of the included crystal. In the immediate vicinity of the garnets there is a greater development of sericite than elsewhere. The schistosity is very perfect and the sericite fibres are oriented parallel to it except where they are compelled to change their direction on account of inclusions. Planes of parting are very frequent in the microscopic sections, these are frequently gliding planes shearing movements taking place along these. Sericite is more abundantly developed on these planes than elsewhere in the rock. These planes often pass directly through the garnet grains instead of passing around them though the latter method of occurrence is the more common.

The light schists.— The light colored schists so closely resemble the dark schists that no separate description is necessary. The only marked difference is the great amount of fine rutile needles which are often found in the former, occurring in nests or compact felt-like masses.

The schists of the northern portion of the island are more metamorphosed on the west side than on the east, there is a progressive development of schistosity apparent even within the narrow limits afforded by the width of the island. The total thickness of the schists is estimated at 1,200 feet. In order to set forth more clearly the variety of formations present in the schist series, a section from one of the low cliffs on the west shore will be described. The rocks exposed in this section are representative of the whole series. The lowest number, between two and three feet in thickness, is extremely rich in graphite and contains large garnet inclusions, flakes of magnetite are abundant, ilmenite and its decomposition product leucoxene occur more sparingly, the rock is extremely soft, finely schistose and in some localities is so rich in particles of carbon as to resemble coal. This schist is overlaid by a fine grit, a few inches in thickness, and chiefly of interest because it contains fragments of the underlying rock, there being a slight unconformity between the formations. The third member of the series is a fine grained dark gray schist with large garnet inclusions. The ground mass consists of fine clastic grains of quartz and feldspar, which closely interlock. Ilmenite, magnetite and graphite are very abundant. This bed contains considerable ottrelite, an occurrence which will be more fully described later.

The next higher formation is a thin bed of carbonaceous schist, with schistosity remarkably developed. Long narrow ilmenite plates and numerous rose colored garnets characterize the rock. The main mass of the rock consists of very fine sericite flakes all arranged parallel to the schistosity. The graphite being intimately mixed with the sericite, not as is frequently the case collected into masses. There is a greater amount of feldspar in the rock than usual and a greater difference in the size of the quartz grains than is wont to be the case. Biotite which is abundant, adds to the schistose character of the rock. Succeeding this bed is a layer of iron gray schists, tending to assume gritty characteristics. This formation is richer in varied mineral constituents than any other on the island. It contains ilmenite, fine flakes of biotite and hornblende, garnets, staurolite, chlorite, zircon, graphite and rutile. Quartz grains are numerous and the rock is not as finely schistose as the more feldspathic varieties. If feldspar is abundant, schistosity is well developed, but in proportion as quartz enters into the composition of the rocks, schistosity disappears. Evidences of dynamic force are clearly shown in these more quartzose rocks, because the crushing of the grains is more apparent, than in the case of other minerals.

The next higher rock is microscopically similar to the black carbonaceous schists already noted. The rock is markedly schistose and garnetiferous. The schistosity curves gracefully about the crystals of garnet which are rarely crushed to a mosaic and drawn out into augen. The rock is not as completely metamorphosed as many rocks of the series, and this is shown by the incomplete fracturing of the garnets, by the lenticular, not flattened, condition of the augen and by the condition of the garnets which are unusually fresh and unchanged. Graphite in this formation occurs included in the garnets and also as a zone about them. The following member of the series is another dark gray schist, containing small garnets, magnetite and graphite. Quartz is the chief constituent, the grains are fine and uniform in size and are flattened out parallel to the schistosity. At intervals there are slight folds, the the force which produced them was later than the schistosity because the quartz grains in the neighborhood are disturbed and turned from their alignment, which is so perfect in other parts parts of the section. When examined microscopically these disturbed grains are found to extinguish later than other portions of the rock, which shows that they have been crowded out of parallelism with the other constituents of the rock. The last member of this particular section is a fine carbonaceous schist with a metallic lustre and very rich in garnets. Microscopically this schist is shown to be a fine grit, containing fragments of a yet finer grit. The materials of this rock are greatly compressed. The flattening of the uniform quartz grains is excessive, and yet so regular is their arrangement that they seem to be placed in position by human hands. The rock has been slightly folded, the long ilmenite plates are bent about the garnets and the secondary chlorite is twisted into confused and intricate patterns.

This enumeration of the schistose beds might go on indefinitely. Enough has been said to indicate their general character. They consist largely of alternating carbonaceous schists and fine grits. The structure of these beds indicates that there was a frequent change of conditions in the deposition. Fine sediments were laid down, then accompanied, doubtless, by a change of level, there was a deposition of coarser detritus. This alternation of conditions was rapid, as is indicated by the thin beds. The instability of the land lasted during the deposition of this great series of schists, for the repeated alternation of beds continues to the top of the series. One of the uppermost members is a coarse thick-bedded conglomerate, formed largely of quartz pebbles ranging in size from one inch to four or five inches in diameter. The strike and dip of the beds agree with that of other members of this series in northern Conanicut. It is this hard resistant rock which gives rise to the long ridge in the center of the island.

Throughout the carboniferous schists there are a great number of quartz veins. At the points of intersection masses of quartz are formed five or six feet in diameter. The shore is strewn with these quartz blocks, which are a prolific source of pebbles. Often in the vicinity of such veins the beach is made up wholly of fragments thus derived from the veins. There is now going on a repetition of the processes by which the great beds of quartz conglomerate were formed in the past.

As already stated the rocks of western Conanicut are more disturbed than those of the east side. This is shown by the greater degree of folding, by the greater dip of the rocks, and microscopically by the relatively greater amount of crushing which the constituent minerals have undergone. As a whole the texture of the west shore rocks is also coarser. There is more grit and conglomerate in this locality. Evidently the ancient shore line is being approached in passing from east to west.

THE OTTRELITE SCHIST.

The schists at the northern extremity of the island contain ottrelite in many localities. The ottrelite bearing rock is quartzose, indeed closely resembles quartzite, and it lies interbedded with the graphite schists in thin layers, which do not extend to any great distance. The occurrence resembles cores of coarse rock included in the black schists. They may be regarded as lenticular augen included in the schist. The masses of rock contain numerous rhomboidal crystals of ottrelite irregularly distributed throughout the siliceous matrix. The quartz grains vary in diameter from .04 to 1 cm. The ottrelite crystals are 4 or 5 cm. in length. They contain included within their borders patches of the ground mass, flakes of iron oxide and graphite. The edge of the crystals is commonly bordered by interlocking quartz grains, which do not orient with each other. These crystals are fresh and contain few inclusions, thus being strongly contrasted with the grains of the ground mass, which are full of inclusions. The former are of secondary origin and it is doubtless the development of this secondary quartz that gives the rock its quartzite character.

The ottrelite plates do not lie in any given plane, as for instance that of schistosity, but are indefinitely placed in any position. The character of the formation, the inclusion of portions of the ground mass, the orientation of every portion of the large plates indicate that the ottrelite was formed secondarily subsequent to the formation of the schistosity even, for it must have been oriented with this structure if formed prior to or during its formation. As the ottrelite formed and spread it included the ground mass within its borders. The secondary quartz was formed later since the direction of its growth is frequently determined by the edge of the ottrelite crystal. The ottrelite is frequently altered to chlorite. The latter in turn becomes opaque and dull colored, giving rise to a substance resembling kaolin. The pleochroism of the ottrelite is yellow green parallel to c and olive green parallel to a. As in most of the metamorphic rocks garnets abound in the ottrelite schist; they are of pale rose color and sometimes have a slight double refraction. They are usually changed to chlorite and surrounded by a zone of iron oxide. As stated above, there is a remarkable contrast between the core of ottrelite bearing schist and the surrounding schists. The ottrelite schist resembles an included boulder, for there is no gradual transition from black schist to ottrelite schist, the contact is sharply defined.

In many cases the waves have worn away the soft schists and left the ottrelite bearing cores outstanding which serves to heighten the impression that they are erratic boulders. In spite of this appearance they are doubtless formed in situ as lenticular augen of quartz in the schist, the pressure giving rise to the lenticular form of these augen as well as giving rise to the secondary mineralogical changes which have taken place. Local deposits of grit will account for these augen. The materials of the grit were of such chemical nature that ottrelite formed during the dynamic metamorphism which followed deposition.

THE GRIT.

The grits are made up largely of quartz grains, on the average $\frac{1}{2}$ cm. in diameter. The grits are often rich in different mineral ingredients. They contain not only ilmenite, magnetite, biotite and hornblende and more common ingredients, but also staurolite, garnets, zircon, and rutile. All these included minerals are usually surrounded by zones of graphite. In these rocks as in others of the series, the schistosity depends upon the mineral ingredients. If feldspars be abundant, especially if altered to to sericite or chlorite, schistosity is well developed; but in proportion as quartz enters into the composition of the rocks the schistosity disappears. Interbedded with the dark schists are light gray schists, resembling those already described as existing near the granite area.

In the ground mass of this rock, though there are yet unaltered feldspars, the greater portion of this mineral has become sericite. The latter occurs in its characteristic felty arrangement, parallel to the cleavage, so perfectly are the fibres oriented that they all extinguish at once, except diagonal patches which do not so extinguish, but a further turning of the stage through 50°–60° is necessary before they become dark. These portions are therefore not oriented with the main mass, but are turned to one side some 60°. The disturbed portions are narrow bands crossing the schistosity diagonally.

These bands are dark when the rest of the slide is light. The microscope shows that the sericite in these bands has been forced out of its orientation and folded into minute ridges, each band constituting a ridge. These minute folds are found to agree with those folds which in the field were made by the second N. W. force. In this occurrence is found the beginning stages of a double schistosity. If the slight folds had suffered still further pressure, if the movement which formed these had continued, the folds would have become closely appressed, fractures would have appeared along the crest of the ridges and thus gliding planes or incipient schistosity would have arisen. Examples in which this further action has gone on are found in the Conanicut rocks. In a general way the black schist series of Conanicut Island consists of fine carbonaceous schists alternating with fine grits or conglomerates. The alternations are frequent and forcibly illustrate the unstable condition of the land during the deposition of the thin beds.

Through a series 1,200 feet thick the same conditions do not exist for more than a few feet consecutively.

This series above described includes the principal formations of Conanicut. On the smaller island locally known as Beaver Tail, the same series occurs in much the same order. So close is the resemblance that the rocks do not need especial description except in those few instances where there is an abnormal development of cleavage or folding. The light colored sericite and rutile-bearing schists predominate with frequent inter-beds of graphite schist. The banded black and white schists are a prominent feature at Hull's Cove. The schists stand vertically, the cleavage being developed at right angles to this, thus presenting that unusual phenomenon, in which the bedding is vertical and the cleavage at a very low angle.

The most interesting phenomenon of these banded schists, as it is indeed of the whole island, is the behavior of the garnet grains while under pressure. When the force began to act which produced the perfect schistosity found in these rocks, the inclusions were forced either to adjust themselves to this pressure or failing in that to be crushed to fragments. In many instances the former plan was adopted and the phenomenon is presented of garnet grains and quartz fragments turning in their beds until their longest diameter was parallel to the schistosity. Both methods above mentioned are repeatedly found in the schist. If the grains were brittle, they were crushed to a mosaic, and then flattened out into long lenticular augen. If they were unable to resist pressure they turned in situ. The attempt on the part of individual grains to turn rarely met with complete success, though they adjusted themselves to such a degree that the pressure did not crush them.

That there has been an actual turning is shown by the sericite flakes which surround the grains. The orientation of the sericite, so noticeable a feature of the schists, is wholly destroyed and broken up in the immediate neighborhood of the grains. The flakes orient themselves with the outline of the grain however irregular that may be. They follow each irregularity, wherever a projection occurs on the grain the flakes are much more crowded and confused on one side of the projection than the other, the side toward which movement was taking place, the flakes of sericite have not only concentric arrangement but also a spiral arrangement, the whorls gradually con tracting as the grain is approached. The sericite flakes have an arrangement, not unlike that of chips in a swiftly moving eddy, they are oriented but gradually grow together and form more and more contracted circles as the garnet grain is approached. The grains themselves are broken across, one fragment being crowded over the other or turned more than the other so as to be in more perfect orientation than the other.

In such cases fracture arises from the inability of the grain as a whole to accommodate itself to the turning movement, the fragment breaks and one portion is thereby more easily permitted to get into alignment with the crushing force. The explanation of this phenomenon seems to be closely connected with the particular type of cleavage here developed. In all these schists the cleavage is Sorby's second type "slip-strain" cleavage, or the "Ausweichungs Clivage" of Heim. Gliding planes are frequently developed, they are rendered easy of motion by the abundant development of sericite flakes, along these planes therefore easy motion takes place. Between the planes of movement occur the garnet grains, the upper plane moves in one direction the under plane in the opposite, the result of these opposite movements upon any body between them is to roll it around in the direction toward which the plane moves, the top is pushed in one direction the bottom in the other a slow revolution takes place if the grains were of such shape as to admit this, motion taking place until the larger diameter of the included fragment is parallel to the gliding plane, when rotary motion would cease.

The rocks of Beaver Tail show a more constant and higher degree of schistosity than the rocks of Conanicut proper. Metamorphism in all its phases is more noticeable in passing from east to west, the folds are more frequent, more compressed, more overturned, fracturing and granulation of included fragments is more common, schistosity is more abundantly displayed, sericite more plentifully developed, as is always the case in this area, sericite is an index of the amount of dynamic metamorphism. All these phenomena are an increasing factor to the westward, combined with this feature is another, namely that the sedi ments of the rocks become coarser to the westward, in tha direction we approach an old shore line, and it is probably true that from this old land the forces which caused metamorphism came, since the evidences of metamorphism have greatly increased as this area is approached.

The contacts between the light and dark schists afford opportunity for noting the contrasts between the two rocks. The white schist is more compact and homogeneous; the black is divided by innumerable distinct cleavage plans. Though cleavage is present in the white, it does not manifest itself as in the black. This is due to a variety of causes. In the first place the light schists are composed almost wholly of sericite flakes arranged parallel to the schistosity, together with rutile needles and occasionally a grain of quartz hidden in the meshes of the sericite. There is no contrast of different colored minerals to bring out the structure of the schistosity. On the other hand, the dark schist has a darker sericite, which is filled and colored by black specks of iron oxide or graphite, together with numerous light-colored rutile needles, which contrasting with the dark background make the structure more tangible. Each minute cleavage plane is filled with very dark graphite flakes, and the course of each plane is easily traceable. The contrast between the black graphitic layers and the lighter intervening ones is so sharp that the attention is at once drawn to the structure. The black schists frequently are not so exclusively composed of sericite, but contain much quartz and some feldspar. The ground mass is not homogeneous, and varies not only in component minerals but in the size of the fragments. Each grain of the structure is clearly seen; then there becomes an individuality of structure which contrasts markedly with the confused twisted fibrous structure of the light schists. Long distinct planes of schistosity are not a feature of the sericite schists, because of the very nature of the ground mass. Cleavage between individual flakes is perfect, and while the flakes are perfectly oriented they are by no means on continuous planes, but are rather twisted into a feltlike mass. So cleavage planes are not continuous. On the other hand the coarser ground mass made up of crushed grains of quartz does allow for the passage of continuous planes.

Thus it is that the coarser and more brittle rock shows clearer evidences of cleavage. Long narrow augen of perfect lenticular shapes are included in the light sericite schists. These augen are now made up wholly of sericite but the outlines of the augen are clearly discernible because of the different arrangement and coarser character of the sericite there than that in the ground mass. Probably the augen were made up of a mosaic of coarser feldspathic fragments, broken down from a large inclusion or fragment in the original rock. The coarser materials of the augen were altered into coarser and more irregularly arranged flakes of sericite.

As is so characteristic of these schists there are numerous little folds lying diagonally across the schistosity at an angle of about 60°. These extend fully across the section and are visible at intervals throughout the length of the sections. The crests of the folds are from .1 to .2 cm. apart on the average, their height is from .03 to .05. The slight puckering of the light schist is in sharp contrast to the coarser but more infrequent ones of the dark schist. The folds in the latter rock are usually at least .5 cm. apart from crest to crest. There will be a series of folds and then an undisturbed area of 5 cm. or more in breadth followed by a series of folds again.

The difference in the ingredients of the two rocks accounts for this contrast in method and closeness of folding. The sericite flakes readily move over each other and quickly adjust themselves to pressure, hence they fold frequently and uniformly. The dark schists with their quartzose layers do not so readily conform to pressure and longer resist it; hence when pressure accumulates as it must until the rock no longer can resist, they form into folds, large because of the accumulated pressure which causes them, lacking the fine even characteristics of sericite folds because of the coarseness of the materials and their inadaptibility to move over each other or readily adjust themselves to pressure. Augen are frequently found in the black schist and are sometimes folded, indicating, as the phenomenon of the folded schistosity indicates, that the master pressure which induced the schistose character of the rocks was first in point of time and that subsequently another force has slightly folded the schistosity and the augen. The minute puckerings are frequently so compressed that in the axes of the crests incipient fractures appear, the beginning of another set of schistose planes.

In some portions of the rock this new set is plainly indicated and in these localities there is true double schistosity. This second set of cleavage planes is, as already indicated, the slip-strain cleavage of Sorby. The planes are very numerous, frequently one thousand to the inch and are unquestionably gliding planes along which movement takes place, when crushing is so great that folding is no longer possible. When gliding planes are so numerous as that, a very distinct schistosity is observable microscopically. Where the planes are few, no such structure is observable to the unaided eye.

Schistosity is a matter of degrees. A rock is truly schistose when the planes are few and are not distinguishable; only when the gliding planes are numerous and closely appressed does it becomes a macroscopic structure. That the sericite flakes of these schists are quite largely developed by pressure is indicated by the method of formation. Initially they begin to form in planes of faulting or planes of movement. In rocks which have suffered little deformation the sericite may be largely confined to these planes. If pressure continues however and the movement of particles in the rock becomes universal, sericite forms throughout the mass of the rock. Rarely some peculiar groupings of sericite about plates of ilmenite or iron oxide are noticeable. The mica radiates from the iron inclusions out some distance into the mass of the rock, regardless of pressure lines. In such cases, the iron is oxidized and the arrangement suggests chemical action as the cause, the changes originating with the inclusion itself.

In most of these schists found in Beaver Tail there is an abundance of rutile occurring in sagenite webs, in needles, and in genal twins. This mineral is very abundant in the metamorphosed rocks, both those of clastic and igneous origin. It is doubtless a metamorphic mineral in all cases. The perfection of the crystals found in the clastic rocks certainly precludes the supposition that they could have been washed out of the granite rocks and redeposited in their present position.

The schists of the western portion of Beaver Tail are coarser than those already described. They are also more folded and faulted. The folds are closely compressed and they are so developed in some cases as to result in over thrusts and overturned folds. The strata on a small but elaborate scale are faulted, contorted and crumpled, all indicating violent and sharp dynamic action, though the folds resulting are rarely over ten feet across the base. The contortions of the rocks, however, are of a very extreme character. The pebbles and grains of quartz are flattened and stretched out to an extreme degree. Fracturing rarely occurs, but by the slow pressure which must have existed under the circumstances the pebbles are flattened to great degree. We have passed in review the deposition and deformation of the schists, a great series which, in spite of the degradation which has taken place, now amounts to a thickness of 1,200 feet on this island alone.

DIKES.

While the process of metamorphism was in progress or before its existence there occurred an eruption of igneous material in the form of narrow dikes. These dikes are found in the granite area and in the schists. They are folded and faulted and have even received a schistose structure in common with the country rock about them. The dikes are five in number, all have a general microscopic mineralogical and structural resemblance and are probably of the same approximate age.

Dike No. 1.—The first dike met with intersects the granite. Its trend is N. 23 E. and dip N. 73 W. Its width is 15 ft. The core of the dike is dark colored and contains a large proportion of biotite, arranged in parallel planes, so that the rock closely resembles a schist, at the contact with the granite the dike is light colored and very much decomposed. Biotite is here replaced by muscovite, inclusions of granite are found in this altered zone.

Microscopically the rock is porphyritic in structure. The ground mass is a fine grained aggregate of orthoclase with a few fragments of striated feldspars scattered here and there through it, especially microcline. The outlines of the fragments are irregular. A crystal face or angle is rarely seen. In this holocrystalline granular mass are crystals of biotite, and sometimes magnetite and apatite as minute accessory crystals. The biotite occurs in two generations. First, as large irregular plates 3 cm. long by 2 cm. wide; second, as lath-shaped idiomorphically developed crystals, varying in length from .3 cm. upward to 1.5 cm.; the width rarely exceeds 5 cm. The second generation are arranged in parallel layers beautifully exhibiting flow structure, this feature is shown notably at the contact with the granite, where the biotite closely follows in and out all the sinuosities and irregularities of the granite. In many cases fragments of granite have been torn off and now lie imbedded in the mass of the dike; the biotite is found bent and wrapped about these inclusions.

Dike No. 2.— This dike occurs at a point just east of Hull's Cove. Its strike is N. 60° W., its dip 30° N., 50° E. It came up along the cleavage of the schists, which is here well developed. Its width varies in different portions of its course, the average is 6 feet. The rock is broken up into irregular blocks by jointing. Slickensided surfaces are frequent, this faulting though extensive is not on a large scale, the throw being usually but a few inches.

The dike is slightly folded, the axis of the folds are N. E. and S. W., the direction of the force was parallel to the strike of the dike and did not develop schistosity as in the case of dike no. 1, whose strike was at right angles to the force. Instead of producing schistosity it folded and faulted the dike.

The rock microscopically is light gray and fine grained, containing small crystals of red feldspar, octahedra of magnetite, no ferro-magnesian minerals. The rock resembles the altered portion of dike no. 1, though it is more metamorphosed than that rock.

The rock is now so altered and decomposed that its original character is indeterminable when examined by itself. Its identity with the altered portion of dike one leads to the conclusion that originally both were the same type of igneous rock. Dike no. 2, on account of its small size and its fractured and jointed condition, was especially liable to secondary changes. So completely have these operated that very few traces of the original structure remain.

Dike No. 3.—This igenous rock cuts the schists of Lion's Head, and like its neighbor, dike no. 2, it follows the cleavage of the schist, which dips 30° N. 60° E., the strike being N. 30° W. The width varies from 2 to 7 feet. It is very much faulted and jointed. The fault planes lie across the strike, the throw is rarely over 4 or 5 feet, but in a few cases it is much greater, the fault planes show slickensides clearly, but their direction is so nearly parallel to the dip of the dike that the amount of throw can not be estimated. In its macroscopic and microscopic characters the rock is similar to dike no. 2. Their identical structure and their similarity of occurrence all indicate that the two dikes, if not one and the same, are yet closely allied.

Dike No. 4.—This dike intersects the schists of the west shore, striking N. 30° E. and dipping 40° W. N. W., its dip agreeing with that of the schistosity. It contains a core of biotite rock similar to dike no. 1. The outside is altered to the now familiar light colored rock, which consists largely of feldspar, calcite and muscovite. The dike has not been folded because its direction of least resistance is nearly parallel to the folding forces, but schistosity has been extensively developed within it.

Back from the shore where this dike occurs and some forty rods to the northeast, is a ridge one hundred feet high, covered with vegetation and nearly buried by drift. A few outcrops are found. The specimens taken from the exposures were precisely like those of dike no. 4. The rock on the outer portions of the ridge is light colored, while within it is schistose in appearance. The identity of the two rocks is so complete that they are regarded as both of the same origin. This ridge is doubtless a dike once continuous with dike number four, but now separated from it by faulting. Because of the close resemblance of this dike to others of the island no further description is needed.

The structure of these dikes, mineralogically and petrographically resembles that of the *minettes*, and such is the name applied to them in the present paper.

SUMMARY.

From the evidence presented in the foregoing pages, the geology of Conanicut Island may be summarized as follows: First, there was a series of slates of unknown age, into which was intruded a mass of granite, porphyritic in character. This granitic complex became exposed to weathering influences until a great bed of debris lay upon its surface. This surface was depressed beneath the sea, and upon it was laid a great series of clastic rocks which are carboniferous in age, and which have been subsequently metamorphosed into schists. The granite was, therefore, the carboniferous shore line.

Following the deposition of the schists there occurred the eruption of igneous matter in the form of dikes. Secondary action has played a prominent part in the formation of veins, notably those of quartz. Also in the replacement of original minerals by epidote, calcite, chlorite, etc., the latter mineral often occurring in the form known as *helminth*.

An unknown amount of erosion has occurred, removing a large portion of the several formations. Finally the island was covered by a mantle of glacial drift, which is the last recorded event in its geological history.

Beloit, Wis.

THE SENSE OF SIGHT IN SPIDERS WITH SOME OBSERVATIONS ON THE COLOR SENSE.

GEORGE W. AND ELIZABETH G. PECKHAM.

But few observations have been made upon spiders to determine their range of vision. According to Plateau, the German physiologist Müller credited them with distinct vision at a short distance, and so also did Lacordaire. Among modern naturalists, M. Eugène Simon speaks of the genus Lycosa as possessed of good powers of sight,[1] and as Simon has passed very many years in the study of this group his opinion is entitled to great weight. Dahl believes that a jumping spider (Attus arcuatus), saw a small fly, eight inches away.[2] Hentz, from a study of Marptusa familiaris, says that the sight of spiders, though acute, is not unerring.[3] The Rev. Dr. McCook, who has made a special study of the habits of spiders says: "No one who has watched them (jumping spiders) stalking prey during the day could well fail to conclude that they were guided by a tolerably accurate sense of sight. * * * So also with Citigrades. I have seen young Dolomedes sexpunctatus leap from the side of a box and catch a fly on the wing, and return to its perch by the rebound of its drag line. Such an act not only shows ability to see but also some faculty to estimate distance, unless we suppose it to have been a chance shot.[4]

Also Bingley says of the jumping spider: "If it sees a fly at the distance of three or four yards, it does not run directly to it, but endeavors, as much as possible, to conceal itself till it can arrive near; and then creeping slowly up, and but seldom missing its aim, it springs upon the insect's back, and it is

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[1] Historie Naturelle des Araignées, First Edition, p. 364.

[2] Versuch einer Darstellung der psychischen Vorgänge in den Spinnen. Vierteljahrschrift f. Wissenschaftl. Philosophie, pp. 94, 95, IX, I, 1884.

[3] Spiders of the United States, p. 57.

[4] American Spiders and their Spinning Work, Vol. II, p. 286.

then almost impossible for the fly to effect an escape. But if, before the spider gets to it, the fly takes wing, and fixes upon another place, it whirls nimbly about, and still keeps its eyes upon it, in order to commence a fresh attack."[5]

It is not probable that a spider could see a fly at a distance of three or four yards, but Bingley could scarcely have spoken in this way if he had not been sure that it could see to a considerable distance.

In 1886 Forel published a paper on the sensations of insects. It is his conclusion that the sense of sight in spiders is so bad that if the flies were not so stupid and so imprudent they would never be caught. He says that the jumping spiders miss fifty flies to one that they catch.[6] This author, however, speaks of his experiments in such a general way, giving no details, that they are of but little value in the solution of the problem. It is rash to draw positive conclusions from superficial observations. To an ordinary observer nothing could seem more senseless than the way in which ants run about on the ground. Even after an ant has found some choice morsel which it wishes to carry to the nest, it runs now this way and now that in what appears to be a perfectly aimless manner; and yet if a person has the patience to follow one of them through all its wanderings it will be seen to reach the nest at last. Another animal which might easily be misunderstood is a fish that inhabits our inland lakes (Coregonus artedi, var. sisco) that during a very short season of the year will bite at almost anything. After that time they may have their favorite fly dangled all around them and yet not take it under any circumstances, appearing perfectly blind.

To discover the limits of the special senses of an insect is a very difficult matter. Only a prolonged study of its life history, pursued through several years and during different seasons, on a number of different species and on many individuals of both sexes, is likely to lead to important conclusions; and in reporting their experiments all writers should remember Lange's words on the subject of scientific observations: "An

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[5] Animal Biography, Vol. III, p. 455.

[6] Sensations des Insectes, premiere partie, Recueil Zoologique Suisse, T. IV, No. 1, p. 41.

exactly described procedure with an exactly described animal can always be repeated, by which means our interpretation, if it is due to variable bye-conditions, is at once corrected, and at all events thoroughly cleared from the influence of personal preconception, which has so great a share in so-called self-observvation."[7]

In 1887 Prof. Felix Plateau brought out a paper upon the sense of sight in Arthropods, and by 1888 he had published four more papers, covering the whole field of Arthropod vision. In the second of these papers he treats of the sight of spiders. M. Plateau is in accord with naturalists generally in the opinion that the question of the range of vision in insects is only to be determined by observation, and that, so far, morphology has been of but little use in solving the problem. He has, himself, followed the experimental method, but in working over so large a field as the Arthropoda he has very naturally drawn some conclusions that a more intimate acquaintance with the creatures in his hands would have taught him to avoid.

Thus he states, after experimenting with a small number (five) of species, that the sight of two large groups of spiders, the Attidæ and the Lycosidæ, is very bad, the limit of clear vision being about one or two centimeters.

The observations upon which he bases this conclusion were different for the two groups. In studying the Lycosidæ he took from two females the cocoons which contained their eggs, and noted that although they sought for them eagerly they did not find them until they came very close. These experiments will be considered further on.

For Dolomedes fimbriatus and for two Attidæ, M. Plateau pursued a different plan. He first noted, in numerous instances, that both free and captive spiders did not leap upon a fly until it came as near as two centimeters.

He found that Epiblemum scenicum turned from side to side to follow with its eyes the movements of a fly ten and twelve centimeters away, and that it ran after the fly from a distance of five centimeters; but this, he says, signifies only perception of movement and not perception of form, since it is at a much

[7] History of Materialism, Vol. III, p. 178.

shorter distance that Epiblemum sees its victim clearly enough to capture it. In other instances the spiders paid no attention to living flies which were not in motion, although passing at a distance of four centimeters.

M. Plateau remarks that the distance of two centimeters is not chosen because it is the limit of the spider's leaping powers, as it is able to jump twice as far.

Of Marpissa mucosa he says that at four centimeters the spider perceives the movements of a fly, but that it is only the movements that are noticed, since at this distance, and even at three centimeters, it seems to lose sight of its prey and to relapse into complete indifference if the fly becomes perfectly motionless.

It seems to us that these experiments and a number of similar ones performed by Plateau, show not how far the spider can see distinctly, but at what distance it usually seizes its prey. It is not safe to take for granted that if the spider does not try to catch the fly he therefore does not see it. As a matter of fact spiders will often let flies—which certainly are, as M. Forel has said, both stupid and imprudent—not only come within two centimeters of them, but climb upon them and walk all over them, practically putting their heads into the lion's mouth, and yet will seem unconscious of their existence. Perhaps they are not hungry. At any rate such are the facts. Dr. McCook says, "One of our largest indigenous Laterigrades, the Huntsman Spider (Herterapoda venatoria), received from Florida and kept in captivity, permitted a large fly placed in her cell to run between the legs, fly into the face, alight on the back, without any attempt to capture it. In the course of time, however, the fly lit on the side of the box a short distance in advance of the Huntsman. She perceived it, crouched, slowly moved her limbs, stealthily and by almost inperceptible advances approached, then swiftly shot forth her claws and secured her victim.[8]

M. Plateau tried another set of experiments with the same spiders in which all the conditions were the same except that instead of a fly he used three rude imitations of that insect,

[8] *Ibid*, p. 286.

consisting of a ball of blackened wax, of a little gray feather, and of a ball of black and white paper. As he made these things move about they were noticed, pursued, and in some cases were seized by the spiders, just as in the case of the true fly. Without doubt the spiders were to some extent deceived by the artificial insects. They did not necessarily take them for flies, but they probably hoped to find in them something edible. But this, after all, does not argue that their vision is very poor, since, in nature, they must be constantly meeting with new forms of life upon which they may prey. Spiders eat a great variety of things—caterpillars, beetles, bugs, walking-sticks, and, in fact, all manner of insects, as well as other spiders.

M. Plateau gives an example of very hasty reasoning in his remarks upon H. F. Hutchinson's statement that he has seen a jumping spider, Epiblemum scenicum, pursuing its own reflection in a mirror.[9] He says that it would be difficult to imagine an experiment which would more fully prove that spiders distinguish form very badly, seeing movements rather than anything else.[10] Does he then suppose that the spider mistook his reflection for some insect which would serve him as prey? Such an hypothesis is quite uncalled for, and is, indeed, untenable. We once owned a very intelligent dog that on several occasions nearly knocked down a large pier-glass by rushing at his own reflection and attempting to fight it. He became furious whenever he entered the room; and one of our boys, when two years and four months old, used to search eagerly behind the glass for the little boy that he saw in it, and it was several days before he gave up trying to find him. Mr. Hutchinson's spider, like the dog and the boy, mistook his reflection for another spider. may be that he wished to catch it and eat it, as is commonly done among spiders, even of the same species; or very probably, if it was in the mating season, he saw, in his reflection, a rival male, and was trying to give battle.

We find, by reference to some notes made in 1887, that when

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[9] Nature, Vol. XX, 1879, p. 581.

[10] Recherches Experimentales sur la Vision chez les Arthropodes deuxiéme partie, p. 10.

a small looking-glass was placed before a male of Astia vittata, in the mating season, he would prance before his reflection in a most ludicrous fashion, throwing forward his first legs and advancing toward his supposed rival as the glass was slowly moved away, or retreating as it was moved toward him; and again, that both the male and female of Phidippus morsitans noticed their reflections in the mirror. The male raised his legs as they do upon seeing another male, while the female crouched, raised her first legs, and finally sprang upon the glass. She followed her reflection, at a distance of one inch, all around the box in which she was confined. The females of this species are exceedingly intolerant of each other as well as of the males. Two of them can not live in the same neighborhood; one is always killed and devoured by the other.

Let us now turn to M. Plateau's experiments upon the Lycosidæ. The females, in this group, commonly carry the cocoon containing their eggs about with them, either attached to the under and hinder part of the abdomen or, as in Dolomedes and Micromata, held grasped in the falces, under the cephalothorax. Both Plateau and Forel having, at several different times, separated the spiders from their eggs, and having noted their difficulty in finding them again, have concluded that their sight is very poor and short.[11]

It is indeed a well established fact that when the cocoon is taken away from one of these spiders she is very much disturbed by its loss, and searches eagerly about for it, and yet that she may run all around it without finding it, never recognizing it unless she comes very close. This is the truth but not quite the whole truth. As a matter of fact, she never recognizes it unless she touches it; but let her graze it ever so slightly, with any part of her body and she instantly seizes it and reattaches it to her abdomen.

The action is so sudden and rapid that one may easily make the mistake of supposing that the spider, in coming very near, recognizes the cocoon through the sense of sight, but close attention will prove that this is never the case. She always comes into actual contact with it before taking it. We feel very

[11] Plateau, *Ibid.*, p. 21; Forel., *Ibid*, p. 19.

confident that when the spider loses the cocoon she never looks for it but feels after it. This is not so strange as at first appears, for it is quite possible that the spider constructs the egg-sac, deposits her eggs in it, closes the aperture, and attaches it to her body without ever seeing it.

The pages of notes that we have collected on this point would be tedious reading, but we offer a few experiments in evidence of our view of the matter.

The cocoon was taken from a female of Pirata montanus. She seemed much disturbed and hunted for it, but though it was only a few inches away she did not find it. The cocoon was then placed one-fifteenth of an inch from her, and still she did not take it. She several times passed very close but until she touched it she did not notice it. The experiment was repeated upon another spider of this species with the same results. We next tried Pardosa pallida, and found that she also depended upon touch and not upon sight to recover her eggs. The same was true of Pirata minuta. No matter how anxious she was to find her eggs, and no matter how close they were brought to her, she never recognized them except by touch. We then changed the form of the experiment by suspending the cocoon of Pirata montanus at the end of a thread. As the spider searched anxiously about, it was lowered until she could barely pass beneath without touching it. This arrangement required some manipulation but we finally succeeded in suspending several cocoons at exactly the right height, and then watched the spiders as they passed and repassed without observing them. If, however, we allowed the cocoon to graze one of the posterior legs the spider instantly turned and seized it. The position of the eyes of these spiders is such that unless they were totally blind they must have seen these suspended cocoons, but they are as dependent upon touch for recognizing their eggs as thorough-bred bloodhounds are upon their sense of smell when hunting their game, or as English greyhounds upon sight.

Exactly the same experiments were performed upon Dolomedes tenebrosus and Micromata carolinensis with exactly the same results. Their distress at losing their eggs was great and their search after them patient and persistent, but always unavailing until they touched the cocoon.[12]

We have also made experiments to determine what the powers of vision are in the Lycosidæ. When at liberty, these spiders rush along so rapidly and seize their prey so suddenly that it is very hard to say at what distance they perceive an object. Even in confinement they are more difficult subjects than Attidæ.

A male of Lycosa nidicola was placed in a narrow case of colored glass made up of plates each of which was four inches wide. The case was sixteen inches long. The spider was standing at one end when we put a green grasshopper in at the other. After a time he began to move down the case. When eight inches away from the grasshopper he appeared to see it, making a change in his movements, but whether this inference was correct or not he certainly saw it at four inches, since when separated from it by the width of one of the plates he leaped upon it and began to eat it. This experiment was repeated with three other spiders of the same species and all jumped upon grasshoppers or small spiders at from three to four inches; while Lycosa nigroventris leaped upon its prey when two inches away.

Further evidence concerning the powers of sight in the Lycosidæ is given by W. H. Hudson in his very interesting work on the La Plata. He says:

"The king of the spiders on the pampas is, however, not a Mygale, but a Lycosa of extraordinary size, light grey in colour, with a black ring round its middle. It is active and swift, and irritable to such a degree that one can scarcely help thinking that in this species nature has overshot her mark. When a person passes near one—say, within three or four yards of its lurking place—it starts up and gives chase, and will often follow for a distance of thirty or forty yards. I came once very nearly being bitten by one of these savage creatures. Riding at an easy trot over the dry grass, I suddenly observed a spider pursuing me, leaping swiftly along and keeping up with my beast. I aimed a blow with my whip, and the point of the lash

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[12] For a more complete discussion of this subject see our paper, Mental Powers of Spiders, Journal of Morphology, Vol. I, p. 399.

struck the ground close to it, when it instantly leaped upon and ran up the lash, and was actually within three or four inches of my hand when I flung the whip from me."[13]

In another place Hudson says: "The spiders I have spoken of up to now are timid, inoffensive creatures, chiefly of the Epeira family; but there are many others exceedingly high-spirited and, like some of the most touchy hymenopteras, always prepared to 'greatly quarrel' over matters of little moment. The Mygales, of which we have several species, are not to be treated with contempt. One is extremely abundant on the pampas, the Mygale fusca, a veritable monster, covered with dark brown hair, and called in the vernacular *aranea peluda*—hairy spider. In the hot month of December these spiders take to roaming about on the open plain, and are then everywhere seen travelling in a straight line with a slow even pace. They are very great in attitudes, and when one is approached it immediately throws itself back, like a pugilist preparing for an encounter, and stands up so erect on its four hind feet that the under surface of its body is displayed. * * * * In the case of the hairy spider I do not think any creature, however stupid, could mistake its meaning when it stands suddenly up, a figure horribly grotesque; then, dropping down on all eights, charges violently forwards."[14]

When in Guatemala, some years ago, we frequently made these Mygales rise up on their hind legs, as is described by Hudson, by pointing the stick of a sweep-net at them, always keeping at a safe distance, since if excited they would jump a remarkable distance to reach the offending object.

M. Plateau criticises Eugene Simon's statement that Lycosa leaps upon its prey from a distance, saying that his judgment must be based upon very superficial observations.[15] We trust that we have shown that it is rather venturesome for a critic who cannot have devoted more than a few weeks to the subject to so lightly dispose of the opinion of a naturalist who has studied spiders in many parts of the world, both in the closet and the field, for more than twenty-five years.

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[13] *The Naturalist in La Plata*, p. 192.

[14] *Ibid.*, p. 191.

[15] *Ibid.*, p. 21.

One would naturally expect that the orbweavers would not be very far-sighted. Living as they do in webs, the vibration of the lines would seem to be sufficient both to enable them to capture their prey and to carry on the preliminaries to their mating. Still the evidence offered by Rev. Mr. O. P. Cambridge, and by Hentz, to some extent confirmed by our own experiments, renders it fairly probable that some of the sedentary species have distinct vision for stationary objects at from two to four inches. Cambridge, as quoted by Dr. McCook,[16] "records that he has more than once seen an English Orbweaver, Meta segmentata, drop from her web upon an insect which it had espied on the ground a little way below it, and ascend again with its prize by means of the line drawn from its spinnerets in the descent." As Dr. McCook goes on to say, this is certainly a remarkable degree of keen sightedness for an Orbweaver, and especially for one that habitually affects a shadowed habitation.

We have confirmed the statement of Hentz,[17] that Eperia prompta sometimes catches its prey by running and leaping upon it, like an Attus. We have also made some experiments upon the Therididæ [18] which showed that Theridion blandum and Theridion frondeum recognized their cocoons at three and at four inches, respectively. In these spiders, although the cocoon is not attached to the mother's body, she keeps guard over it and evidently knows it by sight.

The evidence that we have to offer upon the subject of sight in the Attidæ is based upon a study of twenty species. This study has extended over eight successive summers and we have notes of many hundreds of observations. We have experimented more with the Attidæ than with other families, both because the habits of these spiders make them especially available and because it was easy for us to carry on a double set of observations while we were studying their mating habits.

Unlike all the other families of spiders with which we are acquainted, nearly all of the Attidæ, when shut into a box which

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[16] *Ibid.*, p. 287.

[17] *Ibid.*, p 112.

[18] Mental Powers of Spiders, Journal of Morphology, Vol. I, p. 401.

is supplied with light and air, seem entirely unconscious of the fact that they are prisoners. They catch flies and devour them, sun themselves, mate, lay their eggs, and indeed carry on all the affairs of their daily life in the most natural and unconcerned manner imaginable, passing a whole summer in confinement with an appearance, at least, of perfect contentment.

The movements and attitudes of the spiders of this group are wonderfully varied and expressive, and indicate very delicate shades of feeling. For example, a female of Phidippus morsitans stalks a fly with a stealthy, menacing air, but when she is about to pounce upon and devour a male of her own species, there is added to this an appearance of something so evil and malignant that one almost sympathizes with De Geer in the feelings of horror and indignation with which this sight filled him. The males in the mating season, throw themselves into one position when they catch sight of a female and into quite another at the appearance of another male. Indeed their attitudes express so many shades of excitement, tempered more or less by caution, and of jealousy of each other as to make a very dramatic performance for the observer.

This power of expression through different attitudes and movements is of great assistance in determining not only how far the spider can see but how much it recognizes of what it sees, or, in other words, its power of distinct vision, since it acts in one way when it catches sight of its prey, in another at the appearance of a male of its own species, and in still another when it sees a female. Dr. McCook says: "Their rapid and marked change of manner when prey is sighted, the mode of approach, like the action of a cat creeping upon a bird, the peculiar behavior displayed when the final spring is made, are not to be accounted for on any theory other than a keen sense of sight."[19]

Similar observations have been made by Hentz on Marptusa familiaris. Of this spider he says: "It dwells in cracks around sashes, doors, between clapboards, etc., and may be seen on the sunny side of the house, and in the hottest places, wandering in search of prey. It moves with agility and ease, but usually

[19] *Ibid.*, p 286.

with a certain leaping gait. The moment, however, it has discovered a fly, all its motions are altered; its cephalothorax, if the fly moves, turns to it, with the firm glance of an animal which can turn its head; it follows all the motions of its prey with the watchfulness of the falcon, hurrying its steps or slackening its pace, as the case may require. Gradually, as it draws near to the unsuspecting victim, its motions become more composed, until, when very near, its movements are entirely imperceptible to the closest observation, and, indeed, it would appear perfectly motionless, were it not for the fact that it gradually draws nearer to the insect. When sufficiently near it very suddenly takes a leap, very seldom missing its aim."[20]

There is a considerable difference in the character of the different species as well as among individuals of the same species, but we have found nearly all of our Wisconsin Attidæ very good subjects for experiment.

In the summer season it is our habit to keep from twenty to forty species in confinement for several weeks at a time. They are put into boxes of two sizes, the larger ones being 15 inches long by $11\frac{1}{2}$ wide and three deep, and the smaller $7\frac{1}{2}$ long by $5\frac{3}{4}$ wide and $2\frac{1}{2}$ deep. The sides of each box are marked off into inches so that the distances of the spiders from each other and from the flies can be easily noted. The bottom is of cotton cloth and the top is a glass slide.

As may be easily imagined it is something of a task to feed so many prisoners. Our principal food supply is found in the gnats that settle upon the wire screen which encloses the porch of our cottage. These are well liked by all the smaller species, while the larger ones take house-flies, May-flies, and small grasshoppers.

When several gnats were put in at one end of a box containing six or eight spiders their attention was immediately excited and two or three of the gnats would be captured almost before they had settled on the sides of the box. Those that were not caught would settle at once and become motionless. As the bodies of these little gnats were white and nearly transparent they were very inconspicuous, whether resting upon the sides

[20] *Ibid.*, p. 56

of the box, which were of yellow pine, upon the bottom, which was of white cloth, or upon the top which was of glass; and yet they were evidently recognized by the spiders at all distances up to five inches, as may be seen by the following observations which are taken from our notes.

A female of Astia vittata was standing with her back to a motionless gnat three and one-half inches away. On turning she caught sight of the gnat and at once began to approach it stealthily. She sprang upon it when one inch away and caught it.

A female of Astia vittata was walking about the box when she caught sight of a gnat five inches away. She showed her perception of it by a contraction of all the muscles of the body and by lifting her head and fixing her eyes upon the prey. After a moment, she began to advance, rapidly at first and then more slowly. She jumped when about one inch away.

Into a box containing a male of Hasarius hoyi we put eight gnats and four small flies. They all settled and became quiet. The spider, neglecting several gnats and flies which were close to him, fixed his eyes upon a gnat five inches away and approaching it by short jerks, from in front, pounced upon it, holding it tightly a moment and then letting it go. One of its legs was broken. It fluttered off to a distance of seven inches. After a moment the spider followed it and caught it again, still paying no attention to several nearer ones. This he repeated six times, letting it go each time. He then began to catch other gnats and flies at distances of from one to four inches. He made in all twenty-five captures, jumping always when about an inch away. His actions were exactly like those of a cat playing with a mouse. It seems remarkable that he could see clearly enough to follow the gnat which he had at first singled out among a number of others which were almost identical in appearance.

A mosquito alighted four inches from the nest of a male of Philæus militaris. The spider crept out, approached cautiously, and when one inch away jumped, but the mosquito escaped. A moment later it flew back and settled two inches from the spider. This time he ran quickly up, leaped, and caught it.

A tiny black fly approached to within two inches of a male of Habrocestum splendens. The spider advanced very slowly facing the fly, which seemed to be fascinated, gazing into the spider's eyes, but backed slowly away moving its abdomen up and down in a peculiar manner. They moved along in this way for two and one half inches, when a gnat flying by, distracted the attention of the spider.

Again, a hungry male of this species was put into a box where there were several small flies. He at once began to stalk a motionless fly which was standing five inches away, but lost it. He then fixed his attention upon another fly four inches away but before he approached it the fly began to move and walked slowly away from him around the corner of the box and then up on to the glass cover. The spider followed the fly with his eyes, moving his head around to keep it in view. The same spider afterward stalked a fly which was standing quiet three inches from him.

A female of splendens, being dropped into a box, at once saw a motionless gnat full four inches away, lifting her head and drawing her legs together as she approached it. Another female of the same species noticed motionless gnats fifteen different times at distances of from two to five inches.

A female of Epiblemum scenicum being put into a box containing flies lifted her head and drew herself together on see- a motionless gnat five inches away. This was repeated with a fly at three and one-half inches.

A male of Anoka mitrata followed a moving gnat at distances of two, of four and of six inches.

A male of Phidippus rufus, standing in a corner of his box turned around and brought into view a small green grasshopper which was standing quiet two and one-half inches away. He at once began to creep forward as they do when approaching prey and soon seized it. There can be no doubt that he saw it at once. He had before made several half-hearted moves toward some small flies which were walking about from one-quarter to one-half an inch from him, but only when they actually intruded themselves upon him. At another time this spider saw a motionless grasshopper three and one-half inches away and jumped at it. The grasshopper threw him off and hopped five inches away where it stood still. He at once ran toward it, jumped at it and caught it.

A gnat often brought destruction upon itself by flying across the box, although it immediately settled and became quiet, as the motion would attract the spiders at any distance up to fourteen inches. A spider having once caught sight of a gnat had no difficulty in finding and capturing it after it had ceased to move.

One of our little ant-like species, Synemosyna formica, seems to have the weakest vision of the whole family. A male of this species saw flies in motion four inches away, but if they were quiet did not show that he noticed them further off than one and one-half inches. They never eat any but living creatures, but they often seem to be deceived by dead flies and gnats, leaping upon them when one-quarter of an inch away, and then relinquishing them.

By far the most interesting experiments on vision, however. are those that have to do with Attidæ in their mating season. Here we have evidence that spiders not only see, but see clearly at considerable distances.

Thus we had a male of Saitis pulex, which we put into a box containing a female of the same species. The female was standing perfectly motionless, twelve inches away, and three and a half inches higher than the male. He perceived her at once, lifting his head with an alert and excited expression, and went bounding toward her. This he would not have done if he had not recognized her as a spider of his own species. When four and one-half inches from her he began the regular display of this species, which consists of a peculiar dance. This he would not have done had he not recognized her sex. A male of this species, on the floor of the box, caught sight of a motionless female on the glass, nine inches away and four and one-half inches above him. He raised his body almost vertically and gazed alternately at her and at a male, which was five inches away in another direction. At other times the males recognized the females at eight, nine and eleven inches, and the females recognized the males at six, seven, nine and one-half and eleven inches.

A male of Hasarius hoyi was dropped into a box with another male, which was standing seven inches away. He at once threw up his first legs, this being a challenge to battle. The other male responded by throwing up his first legs. The two advanced upon each other slowly and when only two inches apart began to circle about each other, waving their legs. The same male when put into the box with a female, saw her as she stood quite eleven inches away and at once lifted his first legs, not straight up, as in the case of the other male, but obliquely, and began to move with a rapid gliding gait, from side to side, this being the characteristic display, before the females, in this species. At other times we saw the males of this species challenge each other at two and one-half, at three, at four, at five, at six and at six and one-half inches, and saw the males display before motionless females at two, five, eight and ten inches. The females of this species gave evidence of recognizing males which were perfectly quiet, raising the head with a comprehensive glance and then turning and running in an opposite direction, at four, five, six and eight inches, and one female followed with her eyes the movements of a male, as he walked about the other end of the box, at least ten inches away.

A male of Anoka mitrata saw another male which was not moving when eight inches away, and at once threw out his long plumy first legs. As he takes this attitude both in courtship and in fighting, he may not have been able to distinguish the sex of the other spider, but he certainly recognized it as being of the same species, as he would otherwise have remained quite indifferent.

Another male of this species saw a motionless female nine inches away. He raised himself high on the first pair of legs and eyed her attentively. After a moment he ran toward her, and when four inches away he extended the first pair of legs at a right angle to the cephalothorax, and turned his abdomen first to one side and then to the other, this being his characteristic display. They frequently saw at from six to eight inches when both were standing still, one of them often bending far to one side to see the other more distinctly. It was a common thing for two males, or for a male and a female to back against each other, not aware of their proximity to each other until in actual contact, when they would turn around very quickly.

A male of Philæus militaris, on being put into a box, at once noticed a female that was quietly eating a fly seven inches away. He looked at her, raising himself on his first legs to see better, and after a moment ran toward her with his palpi outstretched. At two inches he threw up his legs and began his display. Two males of this species challenged each other to battle when standing twelve inches apart, and both males and females repeatedly recognized each other at all lesser distances.

Dendryphantes capitatus noticed a quiet female eight inches away and ran toward her, beginning his display at five inches.

Icius hartii began his display before the female, showing recognition of sex, at three inches.

A male of Zygoballus bettini noticed a female six inches away, raising his head and then turning it to see her better as she walked around him.

A male of the little antlike spider Synageles picata, began his display before a motionless female when four inches distant.

A male of Habrocestum splendens, upon being put into a box with a quiet female, became wildly excited, beginning to show off like a peacock when five and one-half inches from her.

In Icius elegans the males and females gave evidence of recognizing each other at all distances up to seven inches.

The males and females of Phidippus morsitans showed that they recognized each other at all distances up to thirteen inches, when quiet or moving slowly. The male danced before a motionless female at six inches.

A male of Epiblemum scenicum noticed a female that was sucking the juices of a fly seven inches away. He raised himself high on his first legs to see her better, and after a moment ran toward her with outstretched palpi.

Phidippus rufus, put into a mating box, seemed to see a female seventeen inches away—at any rate he advanced directly toward her. At nine inches he showed signs of excitement, and at six inches he made his display, raising himself high upon his six back legs, while he lifted the first pair obliquely forward and upward, crossing the tips and widely extending his palpi, while his abdomen was dropped so that it dragged on the ground. He advanced with a swaying motion. When he was close to her she ran rapidly away, leaving him in her corner, and taking up her position fifteen inches away remained quiet for some time with her eyes fixed upon him. Later on he noticed her when she was quiet, eleven inches away, and she followed him with her eyes, moving her head, as he walked all around the box, at a distance of from ten to fifteen inches.

A female of Marptusa familiaris standing four and one-half inches lower than the male and thirteen inches away followed him with her eyes as he moved slowly back and forth in a semicircle before her. They showed, she by a characteristic vibration of the palpi, he by the outstretched position of his first legs that each distinguished the other's sex. We have never seen the male of any species make his display before the female at a greater distance than this. The same performance was repeated when they were nine inches apart.

It is evident that the spiders recognize each other by sight and not by any other sense, as they remain perfectly unconscious of each other's presence when back to back no matter how excitable they are when they come within each other's range of vision. The males of Dendryphants capitatus are extremely quarrelsome, especially in the presence of the female, yet sometimes two males while displaying before the females, will each remain unconscious of the close proximity of the other, even backing up and bumping into each other. We once interrupted the courtship of a male of Dendryphantes elegans by taking him out and gently blinding his eyes with paraffine. He was then restored to the box where he remained quite indifferent to the presence of the females, which had excited him so much a few moments before.

The same experiment was tried upon a male of Saitis pulex. While dancing in the greatest excitement before a female he was taken from the box and his eyes were blinded with paraffine. He was handled gently, and the paraffine was not hot. He was then replaced in the box but remained perfectly quiet although several females passed near him. After a time the females were removed from the box and the blinded male was left alone. The next morning we found him trying to remove the paraffine by rubbing his face with his palpi. Two females were put in, close to him, but he did not notice them. One of the females seemed interested in him, approaching and finally touching him, but he was entirely unresponsive, and only moved away. By afternoon of the same day he had cleaned his eyes and we found him dancing before a female three and one half inches away.

We repeated these experiments several times upon these two species, and also upon Phidippus rufus and Astia vittita always with the same results.

We think that our experiments on vision prove conclusively that Attidæ see their prey, (which consists of small insects) when it is motionless, up to a distance of five inches; that they see insects in motion at much greater distances; and that they see each other distinctly up to at least twelve inches. The observations on blinded spiders and the numerous instances in which spiders which were close together, and yet out of sight of each other, showed that they were unconscious of each other's presence render any other explanation of their action unsatisfactory. Sight guides them, not smell.

EXPERIMENTS ON THE COLOR SENSE.

Some years ago we made a few attempts to test the color sense of the Attidæ by painting the females in the mating season. The results were more or less doubtful. The males unquestionably altered their demeanor at first but some of them became reconciled, after a time, to the new style of coloration. The experiments were as follows:

A female of Astia vittata was put into a box with four males, one of which was of the variety niger. (This species has two forms of male; one of them is colored somewhat like the female, while the other is black). All the males at once became greatly excited vying with each other in their display before the female. The niger, always more active and excitable than the other variety, would have succeeded in mating with her if they had not been separated. All continued to dance before her until at the end of fifteen minutes she was taken out, and painted with water colors, all over her abdomen, a bright blue, the natural color being pale with reddish bands. After the paint had dried thoroughly she was put back into the box. The three light colored males now treated her with complete indifference, passing close to her without paying her the slightest attention, exactly as though she belonged to another species. The niger showed some curiosity, keeping near her and watching her, but did not dance. After twenty minutes he suddenly leaped upon her, but was taken off. He then left her and did not renew his attentions. A second female was now put in. All four of the males at once began to dance excitedly before her and continued their display without pausing, for fifteen minutes when she was removed. All this time they had paid no attention to the blue female, but now they began to notice her a little, not dancing at all but sometimes pausing to look at her when they came near. They were left together for half an hour longer with no further results.

In the next experiment we used entirely different spiders, though of the same species. A female was put in with four males, one of them being a niger. All became excited and at once began to dance. At the end of five minutes she was taken out and painted blue, as before. When dry, she was replaced. None of the males paid any attention to her for the first ten minutes, but after that one of the light colored ones gradually became excited, and ended by dancing before her in the most eager manner possible. The other males remained indifferent.

This experiment was repeated with a fresh lot of spiders with the same results at first; but after the painted female had been in with the males for thireen minutes first one, then a second, and then a third of the light colored males danced before her.

At another time we put a female vittata into a box with six males, two of which were of the niger variety. Within a minute all but one (a light colored one) were dancing and posturing before her. We took her out, and painted her cephalothorax and abdomen bright red. When she was put back only two of the males noticed her, one of these being of the vittata, and the other of the niger variety. These two did not dance nor display at all, as they had done before, but walked about her, eying her attentively, for some minutes. Then one of them, and when he was removed, the other leaped upon her without any preliminaries. The vittata variety returned and danced a little before her, but then retired, and paid her no further attention. The niger, however, danced a long time and leaped upon her repeatedly, being as often taken off. The other males in the box seemed perfectly indifferent. After a time she was removed and another (unpainted) female put in. All of the males now became excited and danced before her. She was taken out and her cephalothorax, abdomen and legs were painted bright blue. When she was returned to the box the behavior of the males was entirely different. At first they did not notice her at all, though passing close to her, but after a time three, and then four of them danced before her, though less eager than before. We now put into the box another female which was large and heavy with eggs. This condition always lessens the attractiveness of the female in the eyes of the males, and yet this one now received nearly all the attention. She moved about more than the painted female, which, perhaps, made her more pleasing. In the end one of the vittata males mated with the painted female.

The next experiments also indicate a perception of color.

The spiders used were five individuals of Astia vittata, two of Phidippus morsitans, and one of Xysticus ferox.

Astia vittata. 1. June 28. A female that was nearly ready to lay her eggs was put into one of our large boxes. On the following day she constructed a thick silken shelter in one corner and laid her eggs, remaining herself on top of them and under the covering of web, so that she was hidden from view. She was left for twenty-four hours and was then pressed gently out and imprisoned in a bottle, while her nest was entirely surrounded by pieces of bright pink paper, two inches in width, which were pasted on to the sides and bottom of the box. She was then put into the box close to the paper and at once ran across it and crept into her nest.

July 1. The spider was pushed gently out of her nest and three inches beyond the paper. She ran back at once across the pink paper, and crept into her nest.

July 2. Pushed her out twice, once in the morning and once in the afternoon, and let her go back over the pink paper.

July 3. Thinking that by this time she might have learned to associate the color, pink, with the locality of her nest, we took the spider from the box, while bright blue paper was substituted for the pink around her nest. We then made an imitation of her cocoon of white cotton batting, glued it into another corner of the box and surrounded it with pink paper to make it look as much as possible as the true cocoon had done before. The spider was then dropped into the box half an inch from the edge of the pink paper. She at once walked across the paper to the upper end of the cotton (where she had been in the habit of entering her nest), but as soon as her front legs touched the cotton she stopped, paused a moment, and then slowly retreated a little. Before long she advanced again, touched the cotton and retreated as before. This she repeated four times. She then started to walk across the cotton, but drew back again and took up her stand at the upper end where she remained motionless for half an hour, puzzling, perhaps, over the unaccountable thing that had happened to her nest. At the end of the half hour she touched it once more and then walked away to the other side of the box, passing within an inch of the blue paper without noticing her own nest. Within five minutes she returned to the artificial cocoon and stayed near it, walking about and looking at it for an hour. At the end of this time she was pushed gently toward the blue paper. When on the edge of it she caught sight of her true nest, and running to it crept in.

July 4. When we went to the box in the morning we found the spider on the pink paper near the artificial cocoon. She had never before left the nest of her own accord. When the box was shaken slightly she left the false cocoon, but soon returned to it.

We then took her from the box for a moment, removed the pink paper from around the false cocoon, and replaced her near it. She remained in the same place for fifteen minutes, lifting her head and glancing from side to side. She then began to move about, and coming within four inches of the blue paper ran onto it and remained there for ten minutes. She was then pushed up to the entrance of her nest and quickly ran in. A second artificial cocoon was then placed in an unused corner of the box and was surrounded with pink paper.

July 5. We found vittata running about the box. She passed near the plain bunch of cotton and also near the pink paper without paying any attention to them, and finally ran onto the blue paper and crept into her nest.

On July 6, 7, 8 and 9 she was gently pushed to a little distance from the nest and then allowed to find her way back to it across the blue paper. In this way she became accustomed to being away from her nest, more or less, and sometimes stayed out for several hours, eating and drinking as though she had no maternal cares, but always returned to her eggs sooner or later.

July 10. The spider being removed from the box, bright red paper was substituted for the blue around her nest, and the artificial cocoon in another corner was surrounded with blue. She was then put back into the box, but for three hours did not seek for her nest, remaining quiet at one side of the box most of the time and eating four gnats in succession. She was then touched with the end of a lead pencil, whereupon she ran directly across a corner of the red paper, onto the blue, and up to the cotton. At the first touch, however, she left it entirely, and did not return to it. She wandered about the box for half an hour, crossing the red paper three times without noticing her nest. The fourth time that she came onto it she saw the nest, and running to it quickly, crept in.

July 11. Found her in the nest and let her alone.

July 12. She deserted her eggs and could not be persuaded to return to them.

Astia vittata, 2. On July 13 the spider laid her eggs and took her place under the web. She did not come out on the 14 and 15 although gnats were put into the box.

July 16. Pushed her from the nest. She ran to the far side of the box where she caught and ate a gnat. At the end of an hour she returned to her eggs.

July 17. Removed her from the box, surrounded her nest with pink paper, and put her into the box again, five inches away from the nest. She seemed to see it and ran toward it, but stopped at the edge of the paper, and lifted her head as though studying the situation. She then crept under the paper where it was loose, and so into her nest.

July 18. Pushed her from the nest and pressed the paper down so that she could not creep under it again. While doing this we accidentally closed the opening into the nest. The spider soon returned, crossed the pink paper, and tried to get into the nest. She worked for fifteen minutes trying to force an entrance, going all over the nest, poking and working at the web with her first legs as though trying to tear it. She did not seem to use her falces. Some gnats were then put into the box, and while she was eating one we cleared the opening to the nest. She soon returned and went in.

July 19. Took the spider from the box and removed the pink paper. Then put her back but she would not go back to her eggs although she was pushed close to them. We then replaced the pink paper. She seemed to notice it—ran onto it, and finally settled down under the edge where it was a little loose, but did not go back into her nest.

July 20. Found her wandering about the box and could not make her take any further interest in the eggs.

Astia vittata, 3. A box was prepared by papering the four corners, respectively, with blue, pink, red and light green paper. A clear space was left in the middle of each so that the spider could attach her nest to the sides of the box. On July 25 the spider was put in.

July 27. The spider built her nest and laid her eggs in the middle of the green paper.

July 28, 29 and 30. Pushed her out of the nest and let her find her way back across the green paper.

July 31. Took the spider out and substituted blue paper for green around her nest, putting green around an artificial nest in another corner. Put her in two inches from the green paper. She ran onto it, and stayed on or near it for half an hour, not, however, touching the cotton. Once she wandered off in the direction of the blue, but soon returned. After an hour and a half she went up to the cotton and made three vain efforts to get under it, lifting it with her front legs and pushing her head under. She then left the green paper. We guided her to the blue, which surrounded the true cocoon, but she would not stay there. After some wandering about she went on to the green again and once more tried to get under the cotton. We then pushed her on to the blue and she ran to her nest and seemed to be trying to get in, for a moment, but then ran away. We tried several times afterward to make her go back to her eggs, but in vain.

Astia vittata. 4. This spider was put into a box which had been papered with the four colors, as in the last experiment, and she also laid her eggs in the green corner.

On July 27, 28 and 29 she was pushed from her nest and allowed to find her way back over the green.

July 30. The spider was taken from the box while red paper was substituted for the green around her nest, the green being transferred to a false nest in another corner. She was then put in at a distance of three inches from the green paper. She moved toward it, and stayed near it or on it for half an hour, looking at the cotton but not touching it. She then made many attempts to get under the cotton, walking over it (with difficulty) and pushing her head and first legs under the sides. She finally settled down under the edge of the green paper. At the end of an hour and a half she was guided gently to within three inches of the red paper. She looked toward it for a few minutes and then turned away. She was then guided to within two inches of it. She again looked at it, but left it, returning to the neighborhood of the green. After some time she crept on to it and tried again to get under the cotton. She was then guided to the edge of the red paper. She looked toward her nest but then turned away. She was then pushed to within half an inch of her nest when she ran to it, and beat it excitedly with her first legs. She then left it and ran to the further side of the box, in the direction of the green paper. When five inches distant from it she paused, and then crept slowly on to it and remained quiet. She was then taken out of the box while the green paper was restored to the true nest, the red paper being put back into its former position, and the cotton nest removed. She was put back near the green paper, but wandered about the box for two hours. She then re-entered her nest and resumed the care of her eggs.

Astia vittata. 5. This spider laid her eggs in the corner of the box which was surrounded by pink paper. They were laid on August 6. On August 7 and 8 she was pushed out of the nest and found her way back over the paper.

August 9. The spider was taken out and yellow paper substituted for the pink, which was transferred to an artificial nest. The spider was put back close to the yellow paper. She ran at once toward the pink, but before reaching the edge retreated, backing away as though she noticed something wrong. She then approached again, but again retreated.

We left her in the box for two days, but she did not return to her eggs, nor pay any especial attention to the artificial cocoons.

Phidippus morsitans. 1. The spider laid her eggs on June 20, in the corner of one of our small boxes. We at once pasted pink paper around the nest. On July 21, 22 and 23 she was (with difficulty) forced out of her nest and allowed to find her way back over the pink paper.

July 24. We took the spider out of the box and substituted blue paper for the pink around her nest, pasting pink around an artificial nest which we fastened in another corner, and putting a second artificial nest in another corner with no paper around it. We then dropped her in near the cotton which had no paper around it. She did not notice it, but ran violently across the box, across the blue paper, and into her own nest. Being pushed out, and away from the blue paper, she ran onto the pink paper and all over the cotton in the middle of it, although it impeded her very much, trying to get into it or under it. After three minutes of this she went away. She soon found her own nest again and ran into it, but was again pushed out. She ran about the box for some time, going close to the pink and to the blue paper without seeming to notice them. At last she went onto the pink paper and made two faint at tempts to get under the cotton. Then she found her own nest again and worked for a long time trying to get into it from the top and through the front surface, the large opening which she had been in the habit of using being at the bottom. She not only tried to work her legs in, but seemed to be tearing at it with her falces. Then she hung by the posterior end of her body and tried to work her head in. Failing to make an opening, she finally entered by the door at the lower end, but only stayed a minute. She wandered out and passing the plain bunch of cotton seemed to look at it, but did not touch it. After an hour she went back to her own nest, but passing over the entrance, burrowed and tore at the other parts. She seemed to have lost her wits. She finally entered at the proper place.

July 25. We found morsitans wandering about, and guided her toward the pink paper, which had originally surrounded the true nest. She seemed attracted and went to it, and spent fifteen minutes in investigating the cotton by means of her front legs, but did not try to get under it. She then walked slowly away. On coming within three inches of the blue paper she seemed to notice it, walked to it and put her head into the door of her nest, but then withdrew it.

She was left for several days in the box, but manifested no further interest either in the cotton or in her own nest.

Phidippus morsitans. 2. This spider laid her eggs on July 23. We at once pasted pink paper around the nest.

July 24. She was orced out of the nest by pressing a pencil on to it from above. She stayed out for two hours and was then guided back to the entrance.

July 25. When pressed out of the nest she seemed much terrified. She is more nervous than vittata, but at the same time is more inclined to fight, instead of running away. When she does turn tail she rushes off blindly. She stayed out so long that we finally guided her back to her nest, and even then she burrowed and worked over it for a long time before finding the door.

July 26. She was forced out, and in twenty minutes found her own way back.

July 27. Forced her out and to the other side of the box, but she at once returned and entered the nest.

July 28. We took her out and substituted red paper for the pink, putting the pink around an artificial nest in another corner. When she was dropped into the middle of the box she at once ran to the red paper and on to her nest. She was pushed away, and then ran over the pink paper, stopping to touch the cotton with her front legs, but quickly left it and returned to the red. She stood for some time on the paper and then crawled into the nest. We then removed the pink paper and the cottton.

From this time up to August 4, the spider was forced out of her nest every day and found her way back across the red paper.

August 5. The spider was taken from the box and yellow paper substituted for the red, the red paper being put around a false nest in the corner diagonally opposite. When put back she ran to an empty corner and stood there, looking back and forth from the red to the yellow, and from the yellow to the red, for twenty minutes, lifting her head high, and really seeming to study the situation intelligently. At last she started for the red paper; then looked back, turned and went nearly to the edge of the yellow; then turned and walked slowly toward the red—backed away—approached—turned away—came back, and then retreated to the empty corner. After fifteen minutes she walked on to the red paper and approached the cotton nest with her front legs raised in the attitude of defense; then she backed off to the edge of the paper, and then again approached, as if fearing an enemy. She then left the red paper, went to the yellow, and for ten minutes seemed to be trying to get into her nest, after which she went back to the unoccupied corner. After ten minutes she walked to the edge of the yellow paper and then to the edge of the red, and then went back to her corner. Ten minutes more, and she seemed to have made up her mind, for she walked directly to her nest and entered it.

The spider now had a lesson every day for a week, being forced out of her nest and to the other side of the box, and left to find her way back. She always went back to her eggs, staying out sometimes only a few minutes and sometimes one or two hours. She took water but no food.

August 13. The spider was taken from the box and the papers around the false and the true nests were exchanged, the red being put back around the eggs, while the yellow was put around the cotton. This reversed the position that they had had since the last experiment.

The spider was then put in at the edge of the yellow paper which she was now accustomed to seeing around her nest. She remained motionless, looking at the cotton for three minutes, and then approached it with her first legs raised. She had not taken this attitude before since the last experiment, having constantly passed and repassed the cotton nest surrounded by red paper without noticing it. She walked around the cotton without touching it, then left it and went toward the red paper. On reaching the edge she turned and went back to the yellow and went close to the cotton without raising her legs, and then went back to the edge of the red paper. After standing there a moment she returned to the yellow and walked all around the cotton, feeling of it with her first legs. She then went to an empty corner of the box where she remained for thirteen minutes. At the end of this time she went to the yellow paper and took one more look at the cotton, and then turning to the red went on to it and into her nest.

Xysticus ferox. We had expected that this species would be an especially convenient one for these experiments as instead of fastening its cocoon into some corner it places it upon a flat surface and then holds on to it without any covering for itself. We thought that circular bands of colored paper could be dropped so as to surround her, and could be changed from time to time very easily, but she was timid and easily disturbed, and deserted her eggs before the necessary lessons preliminary to the experiment were over.

The paper used in these experiments was of medium weight, smooth but not glazed. The green paper in which two individuals of Astia vittata laid their eggs was of a light shade which did not at all resemble the green of grass or foliage, so that they cannot have chosen it as a familiar color.

Phidippus morsitans seemed to recognize her cocoon by sight more quickly than Astia vittata. It must be remembered, however, that she is a much larger spider and makes a very much larger nest. Moreover, the nest is not only conspicuous for its size, but is very difficult to imitate in cotton, as its silky, sticky texture catches and holds many little particles of dust and dirt, and it thus has a very characteristic appearance. One other circumstance that helped her was that she, although larger than vittata, was placed in a much smaller box.

The boxes in which the spiders were kept were moved about every day, so that the corner in which the nest was placed bore no constant relation to the points of the compass. This factor, therefore, could not have influenced the action of the spiders.

The idea of surrounding the cocoons with colored paper was suggested by our success with similar experiments on the nests of ground wasps. We found that if we placed a large sheet of colored paper with a hole in the middle over the entrance to the nest, Vespa germanica learned within a few hours to associate the color with the nest, and so strong was the association that when the paper was removed to some distance on the ground and a second sheet of a different color substituted for it, the wasps followed the paper to which they had become accustomed and were some time in discovering where their nest actually was.[21]

We have found it difficult to devise tests which will yield positive evidence concerning the sensations of spiders and especially to determine whether they have a perception of color. The experiments which we made with colored glass[22] were open to objections of which we were fully conscious, and those which

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[21] Some Observations on the Special Senses of Wasps. Proc. Nat. His. Soc. of Wisconsin, April, 1887, p. 91.

[22] Mental Powers of Spiders, loc. cit., p. 404.

are here described are far from being conclusive, but it seems to us that since the evidence must, from the nature of the subject be cumulative, they are of value. We, ourselves, are of the opinion that all the experiments taken together strongly indicate that spiders have the power of distinguishing colors.

Milwaukee, Wisconsin, Nov. 20, 1894.

POLITICAL CORRUPTION—AND ENGLISH AND AMERICAN LAWS FOR ITS PREVENTION.

BY CHARLES NOBLE GREGORY, A. M., LL. B.
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Dining at the City Club in New York some months ago I saw on my plate the crest of the club (copied from the old seal of Manhattan), as Wm. Allen Butler says of such heraldry,

"*Gleam through the soup and glimmer through the gravy.*"

Speaking at the club the next day, on the same topic I have to-day, I told them I noticed that their crest consisted, of a spread eagle, a windmill and a barrel; that out in Wisconsin we still cherished in political campaigns the spread eagle and the windmill as legitimate aids, but that we were making an earnest attempt to do away with the barrel in politics.

I refer to this because what I have to say to-day is a part of that attempt.

I am frank to say that I accepted the courteous invitation of your president with especial pleasure, because it gave me the opportunity of discussing with you the necessity of doing away with the barrel in politics, and the best ways yet found by English-speaking men for so doing.

No man can carry a reform alone. All he can do is to win the sympathy and aid of good men for it and let their joint action carry it. It is especially to young men that we must turn to reform old standing wrongs. When one of these is ended we can generally tell of its fate in those well known words from the story of Ananias "and the young men arose, wound him up and carried him out and buried him."

There is a regular progress in moral development. There are times and seasons in economic and civic reforms, which it is wise and convenient to regard. Efforts for any especial right or to amend any especial wrong, are more efficient and salutary and their results more permanent when they are a part and culmination of a large movement and when needed preliminary reforms have been accomplished.

The foundation must be looked to by the law maker as well as the house builder.

I take up Political Corruption in Politics and Laws for its Prevention now because I believe it timely.

It has for fourteen years past greatly engaged the wise attention of English law makers, and during the past three years many bills have been offered, some excellent laws passed and much public discussion evoked on the subject in our own country.

The passage of ballot laws of the Australian type in many of our states has greatly reduced the old interference with the freedom of voting and made the buying of votes less satisfactory. It has moreover made the printing of the ballots a public charge and justly relieved candidates not only from the actual cost, but from the far more onerous constructive cost, of printing and distributing the ballots. This was the old plea under which heelers and committee-men of every rank bled the candidate's pocket and the candidate's friends, but our present law leaves the custom as obsolete as a last year's athlete. Many who have always a specious pretext for smothering reform, urge that nothing more is needed; that no man will buy votes under a system which prevents him from seeing them delivered. But that there is honor among thieves is proverbial, and in England, where the ballot is traced by a counter foil, in case of fraud or bribery, it is found that, even under an Australian law, the vote generally follows the bribe.

The natural supplement to ballot reform has proved in Great Britain and in several of our states a Corrupt Practice act. "The two great natural and historical enemies of all republics," says Mr. Justice Miller, perhaps the ablest jurist who has in recent years served on our Federal Supreme bench, "are open violence and insidious corruption," and in the order in which the judge names them they menace the freedom and purity of the ballot, the chief support of republics.

At first men take their meat with spear and bow, later they buy it. The beasts of the field have no commerce, the ruder tribes of men but little. Force is their sole resource. But in later soeiety, "when men change swords for ledgers," violence disappears and barter and purchase take its place. So the story of the interference with voters begins with force and domination and ends in bribery. We early find a Duchess of Norfolk demanding that her Lord's menial servants be returned to parliament and the King's letters directing the sheriff to return such as his privy councillors might nominate.

In Jack Cade's Insurrection, the commons of Kent complained from Black Heath that they could not have their free election "but letters beene sent from diverse estates to the great rulers of the countrie, the which embraceth these tenants and other people by force to choose other persons than the common's will is." And certain freemen of Huntington protest in the same year against the return of two Knights of the Shire and complain of armed interference at the polls and say "so we departed for fear of the inconvenience that was likely to be done for manslaughter."

Pelham and the Duke of Grafton brought armed forces to the Hustings to intimidate the opposition, and when Willian Pitt was prime minister, guards and sailors surrounded the polling place in support of the court candidate and menaced all who opposed.

The best witness of the old wrong and the old fear is the law still on the statute books of our own and most of our sister states forbidding the parading of the militia, the modern representatives of force, on election day or for a certain time before. But the temper of the world has changed. A military officer is of little consequence now except in a Washington drawing room. Wars now are won, not by great generals, but by good financiers. It is a question of supplies rather than of hardihood or heroism. As Lecky points out, the rich commercial nation is most potent even in war, because it alone can provide the equipments for a great campaign. Just so, money or money's worth has taken the place of direct force in controlling political action, and the danger which our time must meet is corruption, not violence.

Great offices are got, not by great characters, but by great bank cheques, and as has been well pointed out, many senators of the United States(if we may judge by the history of our own state about 50 per cent.) cannot with entire delicacy refuse their ratification to the purchase of public places when they recall that they themselves climbed the golden stair to greatness. When cabinet offices are given, like prizes by popular newspapers, to the persons obtaining the largest number of subscriptions, and the new dignity of ambassador of the United States is saved from barter merely because public opinion is higher and stronger than the opinion of either the Casino at Newport or of the seat of government at Washington, then we must conclude that our institutions suffer, though under illustrious control, from the touch of gold and not the stroke of steel, and that they need statutory protection.

Among men of our race it is 323 years since the political conscience was stung with the sin of venality in elections and stirred in its sleep.

In 1571, for the first time, a fine was imposed for bribery in parliamentary elections. It appears by the journals of parliament for that year that Thomas Lang, returned for Westbury, "being found a very simple man and not fit to serve in that place was questioned how he came to be elected" and the poor man immediately confessed to the house that he gave to Anthony Garland, mayor of said town of Westbury and one Watts of the same, four pounds for his place in parliament.

An order was forthwith made that the town officers refund the £4 to the bribing member and the corporation was fined £20 for the scandalous attempt, but the corrupting Thomas was left "unwhipt of justice." Parliament, like the devil, and other powers, took care of its own even in this spasm of virtue: but this proceeding, not ideally fair, seems to have had but little effect.

When by a peaceful revolution constitutional monarchy was founded in England in 1688, the famous committee of the commons, headed by the wise and patriotic Sir John Somers, afterwards the great Chancellor, demanded among other great reforms, "that the buying and selling of offices . . . be effectually provided against," and William of Orange came to the throne pledged to the redress demanded.

But in 1701, De Foe, dear to all men as the author of Robinson Crusoe and his man Friday, complained that stock jobbers sold seats in parliament and that the regular price was 1,000 guineas. In 1716, the Earl of Dorset said it was a notorious fact "that a great number of persons have no other livelihood than by being employed in bribing corporations."

In 1754, thirty-eight years later, Sir J. Barnard moved the repeal of the oath against bribery just prior to the elections in the interest of public morals, as it was merely the occasion of general perjury. In 1766, the borough of Sudbury publicly advertised its representation for sale. A year later, that Lord Chesterfield, whose most private family letters have been made very public and whose admirable public administration of Ireland has been made very private, wrote that he had offered £2,500 for a seat in the parliament for his son, but the borough jobbers (then a well known class) laughed at him and quoted rates on safe seats at £3,000 at the lowest, many at £4,000 and two or three that they knew at £5,000, and he adds: "This I confess has vexed me a good deal." Still a year later came the famous "Spendthrift Election" where three Earls contested for their several candidates the county of Northampton. Lord Spencer is said in this election to have expended £100,000 and Lords Halifax and Northampton each £150,000.

The result was a tie decided by toss in favor of Lord Spencer, who chose to seat a man from India.

Lord Halifax was ruined and Lord Northampton cut down his trees, sold his furniture at Compton-Wyngate, went abroad for life and died in Switzerland.

In the same year Oxford, that venerable seat of learning, offered to re-elect the sitting members provided they would pay some thousands of pounds bonded indebtedness of the corporation. The members declined and complained to the house, and in consquence the mayor and 10 aldermen of Oxford were committed to Newgate but finally discharged with a rebuke from the speaker. However these indefatigable corruptionists actually closed a bargain while in Newgate walls and sold their representation to two neighboring nobleman, his grace of Marlborough and Lord Abingdon, and the matter was laughed at and forgotten. When Sheridan, that most brilliant of Irishmen, was a candidate for parliament at Stafford, his independent electors cost him five guineas per burgess, and the humane Wilberforce, the friend of the slave, found four guineas the price at Hull. Southey says it rose to £30 a vote at Ilchester. When Wilberforce, in 1807, fought what has been called the "Austerlitz of Electioneering," the candidates between them expended above £300,000, in round numbers a million and a half of dollars, and Sir Henry James tells of a gentleman contesting a cathedral town in 1826, who spent £86,000 mainly in ribbons, refreshments and music. According to Prof. Huxley, four-fifths of the seats in the house of Commons were more or less openly dealt with as private property.

When Wilberforce, one of the highest types of his time, was a candidate for parliament, his sister, speaking at the hustings, promised a new dress to the wife of every elector who supported him, and Mr. Gladstone's own early elections are said to have been characterized by as questionable practices. These are examples of the old system which has begun to disappear. Everything was sold in the old days. Lord Chancellor Bacon sold equity; Lord Chancellor Macclesfield sold places. The great and good Montesquieu defended the sale of all public places by the state on the ground that if the state did not sell them, those controlling them would. In England even the dignities and emoluments of the church were formerly bought and sold as freely as the right to misrepresent the people in parliament, and within most of our memories commissions in the British army were as much a matter of barter and sale as the contents of a junk shop.

One by one these old abuses, these "errors" which "though hoary are errors still," are sloughed off by advancing civilization. In the days of our grandsires, the "good old days," a deacon could go to bed mellow six nights in the week without scanda or abatement of fervor in his "amen" on the seventh; but some extremist would find fault now. Just as intemperance was universal, unquestioned and almost unnoticed a half century ago, so was the universal sale of place and power and rights and justice a little carlier. We are just learning that there are better titles to all these than "titles by purchase."

The great first step toward purifying elections has always been the widening and not the narrowing of the suffrage. It has always been more convenient to corrupt a half dozen great gentleman aud landed proprietors than 1,000 starving weavers, and the Reform bill which did away with old Sarum and other rotten boroughs and the various extensions of the suffrage in England, which have made it, in some ways, wider than our own, have struck strong blows at the purchase of elections.

The removal by Lord Palmerston's famous order in council of May 21, 1855, of the civil service from political control took off perhaps the greatest of all baits for corrupt and venal activity in elections.

A member of parliament is absolutely stripped of the power to obtain, or even speciously to pretend to obtain, paid public place for his supporters. He must solicit their suffrages with something beside the promise of influence and the hope of fat jobs. We still cherish the right of our representatives to corrupt us by patronage, to our shame be it spoken.

A year earlier than Lord Palmerston's courageous order, there had passed "An act to consolidate and amend the laws relating to bribery, treating and undue influence in elections of members of parliament." This statute imposed heavy fines and penalties upon any *candidate* convicted of treating or bribing, or even furnishing a cockade or badge, and provided fully for publicity as to all the election expenses of the *candidate* but did not deal with the errors of those not candidates, and it was naturally ineffective. In 1868, an act was carried by Mr. Disraeli providing for the trial of election petitions by certain of the highest ges, instead of a committee of the house, and this did much to assure a fair judicial determination to such contests and so discourage corrupt practice.

"In 1869, however, a committee was appointed with Lord Hartington (the present Duke of Devonshire) at its head, "to provide further guaranties for the tranquility, purity and freedom of elections." In an investigation of three months' duration this committee unearthed widespread and continuing corruption, and the commission being continued, in 1870, reported in favor of a ballot act which became a law in 1872, and this was revised in 1878. These laws are based on the South Australian system and resulted in at least reducing the intimidation of electors. Since their passage a landlord or employer does not own the votes of his tenants or employes and cannot poll them. But we need not discuss the provisions of these wise laws as our own state—thanks especially to the enlightened labors of Senator, now Congressman, Cooper of Racine, to whom the voters have said "well done thou good and faithful servant"—thanks to him, our state enjoys an admirable ballot and election law.

Milwaukee, where such just men were in charge of politics that many of the safeguards could be dispensed with which were needed by less civilized portions of the commonwealth, was excepted from this law until the last session, but it now applies to all the state.

"Notwithstanding all that had been done, corruption in the English elections continued widespread and flourishing and seemed to warrant Lord Grey's fear that the new reform act would substitute for the old family influence in elections "the bare influence of money in its lowest and most degrading form." In April, 1880, a general election took place. Numerous petitions against the returns were presented, and as the trials proceeded it became evident, says Sir Henry James, "that corrupt practices had in no way diminished"—nine thousand electors in eight of these contested constituencies investigated were scheduled as guilty of corrupt practices. The matter was investigated by royal commission, and when parliament met in February, 1881, Mr. Gladstone's government devolved upon its attorney general, Sir Henry James, the duty of preparing and carrying a measure adequate to correct the evils complained of.

One afternoon at the end of June in 1883 (if a personal reminiscence may be permitted), it being his first day in London and having been to call at the legation of the United States as became a good Yankee, the writer of this dismissed his cab and started to stroll back to his hotel. Presently Westminster Abbey and the parliament buildings loomed up before, delighting him with their noble outlines and their still nobler memories so closely interwoven with the history of our race and our institutions. He walked up the great hall of William Rufus, whose oaken roof had echoed to the coronation festivities of many kings and to the death sentence of one, to the eloquence of Burke and Fox and Sheridan at the trial of Warren Hastings, and whose walls were adorned with the marble effigies of the monarchs of Great Britain, and remembering, even amid these inspiring scenes, the practical aphorism whispered by a fellow traveler that any one in England from the Prince of Wales down will take a shilling in his palm in exchange for a favor, he gave the policeman on guard a little silver to get a permit from a member to visit the house of commons. So he presently found himself in the strangers' gallery, listening to a debate, and there staid till late in the night. The two principal figures in the debate were Sir Henry James, attorney general, and Sir Farrar Herschell, solicitor general, now Lord Herschell and lord chancellor. They were advocating and defending in the style of an animated conversation the present Corrupt Practices Act of Great Britain, drafted by Sir Henry, and for which he had then battled for two and a half years, and which with some modifications, passed in the succeeding month, and became a law, being known as (chapter 51, 46 and 47 Victoria (A. D. 1883), "An act for the better prevention of corrupt and illegal practices at parliamentary elections."

This great statute, which marks perhaps the highest achievement of legislation against electoral corruption, covers forty-three printed pages and is substantially the present law. It makes treating by any one, a candidate or not, for corruptly influencing voting an offence by all parties to it, and under this clause Mr. Clayton, who had paid £326 for bills contracted by the conservative association of his district for treats, excursions and picnics enjoyed before his candidacy, was held guilty and unseated after the last election. It provides against any threats to intimidate voters of any kind, either of spiritual or temporal injury, and under this clause Patrick Fullam, anti-Parnellite of South Meath, was after the same election unseated by two judges, one a Roman Catholic, on account of the interference of the clergy in his favor,—among other incidents it being reported that a priest refused the sacrament to a dying woman unless her husband would vote for Mr. Fullam.

No payments for bands of music, torches, flags, banners, cockades, ribbons or other marks of distinction are allowed, but voters must decide important issues without these intellectual aids which we have always deemed essential supports of political conviction. Under this clause Mr. F. James of Walsall was after the last election unseated, his agent having furnished six thousand cards with his picture to the electors, to be placed in the hat, inscribed: "Vote for James, we're bound to win."

The agent, who was Mr. James' son, pleaded that he did not know the law, but this was held no excuse.

All the above provisions are important and salutary, but the machinery for limiting election expenses, making them public and confining them to innocent purposes, is the particular glory of the act.

In the first place it requires the candidate to name in writing an election agent. All contracts as to any expenses in the election must be made by the agent, and all expenses incurred or moneys advanced for the election must be by him, except the personal expenses of the candidate.

Every payment of over forty shillings must be shown by a receipted bill giving the particulars. The candidate, however, may disburse not over £100 as personal expenses, but anything over that must be paid by his agent, and he must furnish a written statement, even of his personal expenses, to his agent.

Within thirty-five days after the candidate is declared elected, the agent must file in a public office, a statement of all payments by him made, of the personal expenses of the candidate and a statement of all money, securities and equivalents of money received by the election agent from the candidate or any other person for the purpose of the election.

The candidate as well must make a return under oath of all expenditures, and the latter forfeits 100 pounds per diem for every day he sits or votes in parliament after failure to comply with this provision. To make a knowingly false declaration is wilful and corrupt perjury and also a corrupt practice. A summary of the return of election expenses is required to be published in two newspapers. All documents as to an election are kept for two years open to public inspection. A justice is to be removed, a barrister or attorney dealt with for professional misconduct, a licensed victualler reported for participating in any illegalities under this law. A list of persons disqualified to vote by corrupt or illegal practices is certified to every parish in the county or borough, appended to the list of voters and published with it. If corrupt practices have extensively prevailed, the court may charge the costs of the petition in whole or in part on the county or borough, or on any one guilty. No witness is excused from testifying on the ground that it will incriminate him, but may have a certificate of indemnity if he answerr truly. The act moreover limits the expenses to a moderate maximum determined by the number of electors registered. In a borough in England if the electors do not exceed 2,000, it is limited to £350, and £30 is added for every 1,000 electors over 2,000. In Ireland the limit is somewhat lower. In a county the maximum of expense allowed is nearly twice that in a borough of equal voting population.

The law came into operation October 15, 1883. It is addressed to men's interest, to their fear and to their consciences. It compels integrity in elections by loss of political rights, by severe criminal penalties, and by the further exposure of the offender's name to public obloquy, and it searches his conscience and that of his agent by the most exact statements made under oath and accompanied by vouchers. It deserves to be effective and it has been so.

Says the editor of one of our most valued magazines, the Century: "It is true that the English act is long, but it is also true that it was so completely successful from the moment of its application to an election that it abolished corruption and bribery at a single blow."

All prior acts had failed as we have seen, to stop the tide of corruption, ample though they seemed. The expenditures in large constituencies ranged from $10,000 to $35,000 for each candidate, and men of moderate means were as thoroughly excluded from parliament as from our United States Senate.

At the first election after Sir Henry James's act became a law the expenses at once declined from $15,000,000 to $3,900,900, but little over one-fourth as much, and corrupt practice was charged in only two cases instead of ninety-five as at the last preceding election.

At the next election, in 1886, there was a still better showing, and the aggregate expenses of the election in England were but little over one-half the maximum allowed; in Wales, less than one-third. In this election there was not even a single charge of corrupt or illegal practice.

After the next and last election, that of 1892, there were seven petitions alleging corruption in England and three in Ireland. Three of the English petitions were successful and two of the Irish, the latter both on account of the interference of the clergy.

According to Sir Henry James's best memory, no member has been unseated for bribery under this law and not a solitary victim has been entrapped and no difficulty has been found in following and carrying out the prohibitory provisions of the act.

Canada, in chapters 8, 9 and 10 of her revised statutes of 1886, has admirably followed the English precedent and with excellent results.

These acts cover eighty-nine pages and though in some respects different, follow the main lines of legislation on these subjects laid down by the home parliament and with results most satisfactory.

The several states of our own country have for many years had upon their statute books formal and useless enactments against bribery in elections. They simply denounce a penalty against the offense but make scant provision for their own enforcement, and call for no publicity in election expenditures and for no reports from candidates or committees. They have proved about as efficient as the moral sentiments in a copy book or a worsted motto on the wall.

Our first serious attempts at legislation on these subjects, somewhat on the English line though with much less elaboration and thoroughness, appear in a law of Colorado (p. 167) for 1891, and No. 100, Public Acts of Michigan for the same year.

These are full and precise against bribery and require return of expenditures from the candidate, and also, the Colorado law, from the chairman and secretary of every state, county and city central committee, the law of Michigan from every chairman of a state, district or county committee.

The Michigan law forbids the furnishing of any money for procuring the attendance of voters at the polls or contributing money for any other purpose intended to promote an election of any particular person or ticket except for defraying the expense of printing and the circulation of handbills and other papers previous to any such election, or for conveying sick or infirm electors to the polls.

The Colorado law makes its violation a misdemeanor.

The Michigan law makes its knowing violation a felony punishable by a fine not exceeding $1,000, or imprisonment not exceeding two years or both at the discretion of the judge.

Of these laws the Michigan seems the more complete and efficient, but certain named committees being alone required to report, other committees could always be organized for objectionable or secret work and no reports from them could be compelled.

Chapter 693, Laws of New York, 1892, provides a penalty for bribery, intimidation, coruption or political assessments, and requires further that candidates but not the committees shall file sworn statements of all moneys contributed.

The defect of the New York law is obvious, and Dr. Jenks, in the Century for October, 1892, says of it, with justice, that though good, as it stands alone, it is of course of little influence, for the candidates pay large sums to campaign committees that are irresponsible.

J. B. Bishop in the Forum of April, 1893, says: The weakest of our American laws to restrict the spending of money for election purposes is that of New York, and Hon. Josiah Quincy justly calls any statute like it wholly abortive.

It has proved a false guide and model to ill-informed reformers in our own and other states, and laws drafted on its lines have been used by sham reformers as stalking horses from which to kill off more thorough measures which they dread.

Chapter 416, Acts of 1892 of Massachusetts, rather passes the others in efficiency and completeness. It was drawn by experienced and earnest reformers after a careful study of the English act.

It forbids a candidate to pay money to promote his own nomination or election exept his own personal expenses and voluntary subscriptions to a political committee. It makes every combination of three or more persons to promote or defeat any candidate's election a political committee and compels it to choose a treasurer who must receive and disburse all its funds and report them if they exceed $25, and any individual receiving or disbursing money for election purposes to the amount of $20 must also report.

This brings us to the enactments of the past two years. To ascertain these late laws after the close of the sessions for 1893, letters of inquiry were addressed to the secretaries of state of our fifty states and territories (omitting the District of Columbia) enclosing stamps for replies. Including my own state, obliging replies were received from forty-five states and territories. Letters were again addressed to those secretaries who did not answer the first letter, but proved wholly insufficient to merit the kindness of a response from Florida, Mississippi, Texas, New Jersey and Oklahoma. In Alaska there are no election frauds or laws to prevent them simply because there are no elections.

From the answers received, it appears that forty-one states and territories had not revised their law in this respect during that year, except at least in minor details; that a bill on the model of the inefficient New York statute was passed by the senate but killed in the assembly of Minnesota, and a like bill was passed by the senate and in like manner defeated by the assembly in Wisconsin, and that in the latter state another bill shaped on the Massachusetts act was introduced in the senate but received no support in either house, being opposed as "bothersome," and was simply bagged by a senate committee till near the end of the session without report, quite like a campaign fund. In the legislature of Nevada, after a particularly expensive campaign, a bill was introduced, requiring the publication of election expenses, but received only one vote. All honor to that one voter.

On the other hand Michigan revised her already good law and a corrupt practice act modeled somewhat on the Massachusetts law, was introduced into the legislature of Connecticut. This, as an original feature, classified all officers and limited the expenditures of candidates, aspirants for governor, the highest class, being allowed $600, and school officers, the lowest, $50 as a maximum, but the bill failed to pass and was referred over to the legislature of 1895. To Kansas, California and Missouri, three states all west of the Mississippi and having some reputation for train robbers, belong the good work of the past two years on this subject, the laws passed in California and Missouri approaching and perhaps surpassing Sir Henry James's act in comprehensiveness and efficiency.

The California law requires every certificate of nomination to candidacy for public office to be accompanied by a further certificate from the same source naming five electors who consent to act as a committee for the candidate and to receive and disburse all the funds for his campaign, and this committee has exclusive charge of all campaign receipts and disbursements.

They, and the candidate as well, must file sworn statements and show that there have been no illegal expenditures, and the candidate must also swear that he will give no further valuable consideration for any assistance in his election.

Candidates failing to make this report forfeit all right to office, besides other penalties, their official bonds cannot be approved, and their predecessors hold the offices.

No money is allowed to be expended except for specified purposes and all expenses are limited to a moderate percentage amounting commonly toabout 5 per cent. on the salary, but varying somewhat.

The district attorney is bound to prosecute all offenders under this act when duly notified and forfeits his office in case of failure to do so, and any citizen may employ counsel to assist in the prosecution. A penalty of one to seven year's imprisonment is provided for all payments or promises intended to corrupt electors or nominating conventions.

A committeeman making a false return is guilty of perjury, and the penalty is one to seven years imprisonment.

All furnishings of meat or drink, refreshment or entertainment to corruptly influence voters are made misdemeanors, and all threats or intimidation of voters to affect their votes and all intimations from employers to employes by pay envelopes or hand bills or placards threatening to cease work or lower wages in case of the success of any party or measure, are made misdemeanors and any corporation guilty of the same forfeits its charter, and a violation by a candidate of the provisions of the act forfeits his office and the forfeiture can be enforced at the suit of any elector.

This law covers seventeen printed pages and is divided into forty-two sections. It is somewhat novel in its features, but is well thought out, thorough and comprehensive, and gives promise of great efficiency. All persons interested in electoral reforms will watch its workings with lively and hopeful interest.

The golden state seems to have given us a golden law.

Chapter 77, Session Laws of Kansas, 1893, approved March 11, 1893, "An act to prohibit the corrupt use of money and corrupt practices at elections" seems modeled on the Massachusetts law mainly, and requires full verified statements from candidates and treasurers of all political committees alike. It prohibits candidates from giving away, directly or indirectly, cigars or intoxicating liquors on election day, and from giving away intoxicating liquors at any time to influence voters.

During the year of 1892 and prior to the autumn campaign the Civil Service Reform association of Missouri began a most judicious and effective agitation for the amendment of the laws of that state with reference to the use of money in elections. I venture to call attention to its methods and their results as safe models for us all in a work which I hope many of us will not refuse.

In September a printed circular signed by the officers of the association, calling attention in plain but temperate language to the evils of patronage and of the free use of money in elections, was mailed to some 5,000 citizen through the state. The circular reviewed the advantages of the Australian ballot system lately adopted in Missouri, and pointed out that it required as its supplement "legislation restricting the expenditures of candidates at elections." It announced that a bill for this purpose would be introduced in the coming legislature, briefly outlined its provisions and asked aid in affecting public opinion and in selecting representatives with a view to proper action on this subject.

When nominations were made letters were addressed to each nominee, enclosing a summary of the bill and asking an expression of his views on the subject, and many replies were received, mostly favorable. After election correspondence was opened with the members elected, criticism was evoked and the most effective advocates were discovered. The bill was finally placed in the hands of Senator Cochran of St. Joseph, and by his good management, carried in the senate.

A committee of the association including its president spent some days at the capital while the bill was under consideration, and made a personal canvass of the members. The result was there was practically no adverse vote, and a measure so complete and drastic that few would dare propose it was added to the statutes of Missouri and raised the standard of enactment in this respect for every state in the union.

I owe these interesting details to the courtesty of E. C. Elliot, Esq., of St. Louis, one of the committee which carried through this admirable work.

The law covers thirteen printed pages subdivided into 24 sections. The first section defines bribery at elections in a way to include all who effect or attempt the corrupting of an elector by money's worth or patronage or who accept such corruption, and makes it felony punishable by two to five years in the penitentiary and by a forfeiture of $500 to any one suing for it.

Any candidate who within ten days prior to a primary or sixty days prior to an election provides meat, drink or entertainment for any person to corruptly influence his vote is liable to a $25 fine for each offense. Any threats, fraud or duress to compel an elector to vote or refrain from voting in any way, are punishable by from one month to one year in the county jail. Candidates are forbidden to expend for election expenses more than $100 for 5,000 votes and for each 100 votes over 5,000 and under 25,000, $2; for each 100 votes over 25,000 and under 50,000 $1; for each 100 votes over 50,000, 50 cents, the number of votes to be ascertained by all votes cast at the last election.

Every campaign committee and candidate must, within 30 days after election, make sworn return of all expenses of his election contributed or promised by him and to the best of his knowledge by any one in his behalf. A candidate can have no certificate of election until such statement is filed, and he is liable to a fine of not over $1,000 for failure to file the same, and he can not enter on the duties of his office or receive any salary prior to such filing. At any time during the term the person receiving the next highest number of votes for the office may complain that the expenses of the incumbent for his election exceeded the lawful limit, or that votes for him were corruptly obtained by him or with his connivance or by his agents or the committee of his party.

If the attorney general fail within 10 days to bring the suit to vacate the office or to direct the proper county attorney to bring it, the petitioner himself may bring the suit.

If the charges are sustained, the court ousts the incumbent and, unless some unlawful practice is proved against the petitioner, awards the office to him.

No witness is excused from testifying on the ground that it will incriminate him. Any two or more persons raising or disbursing money for election purposes are deemed a political committee, and must appoint a treasurer who must keep and file sworn accounts under a penalty of $50 to $500 or of imprisonment of two to six months in case of failure to report after notice.

It is difficult to see where this law falls behind the English act, and in its provision that the candidate next in number of votes to the one having the majority may obtain the office by proving corrupt practice on the part of the incumbent, it seems more efficient than even Sir Henry James's act. Of course it is new and untried, and Mr. Brice justly says that our juries are more lenient, except in cases of offenses against women, than any European juries. We are loth to enforce the most just and deserved penalties against a fellowman, and in this respect contrast sharply with our English cousins. How far any law against electoral corruption will be enforced among us is a grave question, but this Missouri law seems drawn so as to make its enforcement by private interest probable, and it is a model from which all reforming legislators must now start when they deal with these questions. It takes the good points of the English law and adapts them to our more complicated elections and, at the same time shortens and simplifies the whole statute without in any essential emasculating it. A few days ago I asked Mr. Henry Hitchcock, the eminent lawyer and civil service reformer of St. Louis, and also asked the present mayor of St. Louis, how this law was working. They both told me that in their judgment it was generally complied with and was accepted without difficulty much like the Australian ballot. The mayor told me as an interesting and significant fact that he subscribed $250 for the expenses of his campaign and after the election the committee returned $100 of this. Yesterdays dispatches announced, however, that the grand jury at St. Louis returned fifty indictments for election offenses, an evidence that the law is violated but also that it is enforced.

So far for the laws with which English speaking men have sought to meet electoral corruption. I have only a word for the evil itself. That such corruption exists in all our communities every one who has touched practical politics knows, and that it masquerades under the specious pretext of legitimate election expenses. The periodicals have printed much on the subject during the past two years and various writers have tried to estimate the percentage of venal voters in some of our states or communities. Thus the *Century Magazine* printed an entertaining and ingenious article which intimated that in some parts of New York they exceeded the unbought voters. This statement seems to me more credible since a short time ago reputable neighbor of mine, lately resident in New York state, talking with me in my office, told me that he had been chairman of the republican committee of his old town in New York and at other times served on the town committee; that the town had about 900 voters; that one year he saw at the republican headquarters the list of voters and the price paid for those who were bought, and was the same year shown the like democratic list by the democratic chairman. Out of the 900 voters 446 were bought and paid for. The price averaged about $3 apiece but ranged from $1 to $10, and the buying was about equally done by both parties.

The system was for the workers to hold up their fingers to intimate the number of dollars they would give for a vote and say "I will make it all right for you." The different workers had differently colored cards and gave each bought voter a card with the number of dollars he was to have. The bought voter then called at the headquarters of the party and handed in this ticket over the shoulder of the paymaster who paid back the sum indicated over his shoulder without looking so that he could not identify the voter bribed. My informant said one year when he was on the town committee the two committees agreed to buy no votes and lived up to the agreement. Large numbers of the voters accustomed to be bought, came to town on election day and lay about all day for sale, and finally went home without voting, as they were not bought. He said further that a judge of the supreme court of New York residing in Plattsburg told him that at the last election held before the Australian ballot was adopted a voter at the polls in that city got on a chair and publicly offered his vote for sale to the highest bidder, and after a spirited bidding was paid $35 for it; which illustrates the advantage of sale by auction.

In Rhode Island the bought vote has been estimated at about ten per cent. In an open letter in the *Century Magazine* of November, 1893, Mr. Harrison, of New Hampshire, estimates the bought vote in his state also at ten per cent., though he says men best acquainted with the facts think this too low an estimate. He says further that the number of purchasable voters is increasing largely through the coming into the state of young French

Canadians, who do not at first consider their duties as voters seriously, and adds that very few Irish voters can be bought, and that most of the venal voters are broken down and degenerate New Englanders of pure American descent. He says he knew a New Hampshire man who sold his vote for $25. The man had considerable property and soon after applied for a loan at the bank. The bank president was one of the leaders of the party which bought the vote and replied: "No, he sold us his vote the other day; he can have no accommodations at this bank," and that it is a rule that those who buy votes despise those who sell them. I may add that I have had several interesting letters from Mr. Harrison lately telling me that he has brought on a general discussion and agitation of the matter in his state by this showing, and I learn that a Corrupt Practice act is contemplation.

Prof. J. J. McCook, in *The Forum*, on tabulated statements which seem fair and are certainly persuasive, finds about sixteen per cent. of the voters of Connecticut purchasable. In our own state, I do not believe so large a per cent. susceptible to financial persuasion, but I have known $15,000 spent on the municipal election of a small city, and we are still in the old way summoned on our allegiance to contribute considerable sums to various political committees which engulf everything and account for nothing. As at the den of the beast of prey of which Horace sings *Vestigia nulla retrorsum*, there are no returns. Having served four years on the Democratic congressional committee of this district, I recall two families of Dane county farmers where fathers and sons were understood to try to sell out to the committees of both parties in every campaign, and that the law for biennial elections seemed to them to most unjustly curtail the financial opportunities of the citizen.

Every candidate is taught that he must hire the local band to parade in a wagon bearing his sign, or the bass drum and the trombone and the whole army of harmony will vote against him. Every knock-kneed horse and rattling trap must be hired to carry voters to the polls, or the owners will take sweet revenge at the ballot box; and the candidate, even for judicial place, must visit the saloons and "set it up" for the crowd or the crowd will doubt his patriotism and his fitness for office. I well remember when I was a youngster, a long time ago, starting out one day to address a meeting in one of the remote towns of our county. The statute of limitations has run since and my youth was my excuse for too great compliance. The candidate for sheriff, an honest, kindly, silver-haired, whole-souled farmer famous for his big heart and his big short-horns, and several other county candidates, were of the party.

We drove through the little town of Middleton and were told we must visit all the saloons. "But," said I, "I don't drink." "Then you must smoke." "But I don't smoke." "Then you must take some pop, and if you don't it will be noticed and injure your father's chances." My father was the candidate of his party for congress. Finally, when we had visited all five saloons, and I had begun to lose my enthusiasm for pop, some one said there was yet another saloon. But we were promptly told that the woman who kept it had lost her husband and was a widow, and there was no voter there, and so the candidate for sheriff and his party did not darken that lone woman's door.

All these illegitimate expenses, which the reputable candidates would gladly be protected from, but which none but men of iron dare deny, the official must make up from his office by fair means or foul, and so it is that the liberal candidates who are so profuse in the campaign are so expensive in their term of office. It all falls back on our patient backs and we must sweat for their prodigality. Old St. Francis of Assisi used to preach to the beasts of the field and the birds of the air, and with loving humility he always spoke to them as his brothers, and so it once happened that he addressed a drove of donkeys as "my brother asses," and I will confess when I see with what dull, base patience we, my brother citizens and taxpayers, suffer these evil and corrupt customs whose burdens always fall on our backs at last, I feel that it would be right to address each other as "*brother asses.*" The wrong is upon us and the power to relieve the wrong is with us, and "*patience*" is by no means "*virtue*;" patience is nothing less than *sloth* and *cowardice.*

Abraham Lincoln is a name to charm with still, and how moderate Mr. Lincoln's ideas of expense in elections and how scrupulous and open his accounting was shown in his own congressional canvass. His friends raised $200 for an election fund and placed it in his hands. After the campaign "honest old Abe" explained that he would have returned it all but at one place he got cornered and had to buy a *barrel of cider*, and so he returned only $199.75. Apples were abundant; we were nearer the garden of Eden then than now.

When Hon. Horace Rublee, some years ago served as chairman of the Repubican State Central committee of Wisconsin, he, in a manner greatly to be commended, published a statement of the receipts and disbursements of the committee, and it is to be regretted that so desirable a practice has not become a custom The usage which a gentlemen lately holding the place of an assistant cabinet officer at Washington assured me prevails in the national committees of both parties is a sufficient commentary on their methods. At the end of the campaign they order their records burned. Nothing but fire can cleanse them. The only light they ever see is that of their own combustion. This is a branch of public business whose transactions can not be opened to press or people.

The base and vicious doctrine that though that it is wrong to buy votes, "if we don't the other side will," that we must "fight fire with fire;" that anything is right if it succeeds; these are all maxims of evil which sere and indurate the conscience and the heart. They sap the very foundations of integrity and ruin all that rests thereon. They touch with a lasting blight the roots of character and whether they are in the games of the boys or the work of the men, in the ball field or the caucus or convention or at the polls, they are knavish and unscrupulous and to be branded as such with "neither honesty, manhood nor good fellowship in them."

I do not so much value the penalties denounced in these new laws against bribe givers and bribe takers as I value the sworn reports of receipts and expenditures with vouchers, which are wrung from candidates and committees alike after every election. I trust much to these powerful search lights. I believe in fact that the prevalence of truth and justice in the world were assured when on that first day of recorded time God said "Let there be light and there was light.' I remember that the streets of our cities are perhaps quite as much redeemed from lawlessness by the lamp posts as by the church spires. In politics, where men rise by the formal approval of their fellows I do not believe that public and confessed corruption can have any continuing hold or advancement.

How small a percentage or corrupt change in the votes will effect results is surprising. Thus at the general election in Wisconsin for 1892, which was not considered a close election either, there were 371,559 votes cast for governor and the majority of our Democratic friend Governor Peck over our Republican friend Senator Spooner was 7,598. From this it is plain that a change of a trifle more than one per cent. of the voters would have defeated Gov. Peck, his doctrines and his party, and seated Senator Spooner and his friends. And as Gov. Peck's majority was larger in Wisconsin than President Cleveland's, a still smaller change would have reversed the result in the state as to the federal election. In 1884 when the national election turned on the majority in New York, a corrupt change of 575 votes, or less than one-twentieth of one per cent , in that one state, would have changed the whole national election at which over ten million votes were cast.

If ambitious and unscrupulous wealth is allowed to buy office there will too often be found this small percentage of degraded or necessitous voters who will sell votes enough to turn the scale, and the great body of honest men must submit to masters unfairly chosen and the mercenaries dominate the elections. We must hunt down and destroy these petty corruptions, to borrow a figure from the Plymley Letters, "as a burgomaster hunts a rat in a Dutch dyke, for fear it should flood a province." The Indiana law of 1889, just declared constitutional by the supreme court of that state, is worthy of consideration. It gives to any elector bribed to cast his ballot for a candidate, or sought to be bribed, the right to recover $300 damages and reasonable attorney's fees from any person who so bribes or seeks to bribe him, and thus makes it more profitable to prosecute than to take and hide the bribe. It punishes, too, the moneyed temptor and not the poor and needy victim of temptation.

The office which particularly allures wealth in this country is that of senator of the United States, as was planned and intended by the framers of our constitution who declared their purpose that the senate should represent the wealth of the country and resemble the English house of lords as much as possible; and this leads to a new form of bribery.

The great fortunes of the state vie with each other in disinterested contributions to the campaign funds of the several candidates for the legislature, and the representative of the people takes his seat in the legislative hall with a chattel mortgage on his body and soul held by this or that senatorial aspirant. The idea of barter and sale is scrupulously avoided in conversation and the contract is disguised under the words gratitude and party service. This is not unwhispered of in most of our states, and if the practice exists, such a search light as the Missouri law will help to reveal and amend it. If our legislators are sold to rich buyers, let us insist on knowing the price and the purchaser.

If such dealings are blameless there is no harm, if guilty there is great good, in publishing them. The methods of an honest election can stand like primeval innocence "naked but not ashamed." Bills for corrupt practices acts will be offered this winter in New Hampshire, Connecticut, Rhode Island, Pennsylvania, Delaware, Illinois, Minnesota, Wisconsin, and I know not how many other states. I am in receipt of letters from many sources asking advice in framing these acts. A public spirited and experienced senator has offered his services in support of such a measure before our own legislature.

I hope Wisconsin will not fall behind her sister states in this matter, and that as the old barbarous and historic and universal way of buying places in the church, of buying commissions in the army, of buying appointments under the government, of buying justice from the courts—as these have been swept from Anglo-Saxon practice and tolerance, so the still-existing practice of buying elections, of buying the right to misrepresent the people, may be swept from our practice and our tolerance, and this age prove itself as, with all its faults I believe it to be, less venal than any age of all that went before.

I believe our legislators ready and willing to lead in this good reform, but if they are not then I hope that a rising tide of public opinion will induce them to legislate better than they wish, and in the well known words of Fernando Wood will persuade them "to pander a little to the moral sense of the community." We must say of the system of modern corruption as Lord Chatham, the noble defender of the infant liberties of this country, said of the rotten borough system of England: "If it does not drop it must be amputated."

It behooves all poor men, and most men are poor; it behooves all honest men, and most men are honest, to see to it that the buying and selling of offices be effectually provided against, and to maintain what Jefferson in his first inaugural called a jealous care of the right of election by the people.

That reform which England has in the past twelve years so well achieved against customs of corruption more wide and deep than any we have to meet, in the next twelve months, now that some of the sisterhood have nobly led the way, all the states of our union should nobly accomplish. They have seen these new laws turning the light into the dark places of politics, and as on that first day God saw the light that it was good, so will they. They cannot and they dare not deny to all our people those guaranties for the tranquility, purity and freedom of elections already assured to Englishmen. It was the profane and shameless jest of an Irish Judas that he thanked God that he had a country to sell. The venal voter, though he boasts less loudly, betrays as basely.

The law of the land must see to it that the corrupt rich dare not buy, and the degraded poor dare not sell, the honor and safety of the state; and public opinion, stronger and more far reaching than any statute, higher and better than any enactment, but aided and enforced by adequate laws, must teach every voter in the land to say, with our good Quaker poet as he takes his ballot at the polls:

"The wide world has not wealth to buy
The power in my right hand."

Madison, Wis.

APPENDIX.

The Missouri law[1] is here printed as a supplement to Mr. Gregory s paper.

AN ACT TO PREVENT CORRUPT PRACTICES IN ELECTIONS, TO LIMIT THE EXPENSES OF CANDIDATES, TO PRESCRIBE THE DUTIES OF CANDIDATES AND POLITICAL COMMITTEES, AND PROVIDE PENALTIES AND REMEDIES FOR VIOLATION OF THIS ACT.

Be it enacted by the General Assembly of the State of Missouri, as follows:

SECTION 1. The following persons shall be deemed guilty of bribery at elections, and shall be punished accordingly: First, every person who shall, directly or indirectly, by himself, or by any other person on his behalf, give, lend, or agree to give or lend, or shall offer, promise, or promise to procure or endeavor to procure any money or valuable consideration, to or for any voter, or to or for any person on behalf of any voter, or to or for any other person, in order to induce any voter to vote, or refrain from voting, or shall corruptly do any such act as aforesaid, on account of such voter having voted or refrained from voting at any election. Second, every person who shall, directly or indirectly, by himself, or by any other person on his behalf, give or procure, or agree to give or procure, or offer, promise or promise to procure, or endeavor to procure, any office, place or employment, public or private, to or for any voter, or to or for any person on behalf of any voter, or to or for any other person, in order to induce such voter to vote, or refrain from voting, or shall corruptly do any such act as aforesaid, on account of any voter having voted or refrained from voting at any election. Third, every person who shall, directly or indirectly,

[1] Laws of Missouri, 1893, p. 157.

by himself, or any other person on his behalf, make any such gift, loan, offer, promise, procurement or agreement as aforesaid, to or for any person, in order to induce such person to procure, or endeavor to procure, the election of any person to a public office, or the vote of any voter at any election. Fourth, every person who shall, upon or in consequence of any such gift, loan, offer, promise, procurement or agreement, procure or engage, promise or endeavor to procure the election of any person to a public office, or the vote of any voter at any election. Fifth, every person who shall advance or pay, or cause to be paid, any money to or for the use of any other person, with the intent that such money or any part thereof shall be expended in bribery at any election, or who shall knowingly pay or cause to be paid any money wholly or in part expended in bribery at any election. And any person so offending shall be guilty of a felony, and shall be punished by imprisonment in the penitentiary for a term of not less than two years and not more than five years; and for every such offense he shall also forfeit the sum of $500, with costs of suit, to any person who shall sue for the same in the name of the State of Missouri, to the use of the person suing in any circuit court in this State having jurisdiction of the person of the defendant: Provided always, that the foregoing enactment shall not extend to or be construed to extend to any money paid or agreed to be paid for or on account of any legal expenses bona fide incurred at or concerning any election.

Sec. 2. The following persons shall also be deemed guilty of bribery at elections, and shall be punished accordingly: 1. Every voter who shall, before or during any election, directly or indirectly, by himself, or by any other person on his behalf, receive, agree or contract for any money, gift, loan or valuable consideration, office, place or employment, public or private, for himself or for any other person, for voting or agreeing to vote, or for refraining or agreeing to refrain from voting at any election. 2. Every person who shall, after any election, directly or indirectly, by himself, or by any other person on his behalf, receive any money or valuable consideration on account of any person having voted or refrained from voting, or having induced any other person to vote or refrain from voting at any election; and any person so offending shall be guilty of a misdemeanor, and shall be punished by imprisonment in the county jail not less than one month and not more than one year.

SEC. 3. Any candidate for a public office, or any person seeking to become the nominee of any party as such candidate, who, within ten days prior to any primary election or meeting held to select delegates to a convention to nominate a candidate for the public office which he seeks to obtain, or who within 60 days prior to the election whereat an incumbent for the office so sought by him is chosen, corruptly, by himself or by any other person, directly or indirectly gives or provides or pays, wholly or in part, or promises to pay wholly or in part, the expense f giving or providing any meat, drink, entertainment or provision to or for any person for the purpose of corruptly influencing that person or any other person to give or refrain from giving his vote at such election, shall be guilty of a misdemeanor, and upon conviction thereof shall be fined twenty-five dollars for each offense.

SEC. 4. Every person who shall, directly or indirectly, by himself, or any other person on his behalf, make use of or threaten to make use of any force, violence or restraint or inflict or threaten to inflict, by himself or by any other person, any temporal or spiritual injury, damage, harm or loss upon or against any person in order to induce or compel such person to vote or refrain from voting at any election, or who shall, by abduction, duress or any fraudulent device or contrivance, impede or prevent the free exercise of the franchise of any elector, or shall thereby compel, induce or prevail upon any elector either to give or refrain from giving his vote at any election, shall be guilty of a misdemeanor and upon conviction thereof shall be punished by imprisonment in the county jail not less than one month and not more than one year.

SEC. 5. A person shall, for all purposes of this act, be deemed guilty of the offense of personation, who, at any election held pursuant to the laws of the State, applies for a ballot paper in the name of some other person, whether that name be that of a person living or dead, or of a fictitious person, or who, having voted once at any election, applies at the same election for a ballot paper in his own name or any other name; and any person who commits the offense of personation, or who said, abets, counsels or procures the commission of that offense, shall be guilty of a felony, and upon conviction thereof, shall be punished by imprisonment in the penitentiary for a term of not less than two years or more than five years.

SEC. 6. No candidate for congress or for any public office in this State, or in any county, district or municipality thereof, which office is to be filled by popular election, shall by himself or by or through any agent or agents, committee or organization, or any person or persons whatsoever, in the aggregate pay out or expend or promise or agree to offer or pay, contribute or expend any money or other valuable thing in order to secure or aid in securing his nomination or election, or the nomination or election of any other person or persons, or both such nomination and election, to any office to be voted for at the same election, or in aid of any party or measure, in excess of a sum to be determined upon the following basis, namely: For five thousand voters or less, one hundred dollars; for each one hundred voters over five thousand and under twenty-five thousand, two dollars; for each one hundred voters over twenty-five thousand and under fifty thousand, one dollar; and for each one hundred voters over fifty thousand, fifty cents — the number of voters to be ascertained by the total number of votes cast for all the candidates for such office at the last preceding regular election held to fill the same; and any payment, contribution or expenditure or promise, agreement or offer to pay, contribute or expend any money or valuable thing in excess of said sum, for such objects or purposes, is hereby declared unlawful.

SEC. 7. Every person who shall be a candidate before any caucus or convention, or at any primary election, or at any election for any State, county, city, township, district or municipal office, or for senator or representative in the general assembly of Missouri, or for senator or for representative in the congress of the United States, shall, within thirty days after the election held to fill such office or place, make out and file with the officer empowered by law to issue the certificate of election to such office or place, and a duplicate thereof with the recorder of deeds for the county in which such candidate resides, a statement in writing, which statement and duplicate shall be subscribed and sworn to by such candidate before an officer authorized to administer oaths, setting forth in detail all sums of money contributed, disbursed, expended or promised by him, and to the best of his knowledge and belief, by any other persons or person in his behalf, wholly or in part, in endeavoring to secure or in any way in connection with his nomination or election to such office or place, or in connection with the election or any other persons at said election, and showing the dates when, and the persons to whom, and the purposes for which all such sums were paid, expended or promised. Such statement shall also set forth that the same is as full and explicit as affiant is able to make it. No officer authorized by law to issue commissions or certificates of election shall issue a commission or certificate of election to any such person until such statement shall have been so made, verified and filed by such persons with said officer.

SEC. 8. Any person failing to comply with the provisions of the seventh section of this act shall be liable to a fine not exceeding one thousand dollars, to be recovered in an action brought in the name of the State by the attorney-general, or by the prosecuting attorney of the county of the candidate's residence, the amount of said fine to be fixed within the above limit by the jury, and to be paid into the school fund of said county.

SEC. 9. No person shall enter upon the duties of any elective office until he shall have filed the statement and duplicate provided for in section seven of this act, nor shall he receive any salary or any emolument for any period prior to the filing of the same.

SEC. 10. At any time during the term of office of any public officer, elected under the laws of this State, or under the charter of any city therein, the person who received the next highest number of votes for such office at the election at which such public officer was elected, as shown by the official count, may present an application in writing, and verified by his affidavit, to the attorney-general, setting forth one or more of the following charges against such public officer, to-wit: That at the election at which such public officer was elected, the total amount expended, contributed or incurred by such officer exceeded the sum allowed by section 6 of this act for such candidate or that votes were secured by him or his agent or agents, or with his consent or connivance, or with the consent or connivance of his agent or agents, by some committee or organization or some political party, of which party such public officer was a nominee, or by which he was supported, or the agent or agents of some such committee or organization, by paying, contributing, offering or promising to contribute money or other valuable thing as a compensation or reward, or by some promise or influence the giving such vote or votes, or that votes were withheld from such applicant by reason of such practices by or on behalf of such officer, agent, committee or organization, or by reason of some act on behalf of such officer declared by this act to be unlawful; and further setting forth that the applicant desires said attorney-general to bring an action to have such public office declared vacant on account of said violation of the laws concerning elections. Such application shall be accompanied by a bond to the State of Missouri in the penalty of one thousand dollars, subscribed by two sureties, who shall justify as freeholders of the State, and in double the amount of such penalty, exclusive of all their debts and liabilities, and property exempt by law from levy and sale under execution—such bond to be conditioned for the payment to the State of all the taxable costs and disbursements for which it may become liable for or on account of such action.

Sec. 11. It shall be the duty of the attorney-gencral, within ten days after the receipt of such application and bond, to begin an action against such public officer, or to instruct the prosecuting attorney of the county in which such public officer resides, to bring such action within ten days after such notice, to have said office declared vacant, and for such other or further relief appropriate in an action against the usurper or any office or franchise. Such action shall be deemed to be, and shall be conducted according to the rules prescribed by law for an action against the usurper of an office or franchise; and it shall be the duty of any prosecuting attorney to bring such action within ten days after the receipt of such notice from the attorney-general.

· Sec. 12. In case the attorny-general and prosecuting attorney shall neglect or refuse to bring such action within the time limited in section 11 of this act, it shall be lawful for the applicant to bring such action in the name of the State, but at his own expense and by his attorney or attorneys; and in any action so brought by said applicant, no recovery for costs and disbursements shall be had against the State; provided, that in any case, whether instituted by the attorney-general or the prosecuting attorney, or by the applicant in person, if the court shall at any time pending such action, find the bond given as aforesaid inadequate in amount to cover the costs accrued or likely to accrue in the cause, or shall find any surety or sureties insufficient, additional bond or other sureties may be required by the court within such time and upon such terms as the court may order; and upon failure to comply with any such order of the court, such action may be dismissed at the cost of the applicant and his sureties.

Sec. 13. Such action shall have a preference on the docket of any court of the State in which the same shall be pending, over all other civil actions whatever.

Sec. 14. If it shall be determined in any such action that any one or more of the charges defined in section 10 of this act, and set forth in the petition, has been sustained, judgment shall be rendered ousting and excluding such defendant from such office, and in favor of the State or plaintiff, as the case may be, subject to the provisions of the next succeeding section, and for the costs of the action. But if no one of the charges set forth in the petition in said cause be sustained, judgment shall be rendered against such applicant and his sureties on the bond or bonds for the costs of such action.

Sec. 15. In any such action such applicant, upon his own motion or on the motion of the defendant, shall be made a party plaintiff; and in any case in which such applicant shall be a party, if judgment of ouster against the defendant shall be rendered as provided in section 14 of this act, said judgment shall award such office to said applicant, unless it shall be further determined in such action, upon appropriate pleading and proof by defendant that some act has been done or committed which would have been ground in a similar action against such plaintiff had he been declared elected to such office, for a judgment of ouster against him; and if it shall be so determined at the trial, such office shall be in the judgment declared vacant, and shall thereupon be filled by appointment, or a new election, as may be otherwise provided by law regarding such office.

SEC. 16. No person shall be excused from answering any question on trial of such action relating to any of the acts claimed to have been committed by any party thereto, or any of the persons, committees or organizations mentioned in the twelfth section of this act, on the ground that such answer would tend to incriminate or degrade such person or witness. But no such answer or answers shall be used or be evidence against such witness in any criminal action, prosecution or proceeding whatever.

SEC. 17. Every two or more persons who shall be elected, appointed, chosen or associated for the purpose, wholly or in part, of raising, collecting or disbursing money, or of controlling or directing the raising, collection or disbursement of money for election purposes, and every two or more persons who shall co-operate in the raising, collection or disbursement, or in controlling or directing the raising, collection or disbursement of money used or to be used in furtherance of the election or to the defeat the election to public office of any person or any class or number of persons, or in furtherance of the enactment or to defeat the enactment of any law or ordinance, or constitutional provision, shall be deemed a political committee within the meaning of this act.

SEC. 18. Every political committee shall appoint and constantly maintain a treasurer, to receive, keep and disburse all sums of money which may be collected or received or disbursed by such committee, or by any of its members, for any of the purposes mentioned in section 17 of this act, for which such committee exists or acts; and, unless such treasurer is first appointed and thereafter maintained, it shall be unlawful and a violation of this act for a political committee or any of its members to collect, receive or disburse money for any such purpose. All money collected or received or disbursed by any political committee, or by any member or members thereof, for any of the purposes mentioned in section 17 of this act, and for which such committee exists or acts, shall be paid over and made to pass through the hands of the treasurer of such committee, and shall be disbursed by him; and it shall be unlawful and a violation of this act for any political committee, or for any member or members of a political committee, to disburse or expend money for any of the objects or purposes mentioned in section 17 of this act, and for which such committee exists or acts, until the money so disbursed or expended shall have passed through the hands of the treasurer of such political committee.

Sec. 19. Every treasurer of a political committee and every person who shall at any time act as such treasurer, shall, whenever he receives or disburses money as such treasurer, or for or on account of any of the objects or purposes mentioned in section 17 of this act, immediately enter and thereafter keep, in a proper book or books to be provided and preserved by him, a full, true and detailed statement and account of each and every sum of money so received or disbursed by him, setting forth in such statement the sum so received or disbursed, as the case may be, and the date when and the person from whom received, or to whom paid as the case may be, and the object and purpose for which such sum was received or disbursed.

Sec. 20. Every treasurer of a political committee as defined in this act, and every person who shall act as such treasurer shall, within thirty days after each and every election, whether State, county, city, municipal, township or district election, in or concerning or in connection with which he shall have received or disbursed any money for any of the objects or purposes mentioned in section 17 of this act, prepare and file in the office of the recorder of deeds of the county in which such treasurer resides a full, true and detailed account and statement, subscribed and sworn to by him before an officer authorized to administer oaths, setting forth each and every sum of money received or disbursed by him for any of the objects or purposes mentioned in section 17 of this act within the period beginning ninety days before such election and ending on the day on which such statement is filed, the date of receipt and each disbursement, the name of the person from whom received or to whom paid, and the object or purpose for which the same was received and the object or purpose for which disbursed. Such statement shall also set forth the unpaid debts and obligations if any of such committee, with the nature and amount of each, and to whom owing, in detail, and if there are no unpaid debts or obligations of such committee, such statement shall state such fact.

SEC. 21. Every officer required by law to issue certificates of election or commissions as the result of elections shall receive and file in his office and there keep as part of the records thereof for four years after they are filed, all statements and accounts required by this act to be filed with him. Such statements and accounts shall, at all reasonable times, be open to the public inspection. After four years succeeding the filing of such statements they shall be destroyed by such officer or his successor. Copies of such statements, certified by such officer under the seal of his office, of any such statement or statements; and any copy so certified shall be admitted in evidence in all courts with like force and effect as the original would have produced.

SEC. 22. Every treasurer of a political committee as defined in this act who shall willfully fail, neglect or refuse to make out, verify and file with the recorder of deeds the statement required by section 20 of this act, shall be guilty of a misdemeanor, and upon a conviction shall be fined not less than fifty nor more than five hundred dollars.

SEC. 23. Every treasurer of a political committee, and every person who shall receive any money to be applied to any of the purposes mentioned in section 17 of this act, who shall either:

First—Neglect or fail to keep a correct book or books of account, setting forth all the details required to be set forth in the account and statement contemplated in sections 19 and 20 of this act (except that the book or books need not be subscribed or sworn to), with intent to conceal the receipt or disbursement of any such sum received or disbursed by him or by any other person, or the purpose or object for which the same was received or disbursed, or to conceal the fact that there is any unpaid debt or obligation of such treasurer or committee, or the nature or amount thereof, or to whom owing, in detail; or —

Second—Mutilate, deface or destroy any such book or books of account, with intent to conceal any fact disclosed by such book or books; or —

Third—Fail to file the statement and account contemplated by said section 20, within five days after he shall receive notice in writing, signed by five resident freeholders of the county in which such treasurer or political committee or person resides, requesting him to file statement and account, shall be guilty of a misdemeanor, and on covniction shall be imprisoned in the county jail for not less than two or more than six months.

SEC. 24. All acts and parts of acts inconsistent with this act are hereby repealed.

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THE PERSONAL EQUATION IN ETHICS.

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Ethics as a science has to do with the phenomena of the approval and disapproval of conduct—the source of the distinction between right and wrong. Its fundamental problem as thus conceived is, What are the grounds, or what is the cause, of such judgments? Up to the present time the method of investigation employed has been almost exclusively that of pure introspection. The reason for this fact is not far to seek. Approval and disapproval present themselves as facts of our own conscious life. We become aware of them, as we do of our intellectual processes by looking within, not without. We therefore naturally begin our search for the underlying first principles by making a complete list of our moral judgments and then analyzing them into their simplest elements. This having been satisfactorily accomplished our task seems finished. For it is natural to suppose that the results thus obtained will hold for others as well as ourselves. For, it is argued, we have an equal right with the logician and the mathematician to assume the similarity of human nature in all that is fundamental. But if so, then what I have found true for myself, I may confidently assert of the race at large. Even if some savage tribe should be discovered that exhibited no traces of the moral sentiments which we find in ourselves, this need not affect the soundness of our conclusions. The tribe in question would simply be placed in the category of the non-moral, along with the ape and the tiger. There would accordingly seem no reason for finding fault with the programme announced by Martineau in the preface to his *Types of Ethical Theory*, where we read (p. VIII): "Intellectual pride and self-ignorance alone ca blind us to the fact that systems of philosophical opinion grow from the mind's instinctive effort to unify by sufficient reason and justify by intelligible pleas, its deepest affections and admirations. At all events I attempt no more." In other words the introspective method may be relied upon exclusively to bring to view all the fundamental phenomena of the moral life.

It is the purpose of this paper to show that this conclusion, plausible as may be the reasoning by which it is reached, is entirely fallacious, and that the introspective method, taken by itself, can lead to nothing but endless confusion and irreconcilable contradiction. The necessity of supplementing "subjective" by "objective" psychology is now admitted by all students of the subject. We shall endeavor to prove that a like necessity holds equally well for ethics.

In the first place the correctness of the traditional view depends as we have seen upon the truth of the premise that human nature is fundamentally the same throughout the countless millions of living beings in whom it has revealed itself. But this, it must never be forgotten, is an assumption—a natural one perhaps, to some extent undoubtedly an inevitable one, but none the less an assumption. But who shall take it upon himself to determine *a priori* just how far this similarity extends? The incredulity with which in many instances the publication of Galton's well-known investigations into mental imagery was greeted by the general public shows how natural it is for us to suppose that powers which we may happen to possess must be the common property of all, and that what we cannot do must be alike impossible for others. On the other hand the results which Galton obtained proved how peculiarly dangerous is this attitude of mind. It may perhaps be admitted that the burden of proof rests upon him who in any specific case denies the similarity. But whenever properly attested evidence presents itself, no conceivable considerations can justify us either in ignoring it or showing it the door. But the collection and examination of such evidence involves the use of the objective method, and thus it appears that introspection's standing in court as a source of universally valid propositions is dependent upon the decision of a judge other than itself.

But the main proof of our contention we find in the difficulties in which the moralists have involved themselves by a complete neglect to allow for the influence of the personal equation in setting forth the results of their investigations. They have fallen, it appears, into both of two possible errors. On the one hand they have taken personal idiosyncracies of temperament or taste for fundamental facts of the universal moral consciousness; on the other, they have ignored all elements of the moral life of the race which did not happen to be represented in their own experience. As a consequence we have the continued existence of half a dozen rival schools, in some instances holding diametrically opposite views, and themselves divided into sects frequently on the same good terms with each other as the Baptist and Presbyterian churches in a country village. This cheerful state of affairs is largely due to the unquestioned belief in the existence of one typical moral consciousness, supposed to be the common possession of all members of the race. If so, no further refutation of the theory in question ought to be necessary. But since it seems to be deeply ingrained in the gray matter of the brain of the modern moralist, I think it advisable to call attention to several cases where unbridled indulgence in the method of pure introspection has led to peculiarly striking contradictions in the statements of different writers. Perhaps a few "horrible examples" may make more impression than the choicest of maxims.

I shall select as the first subject of our study one of the most influential writers of the nineteenth century, John Stuart Mill, comparing his attitude towards one of the crucial questions with that of his German critics. Mill stands before the educated community as the champion of the view according to which an action is stamped as right in proportion as it is calculated to promote the happiness of those directly or indirectly affected by it. How did he come to accept this theory? Let a passage from his Autobiography answer. He writes[1]: "When I laid down the last volume of the *Traité* (Bentham's principal work) I had become a different being. The principal of utility, understood as Bentham understood it, and applied in the manner in which

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[1] p. 66.

he applied it through those three volumes, fell exactly into its place as the keystone which held together the detached and fragmentary component parts of my knowledge and beliefs. It gave unity to my conception of things. I now had opinions, a creed, a doctrine, a philosophy; in one among the best senses of the word, a religion, the inculcation of which could be made the principal outward purpose of a life." To appreciate the bearing of these words upon our subject it must be remembered that Bentham's strength lies entirely in his work as a legal reformer. His discussion of ethical principles properly so called, is not only superficial in the extreme, but it is, in the volume referred to at least, very meager. He contents himself mainly with stating his own opinions and calling all others meaningless or absurd. It appears from this that Mill first adopted his views and afterwards in his own writings proceeded to demonstrate their truth. In other words the happiness of his fellow men appealed to Mill as an end worthy of his highest devotion. Whatever was inimical to this, either in the actions of himself or others, must therefore necessarily meet with his disapproval; whatever promised to contribute towards it, he viewed with satisfaction and pleasure. The one class of actions were accordingly for him good, the other, bad. In other words his feelings determined his position; his abstract reasoning was simply a means in his hands of converting other people to his own views. Why is it then that so many of these other people have refused to become convinced? Is it because of any flaw in the arguments? Is it because they have become convinced that the term "sum of pleasures" is meaningless, as Green asserts, or that pleasure is not itself valuable, but is only a sense of value, as some of his followers have informed us? I trow not. The explanation is rather to be found in the attitude of mind that we find expressed by Wundt in the following words:[2] "How the idea of an equable division of happiness among the now living members of the race can arouse the enthusiasm of any human being, with the possible exception of a Utilitarian philosopher, and can overcome the every-day impulses of egoism and personal kindliness, it is absolutely impossible to conceive. . . . . The abstract

[2] *Ethik*, pp. 365, 367.

idea of a sum of chopped-up states of happiness is incapable of kindling a single emotion in the human heart." Right in line with such a confession as this are the remarks a friend once made to me: "I cannot say that I am especially interested in the greatest happiness of the greatest number." The Utilitarian formula did not *appeal* to him as representing an end worth sacrificing anything for. It therefore could not, he reasoned, be at the root of the distinction between right and wrong. "Do Kant's moral writings mean anything to you," I was once asked by a fellow-student. They meant nothing to him, that is to say, they did not represent his experience. And so he argued that the account they gave of the moral life must necessarily be false.

It may be of value to pursue this thought farther by means of a comparison between the ethical theories of Kant and Schopenhauer. What, according to Kant, is the fundamental moral motive and therefore the ultimate ground of the approval and disapproval of conduct? The soul of man, he tells us, is a stranger in a far country. Imprisoned in a body which continually drags it down to earth, it has never completely lost the vision of its true home, the higher world. For the laws which govern the pure spiritual beings who inhabit that world are graven in indelible characters upon the walls of the temple of his own conscience. In virtue of his rational nature these laws are binding upon him also. The fundamental moral motive is therefore reverence for the laws and for the persons of the citizens of this spiritual commonwealth. In this transcendental origin of morality and its freedom from the taint of any connection with the world of time and sense lies solely and alone, he tells us, its commanding authority. He who refuses obedience condemns himself to self-contempt and inner abhorrence. He who obeys has obtained the one unconditional good in life, a beautiful character.

Now what says Schopenhauer to this? Schopenhauer the cynic, who found so little in the world to admire besides himself, and yet who was his life long the devoted worshipper of Kant. He affirms that the idea of obligation which lies at the foundation of the Kantian ethics is simply another form of the familiar principle: "You had better obey the commands of God, or you will catch it in the next world." He maintains that Kant's ideal man who relieves the distress of a suffering world, not from sympathy with the unfortunate, but simply from a sense of duty, is a creature that outrages every moral feeling. Kant's statement that the moral law, to have any genuine authority, must be of supersensible origin, he treats with but half concealed levity. And of the picture which Kant draws of the kingdom of rational spirits in which each one is at once law-giver and subject, he writes: "Difficile est, satiram non scribere." The display of elevation of character seems never to have specially impressed him and the feeling of obligation meant for him, as we have seen, merely the fear of punishment. What then does he take to be the moral motive? Sympathy, he tells us, is the only conceivable one. He bids us imagine two men struggling with the temptation to kill a rival in love. One afterwards confesses that he was deterred from the commission of the crime because it was incompatible with the laws of the transcendental world. The other tells us that when brought face to face with his adversary he was seized with sympathy for him, he forgot his jealousy, his heart melted and he renounced his design. Which of these two characters, asks Schopenhauer, represents the real human being, and which the invention of a theorist's brain? He seems to have no doubt that the universal feelings of man will look upon the latter of his two lovers as the representative of human nature as it is. And yet he does not overlook the fact that both Kant and Spinoza do not regard sympathy as a virtue but rather, if anything, as the reverse. This circumstance is only one more proof in his eyes of their ignorance of the nature of the moral life.

A third set of examples will conclude what I have to say on this part of my subject. It has already been stated that Kant regards character, or the good will as he calls it, as the one unconditionally good thing in life. He writes:[3] "A good will is good not because of what it performs or effects. . . . Even if with its greatest efforts it should yet achieve nothing

[2] *Fundamental Principles of the Metaphysics of Morals* (Abbott's Translation), p. 10.

it would still, like a jewel, shine by its own light as a thing which has its own value in itself." Character was precious in his eyes not because its effects are profitable to others, but because it is attractive in itself. To the Utilitarianism of Mill he would doubtless have replied with Carlyle: "Is the heroic inspiration we call virtue but some bubble of the blood, bubbling in the direction others *profit* by?" (*Sartor Resartus.*) Observe now the contrast between such utterances and the attitude of Professor Sidgwick, generally admitted to be the leading moralist of the present time. He says:[4] "In my view, this subjective rightness of volition is not good in itself, but only as a means to the production of other good effects." And by these good effects, he means the happiness of those thereby affected The contradiction between these two views seems absolute and complete.

We are now face to face with the question, "How is such diversity of opinion possible?" Does it indicate carelessness of observation? Is it due to the blindness of prejudice which, consciously or unconsciously, is striving to force the facts into the moulds of some favorite theory of the nature of things? Or are these moralists spreading before us some phantasmagoria, some invention of their own brain, evolved in the solitude of their study and with no more relation to the facts of real life than the novels of Jules Verne? Certainly not the last, for these various theories have all found ready acceptance with many who are not moralists by profession, and who emphatically have not spent their lives in the study. Of the Kantian doctrine of morals the German poet Schiller says:[5] "After the demonstration which he (Kant) has given us, there can be no more controversy among thinking men *who are willing to be convinced.*" On the other hand, Leslie Stephen, the well known English man of letters, writes:[6] "Indeed the utilitarian argument appears from certain points of view to be so cogent that one is half disposed to regard all the argumentation about morality as grotesque." Nor can carelessness or zeal in the

[4] *Methods of Ethics*, IV Ed. p. 395.

[5] *Aesthetische Schriften*, Ausgabe Kohler (Stuttgart) p. 100.

[6] *Science of Ethics*, p. 357.

service of some pet metaphysical or anti-metaphysical theory account for the facts of the case. The explanation of the contradictory statements of students of ethics is mainly to be found, I believe, in the influence of what I have called the personal equation of these writers themselves. Its origin and its nature I shall now endeavor to point out.

The moralist, like all other members of the human race, has grown up in a community which possesses a code of moral rules. These rules he probably makes it a matter of principle to obey, regardless of whether so doing happens to be agreeable or not. Now the motives which habitually impel to such action so far from being reducible to a single one, really amount to a considerable number. They will doubtless be present in varying degrees of intensity in any given individual, but in comparison with the rest some one is almost certain to be so strong as to overshadow all the others. When such a person comes to make a systematic study of the moral life, if he follows the hitherto general practice of treating his own experience as typical of that of the race, this dominating motive is sure to get more than its fair share of the attention and to be made to play the rôle of the sole fundamental moral force. Its significance for the race is measured by the position it occupies among his own springs of action. But, it will be asked, when confronted with the reports of experience different from his own, why does he not instantly recognize the narrowness of his own theory and proceed to correct and supplement it by making a place in it for the new facts? To understand this we must call to mind the not unfamiliar distinction between moral and non-moral motives for obedience to the commands of conscience. Of the former, self-respect and unselfish devotion to the good of others are sufficient examples. The latter are such as dislike for the penitentiary as a place of residence, fear of eternal damnation, fear of Mrs. Grundy and of loss of social position. The distinction between the two is to be found in the fact that the latter merely lead us to *act* in outward conformity to what society agrees to call right, while the latter, in addition to this, make us *approve* of right action both in self and others. The would-be criminal, for example, hates the moral law, would break it if he dared, and considers every one a fool who is not like minded. The man of high principles, on the other hand, longs to bring every impulse and every thought more and more completely under its sway. Of course it is not meant that fear of punishment is an *immoral* spring of action, but simply that, like dislike of poverty or physical pain, it is morally indifferent, i. e., may lead, according to circumstances, to actions which are either good or bad. In applying this distinction to the problem before us, we must premise that it has always been taken for granted that there can exist but one *moral* spring of action. For it has been declared impossible to bring our ethical judgments into the form of a consistent system unless the grounds of approbation are reducible to a single one. Now when the moralist with a moral life under the more or less complete domination of a single principle, as we have seen is usually the case, is met by a man who claims that his motive for right action is an entirely different one, he seems placed before the following dilemma: Either his neighbor has made the mistake of confounding one of the non-moral impulses with the moral motive, or else his own cherished ideals are non-moral in their character. Such an admission no earnest man will readily consent to make. Take for example a man with a keen sense for the beautiful in conduct; one whose deepest aspirations find expression in the words of our beloved poet:

> "Build thee more stately mansions, O my soul,
> As the swift seasons roll."

Suppose him moreover to have no exceptionally intense sympathies beyond the circle of his family and personal acquaintances. Such a one is the friend whom I referred to above as saying, "I can not say that I am especially interested in the greatest happiness of the greatest number." He will doubtless reason as follows: I am leading or at least trying to lead a life of devotion to the right. But the general diffusion of happiness is not my usual motive for denying myself pleasure, nor is it my reason for approving such sacrifice when made by others. Nor, if the happiness of the race were really the moral end, would morality ever appeal to me as something worthy to claim the supreme place in my life. But it does thus appeal to me. Therefore the general happiness can not, as the Utilitarians claim, be the ultimate goal of moral action. And when they maintain it is, they are simply putting a non-moral spring of action, namely, sympathy, into the place of the moral motive, devotion to an ideal of personal character.

Now what ethics has to do today is simply to admit that the number of motives justly entitled to be classed as moral cannot be reduced to a single one. We may not only *do* what is right, but also *approve* of right-doing, for a variety of reasons. In the case of the civilized man of the nineteenth century, we can discover at least five such, as follows: The first may be termed for want of a better name the teleological. The criterion of judgment is here the relation in which the actor places himself to the desires or the welfare of other persons besides him self. Unselfishness is valued for what it brings to others. The second is the aesthetic, determined by the relation of the action to an ideal of beauty of character. The former of these two lies at the bottom of altruistic Utilitarianism, the latter dominates such widely differing systems as those of Plato, Aristotle and Kant. The third principle is logical in its nature and accounts in great part for our approbation of consistency, fairness, etc. The fourth may be termed that of unreasoned sentiment. As an example of what is meant I may cite the case of the wife of a well-known Arctic explorer, who declared she would rather her husbard would die of starvation in the Polar night than consent to save his life by eating human flesh. The feelings against incest, against over-indulgence in sensual pleasure, and against avarice are largely composed of elements derived from this source. The fifth principal is theological. An action here meets with approval solely because believed to represent the will of God, as keeping the Sabbath day or attending the sacraments. Many have expressly denied this last a place among independent moral principles, claiming that it is only as God is implicitly or explicitly thought of as a moral being that obedience becomes praise-worthy or disobedience the reverse. We cannot make an examination of these contentions here. We content ourselves with the remark that it has at least a *prima facie* claim to a place in this list.

How to evolve from this multiplicity of apparently mutually incompatible principles a consistent system of moral judgments, is a problem which it lies beyond the limits of this paper to consider. One practical corollary from all that has been said must however be sufficiently obvious by this time. Whatever, namely, the resultant formula for morality may be, its validity must not be supposed to be dependent upon whether it happens to coincide with our "deepest affections and admirations,"—to quote Martineau once more—or whether it does not. For these vary from person to person, their exact nature being determined mainly by accidents of temperament. Our own ideals must indeed contribute their share towards the final form of the ethical criterion, for we too are representative members of the human race, but they must not be allowed to determine it by themselves. Such relative self-elimination, such comparative repression of the imperious demands of one's own nature is exceedingly difficult. To all but those who are thoroughly dominated by the scientific spirit, it may be even impossible. But until it is accomplished, works on ethics can be little better than more or less interesting autobiographies. As Karl Pearson has reminded us in his *Grammar of Science:* "The classification of facts and the formation of absolute judgments upon the basis of the classification—judgments independent of the idiosyncracies of the individual mind—is peculiarly the scope and method of modern science. The scientific man has above all things to aim at self-elimination in his judgments, to provide an argument which is as true for each individual as for himself." Certain it is that until this is done, a *science* of ethics is impossible.

Madison, Wis.

ON THE CLASSIFICATION OF CARBON-COMPOUNDS.

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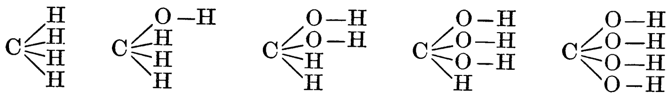
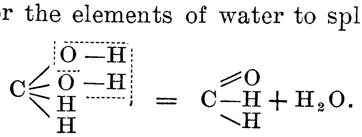
In the winter semester of 1888–9, Professor August Kekulé, in his course on the chemistry of the carbon-compounds at the University of Bonn, Germany, introduced the subject of fatty alcohols, aldehydes, ketones, acids, hydroxy acids, etc., by a lecture in which he gave a general survey of the theoretically possible hydroxy derivatives of the paraffin hydrocarbons. I suppose it was Prof. Kekulé's usual method of treating the subject, but I am not warranted in making so broad a statement. However, this theoretical introduction is fully in harmony with the methods of teaching of this genial lecturer, known and celebrated, not so much for the compounds he has discovered, but for his theories, that have prophesied the possibility of hosts of compounds, which have been prepared by others in the attempt to establish as well as in the attempt to overthrow Prof. Kekulé's theories.

Considering the four hydrogen atoms to be symmetrically arranged around the central carbon atom in the simplest paraffin hydro-carbon methane, it becomes evident that there can be, respectively, but one mono-, di-, tri- and tetra-hydroxy substitution product, as is shown by the following formulas, written for the sake of convenience as though all atoms were in the same plane:



However, it is a generally observed fact, that when two hydroxy groups are connected with the same carbon atom, there is a tendency for the elements of water to split off thus:

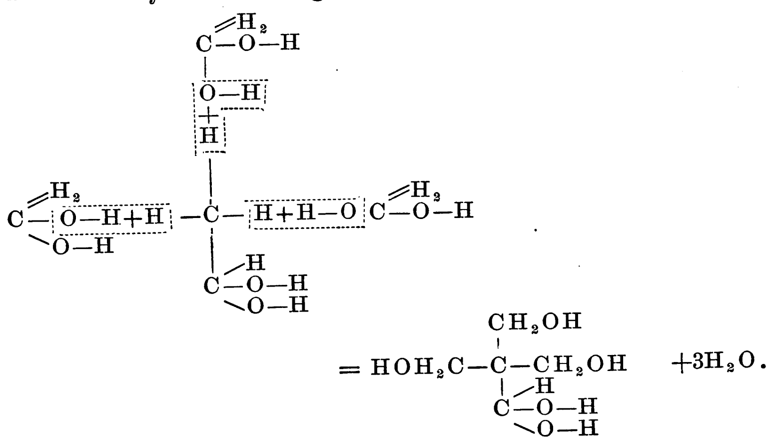


The tendency to form water is explained by the following thermochemical equation:

$(H_2,O) = H_2O$ vapor......................................+57.2 calories, or
$(H_2,O) = H_2O$ liquid at 16° C..............................+68.3 calories.

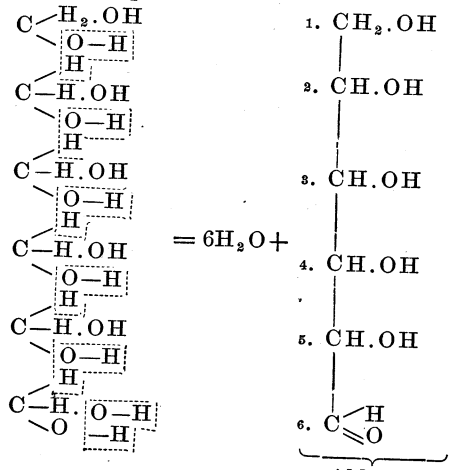
There are striking exceptions to this rule, and as a striking exception the formation of chloral hydrate from anhydrous chloral may be mentioned. The reaction expressed by the following equation, $CCl_3C{\lt}^{H}_{O} + H{-}O{-}H = CCl_3C{\lt}^{H}_{O-H}{}_{O-H}$, is an exothermic one. It must also be granted that e. g. formic aldehyde $C{\lt}^{O}_{H}{}_{H}$ in aqueous solution, at least, may have the formula $C{\lt}^{O-H}_{O-H}{}^{H}_{H}$, i. e., formic aldehyde plus water, in which the hydrate must not be considered as a molecular addition product of H_2O to $C{\lt}^{O}_{H}{}_{H}$, written $C{\lt}^{O}_{H}{}_{H} + H_2O$, but as the diatomic alcohol, methylene glycol $C{\lt}^{O-H}_{O-H}{}^{H}_{H}$.

The synthesis of a number of carbon compounds cannot be explained without this assumption. As examples, the syntheses of penta-erythrite and of several of the sugars may be men tioned. The former results form a condensation of formic and acetic aldehydes according to the following equations:



At the same time the glycol group is reduced to a primary alcohol group, while another molecule of acetic aldehyde, or rather ethyledene glycol, is oxidized to acetic acid, penta erythrite resulting $HOH_2C-C(CH_2OH)_2-CH_2OH$.

The syntheses of the hexoses and of starch from formic aldehyde also can be explained only by assuming the aldehyde group of formic aldehyde to be hydrated to a glycol group when condensation can take place:



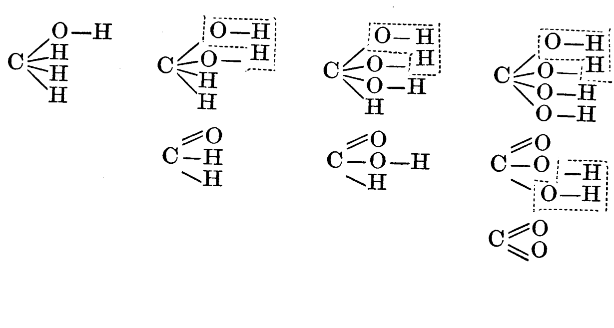
Aldose.

By splitting off water in a slightly different manner the two ketoses may result:

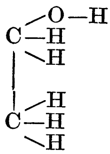
$\underset{1.}{C}H_2OH.\ \underset{2.}{C}HOH.\ \underset{3.}{C}HOH.\ \underset{4.}{C}HOH.\ \underset{5.}{C}O.\ \underset{6.}{C}H_2OH.$ or

$\underset{1.}{C}H_2OH.\ \underset{2.}{C}HOH.\ \underset{3.}{C}HOH.\ \underset{4.}{C}O.\ \underset{5.}{C}HOH.\ \underset{6.}{C}H_2OH.$

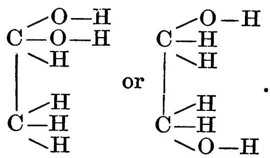
However, to return to the hydroxy derivatives of methane, it will be apparent that by splitting off water from the formulas already deduced the following anhydrides or partial anhydrides will result:



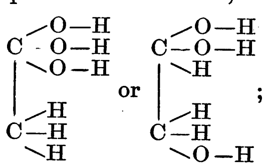
If next in the hydrocarbon ethane the hydrogen atoms are assumed to be alike it will be evident that whereas there can be but one mono-hydroxy substitution product of ethane, viz.:



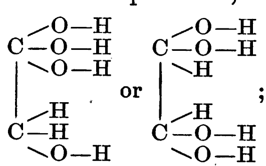
, there can be two di-hydroxy substitution products, inasmuch as both hydroxy groups can be connected with the same carbon atom, or can be more symmetrically distributed by being connected, one with each of the carbon atoms, viz.:



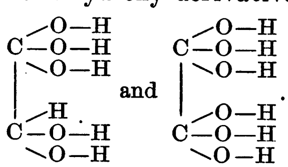
For the same reason there can be two and only two tri-hydroxy substitution products of ethane, viz.:



two tetra-hydroxy substitution products, viz.:



one penta- and one hexa-hydroxy derivative, viz.:



In propane, the third hydro-carbon of the paraffin series, there are two kinds of hydrogen atoms: six hydrogen atoms of the two methyl groups, and two hydrogen atoms of the methylene group. The methyl hydrogens are connected with carbon atoms, which have three affinities saturated by hydrogen and are connected with but one other carbon atom. The methylene hydrogen atoms are connected with a carbon atom which has but two of its affinities saturated by hydrogen and is connected with two other carbon atoms. The possibility of two mono-hydroxy substitution products of propane thus becomes apparent. The one can be formed by substituting a hydroxy group in place of one of the six methyl hydrogens, the other by similar substitution of one of the two methylene hydrogens, thus:

$$\begin{array}{l} CH_2OH \\ | \\ CH_2 \\ | \\ CH_3 \end{array} \quad \text{or} \quad \begin{array}{l} CH_3 \\ | \\ CH.OH. \\ | \\ CH_3 \end{array}$$

Of di-substitution products there are four, etc. Applying these principles of substitution and of dehydration, the accompanying table will explain itself:

If comparisons are now made it will be seen that we can generalize and at the same time classify the mono-substitution products or alcohols, according to the following type-formulas, R′ being equal to the univalent saturated radicle $(C_nH_{2n+1})'$:

$R' - CH_2.OH$ or primary alcohols,
$R'_2 = CH.OH$ or secondary alcohols,
$R'_3 \equiv C.OH$ or tertiary alcohols.

The di-substitution products having the hydroxy groups connected with two different carbon atoms are glycols of the ethylene glycol type, with two primary, or one primary and one secondary, or two secondary, or one primary and one tertiary, etc., alcohol groups. Upon dehydration they yield oxides.

The di-substitution products, in which the two hydroxy groups are connected with the same carbon atom, are glycols of the ethyledene glycol type and readily break up into water and either aldehydes, characterized by the general formula $R' - C \lessgtr^{H}_{O}$; or ketones, characterized by the formula $\begin{matrix} R' \\ R' \end{matrix} > C = O$. It is evident why primary alcohols yield aldehydes and why secondary alcohols yield ketones upon oxidation. The tertiary alcohols can form neither, i. e., with the same number of carbon atoms, because the carbon atom with which the alcohol group $(O-H)'$ is connected has none of its affinities saturated by hydrogen that could be oxidized to a hydroxy group.

The tri-hydroxy substitution products having all three

C_nH_{2n+2}.	MONO- 1	DI- 2	TRI- 3	TETRA- 4	PENTA- 5	HEXA- 6	HEPTA- 7	OCTO-SUBSTITUTION PRODUCTS.

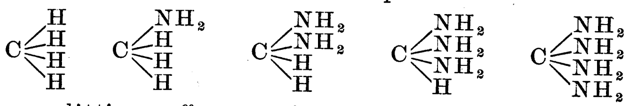
hydroxy groups connected with the same carbon atom, upon dehydration yield compounds characterixed by the group $R'-C\genfrac{}{}{0pt}{}{\lessgtr O}{\lessdot O-H}$, the carboxyl or acid group. It is also evident why aldehydes and not ketones yield acids upon oxidation.

The table also shows that there are compounds of a mixed or double character, such as hydroxy- or keto-acids, alcohol-aldehydes, etc.

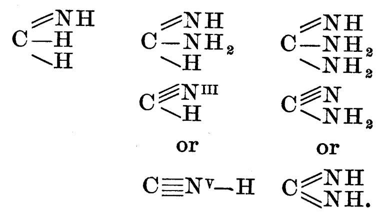
Once having demonstrated the common origin of these compounds, the enumeration of which would be merely a matter of time, and having shown their general relationship, it is much easier later in a course of instruction, when it becomes necessary to treat of alcohols, aldehydes, acids, etc., as classes of compounds, to give a comprehensive rather than a disconnected view of the entire subject. If the student once grasps the idea that alcohols, aldehydes and acids are families of the same tribe the point gained can hardly be overestimated. The student is otherwise apt to regard alcohols and acids, e. g. in the formation of esters, as two rather antagonistic classes of substances, as the alchemists considered inorganic bases and acids, a fantastic notion from which even modern chemistry has not completely freed itself. It appears natural to the average student that the hydroxy-hydrogen of the acid or carboxyl group $\left(-C\genfrac{}{}{0pt}{}{=O}{-O-H}\right)$ should be replacable by a metal to form e. g. sodium acetate, $CH_3C\genfrac{}{}{0pt}{}{=O}{-O-Na}$, but that the hydroxy-hydrogen of an alcohol group, or even the hydrogen of a methylene group e. g. in $\overline{R'}.CH_2.\overline{R'}$, should also be replacable by sodium, is something that usually appears contradictory to his notions of bases, acids and salts. However, if the genetic relations of such compounds has been demonstrated, such false notions will be dispelled. It can also be easily explained to him why in one case the hydrogen should be somewhat more readily replacable by sodium than in another, viz., because of its somewhat modified surroundings.

It may be worth mentioning that the sulph-hydrides or mercaptans, the sulphides, the thio-aldehydes, thio-acids, etc., can be deduced and classified in the same way by replacing the hydrogen of the hydro-carbons step by step by sulph-hydride groups (—S—H)′ and splitting off sulphuretted hydrogen wherever two sulph-hydride groups are connected with the same carbon atom.

In an analogous manner the hosts of nitrogen derivatives of the paraffin hydro-carbons can be derived. In this case the substituting radicle is the amido group, $\left(-N^{III}\begin{smallmatrix}H\\H\end{smallmatrix}\right)'$, derived from ammonia, NH_3. By substituting this group step by step in place of the hydrogen atoms of methane the following mono-, di-, tri- and tetra-amido substitution products can be derived:

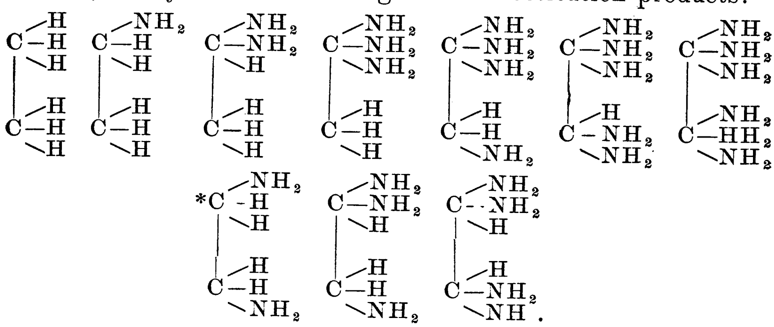


Upon splitting off ammonia, NH_3, the following nitrogen compounds will result:

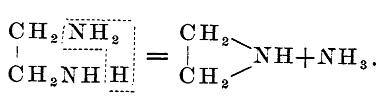


On account of the tri- and penta- valency of the nitrogen atom the number of possible nitrogen derivatives is greater than the number of possible oxygen or sulphur derivatives.

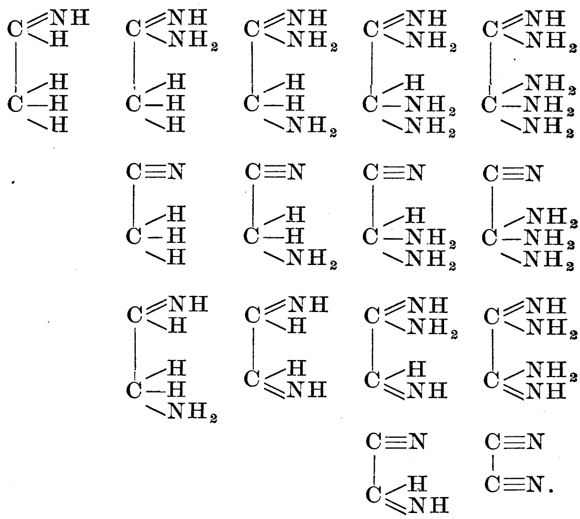
Ethane, the second member of the series of paraffin hydrocarbons, will yield the following amido substitution products:



* Upon splitting off ammonia from symmetric diamido ethane di-methylene imine will result:



These, upon splitting off ammonia, NH_3, will yield the following compounds:



The same process of substitution and removal of ammonia might be applied to propane, the butanes, etc., but these two examples will suffice to demonstrate the process. If we now generalize and classify we obtain the following typical formulas for series:

p. $R'-CH_2.NH_2$
s. $R'_2=CH\ NH_2$
t. $R'_3\equiv C.NH_2$
Monamines.

$R'-CH(NH_2)_2$
$R'_2=C(NH_2)_2$
Diamines.

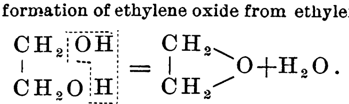
$R'C(NH_2)_3$
Triamines.

$R'-CH=NH$
$R'_2=C=NH$
Imines.

*$R'-C\begin{smallmatrix}=NH\\-NH_2\end{smallmatrix}$
Amidines.

$R'-C\equiv N$
Nitriles.

This is analogous to the formation of ethylene oxide from ethylene glycol:



The compounds resulting are of a cyclic character, which, for the sake of simplicity, are not to be included in the present consideration.

*If R=H then $C\equiv N^{v}-H$ also becomes possible.

The amines in a certain way correspond to the alcohols, and are capable of yielding corresponding alcohols through the diazo reaction:

$$R'CH_2N\,\boxed{H_2+O}\,N.OH = R'.CH_2.N:NOH+H_2O.$$

$$R'.CH_2.\boxed{N:N.}\,OH = R'.CH_2OH+N_2.$$

The valency of the amido group is equivalent to that of the hydroxy group, namely, one.

The imines correspond to aldehydes and ketones. Their derivatives can be obtained by condensation of aldehydes with substituted ammonias, e. g.:

$$H-C\begin{matrix}\diagup H \\ \diagdown \boxed{O+H_2}\end{matrix}NC_6H_5 = H-C\begin{matrix}\diagup H \\ \diagdown N.C_6H_5.\end{matrix}$$

On the other hand, imido groups upon hydrolysi are converted into keto groups, e. g.:

$$\begin{matrix} NH_2C{=}NH \\ \vert \\ N \\ \Vert \\ N \\ \vert \\ NH_2C{=}NH \end{matrix} .(NO_3H)_2+2H_2O= \begin{matrix} NH_2C{=}O \\ \vert \\ N \\ \Vert \\ N \\ \vert \\ NH_2C{=}O \end{matrix} +2NH_4NO_3.$$

This interesting reaction takes place upon boiling the aqueous solution of the nitrate of the base (Thiele, Ann. 270, p. 7).

As far as equivalence of substitution is concerned, the triamines correspond to ortho-acids, the amidines to meta-acids. The amidines can be converted into meta acids by substitution of $(O)''$ for $(NH)''$ and of $(OH)'$ for (NH_2),′ e. g.:

$$CH_3C\begin{matrix}\diagup \boxed{NH+H_2}\,O \\ \diagdown NH_2\end{matrix} = CH_3\begin{matrix}\diagup O \\ \diagdown NH_2\end{matrix}.+NH_3;$$

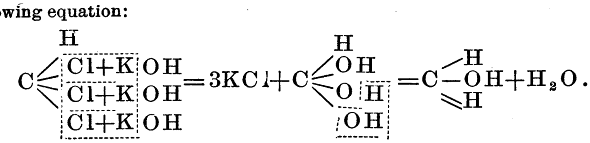
$$CH_3C\begin{matrix}\diagup O \\ \diagdown \\ +O\end{matrix}\Big\vert\, N^{III}\begin{matrix}H_2 \\ H_2\end{matrix} = CH_3C\begin{matrix}\diagup O \\ \diagdown O N^{V}H_4\end{matrix} = CH_3C\begin{matrix}\diagup O \\ \diagdown O-H\end{matrix}+NH_3.$$

Reasoning from analogy points out no analogon among the oxygen derivatives for the nitrile. This is due to the different valencies of the oxygen and nitrogen atoms. However, since the nitrile is a de-ammoniated derivative of an amidine, or a corresponding tri-amine, like them it yields an acid upon hydrolysis. Like the acids the nitriles are tri-substitution products of a methyl group of the underlying hydro-carbon, $R'.C{\equiv}N + OH_2 = R'.C{<}^{O}_{NH_2}$, which is further hydrolysed to the free acid or ammonium salt of the acid as indicated above.*

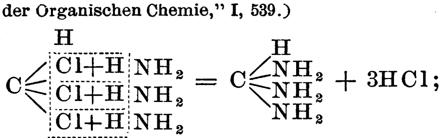
Among the oxygen derivatives carbon dioxide, $C{<}^{O}_{O}$, meta carbonic acid, $C{=}O{<}^{O-H}_{O-H}$, and ortho-carbonic acid, $C(OH)_4$, occupied a singular position. The first two named are the complete and partial anhydride respectively, of tetra-hydroxy carbon.

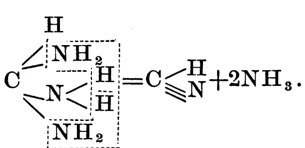
* To illustrate more fully the relation between acids and corresponding nitriles as tri-substitution products of the same hydro-carbon, the following example may be added:

Chloroform, a tri-chlorine substitution product of methane, when heated with potash solution yields potassium formate. The mechanism of the reaction can be explained by the following equation:

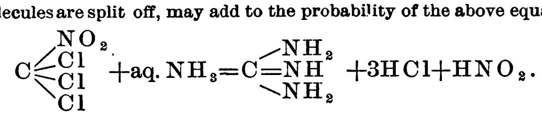


Aqueous ammonia, or ammonium hydroxide, acts like potassium hydroxide; alcoholic ammonia, however, produces hydrogen cyanide, its ammonium salt respectively. Why the mechanism of the reaction in this case should not be explained in an analogous manner is difficult to understand. (Compare explanation of the two reactions, Meyer & Jacobsen, "Lehrbuch der Organischen Chemie," I, 539.)

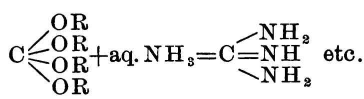




The proof that intermediate compounds are formed, i, e., such in which not all possible ammonia molecules are split off, may add to the probability of the above equation:



Chloro picrin. Guanidine.



Otho carbonic acid ester. Guanidine.

Since there is but one hydro-carbon, namely, methane, in which all four affinities of the carbon atom are saturated by hydrogen, its tetra-hydroxy derivative with its partial and complete anhydrides will occupy a unique position in a system of classification of the oxygen derivatives of the paraffin hydro-carbons.

For like reason we find among the nitrogen derivatives of this series of hydro-carbons several derivatives, which in a system of classification call for an isolated position, i. e., cannot be treated as members of series, since they do not form series of the kind under consideration. These compounds are carbon tetramine, $C(NH_2)_4$, guanidine, $C\begin{smallmatrix}\diagup NH_2\\ = NH\\ \diagdown NH_2\end{smallmatrix}$, carbon di-imine, $C\begin{smallmatrix}= NH\\ = NH\end{smallmatrix}$, and cyanamide, $C\begin{smallmatrix}\equiv N\\ \diagdown NH_2\end{smallmatrix}$. It will readily be seen that the three first compounds may be likened to ortho-carbonic acid, meta-carbonic acid and carbonic acid anhydride, respectively. As a matter of fact, e. g. carbamic acid is stated to occupy an intermediate position between meta-carbonic acid and urea:

$$\underbrace{C\begin{smallmatrix}\diagup OH\\ = O\\ \diagdown OH\end{smallmatrix}}_{\text{Meta-carbonic acid.}} \qquad \underbrace{C\begin{smallmatrix}\diagup OH\\ = O\\ \diagdown NH_2\end{smallmatrix}}_{\text{Carbamic acid.}} \qquad \underbrace{C\begin{smallmatrix}\diagup NH_2\\ = O\\ \diagdown NH_2\end{smallmatrix}}_{\text{Urea.}} \qquad \underbrace{C\begin{smallmatrix}\diagup NH_2\\ = NH\\ \diagdown NH_2\end{smallmatrix}}_{\text{Guanidine.}}$$

With the same propriety, urea can be considered as an intermediate product between carbamic acid and guanidine.

The relations existing between alcohols, aldehydes, ketones, and acids are so generally understood, also the gradual change from the first to the last, or vice versa, that it is not at all necessary to comment on a system of classification of the hydroxy substitution products of the hydro-carbons and their partial and complete anhydrides based upon the theory of substitution and subsequent dehydration.

As to nitrogen derivatives, some further evidence than that already given may not be out of place. That ammonia splits off from numerous compounds containing nitrogen is a fact generally known. The manufacture of ammonia from various sources is based upon this observation. The chemist studying amines, etc., has frequent occasion to deplore the instability of such compounds, owing to the splitting off of ammonia in various operations. A large number of specific observations might be enumerated by way of illustration; a few, however, may suffice.

1. The formation of polymethylene imines from the corresponding diamines: e. g.

$$\begin{matrix} CH_3.CHCH_2NH_2 \\ | \\ CH_2CH_2NH_2 \end{matrix} - NH_3 = \begin{matrix} CH_3.CHCH_2 \diagdown \\ | \qquad\quad NH \\ CH_2CH_2 \diagup \end{matrix}$$

β—Methyl-tetra methylene diamine. — β—Methyl-Pyrollidine [Ber. 20, 1654].

$$CH_2 \begin{matrix} \diagup CH_2NH_2NH_2 \\ \diagdown CH_2CH_2NH_2 \end{matrix} - NH_3 = CH_2 \begin{matrix} \diagup CH_2CH_2 \diagdown \\ \diagdown CH_2CH_2 \diagup \end{matrix} NH$$

Penta-methylene diamine (Cadaverine). — Piperidine [Ber. 20, 2216].

2. The quantitative decomposition of some salts of bases into ammonium chloride and less saturated hydro-carbons, e. g.:

$$C_{10}H_{15}NH_2HCl = NH_4Cl + C_{10}H_{14}$$

Pinylamine hydrochlorate. — Cymene [Ber. 24, 3984].

$$C_{10}H_{17}NH_2HCl = NH_4Cl + C_{10}H_{16}$$

Dihydrocarvylamine hydrochlorate. — Terpinene [Ber. 24, 3985].

3. If several or all of the valencies of the nitrogen atom are saturated by radicles, substituted ammonias frequently split off with equal readiness. Attention may be called to Hofmann's method for the "Abbau" of piperidine bases. [Ber. 16, 2068, and 19, 2628].

$$CH_2{=}CHCH_2CH_2CH_2N \begin{matrix} \diagup\!\!\diagup (CH_3)_2 \\ - CH_3 \\ \diagdown OH \end{matrix} = CH_2CHCH_2CH{=}CH_2 + N(CH_3)_3 + H_2O.$$

So-called Tri-methyl piperidine ammonium hydroxide. — Piperylene. — Tri-methyl lamine.

Not only can ammonia or its substitution products be split off readily from more complicated nitrogen derivatives, analogous to the dehydration of hydroxy derivatives, but, like water, it can often be added with similar readiness. A few examples will suffice to illustrate these syntheses of nitrogen compounds:

1. Formamidine is prepared by the addition of ammonia to hydrogen cyanide:

$$C\begin{array}{l}\diagup H\\ \equiv N\end{array} + \left\{\begin{array}{l}NH_2\\ H\end{array}\right. = C\begin{array}{l}\diagup H\\ -NH_2\\ =NH\end{array};$$

2. Guanidine hydrochlorate by the addition of ammonium chloride to cyanamide:

$$C\begin{array}{l}\diagup NH_2\\ \equiv N\end{array} + \left\{\begin{array}{l}H\\ NH_2HCl\end{array}\right. = C\begin{array}{l}\diagup NH_2\\ -NH.HCl\\ =NH_2\end{array}.$$

3. Substituted ammonias can be added in like manner:

$$\underbrace{C\begin{array}{l}\diagup NH_2\\ \equiv N\end{array}}_{\text{Cyanamide.}} + \underbrace{\left\{\begin{array}{l}H\\ N\begin{array}{l}\diagup H\\ \diagdown CH_2.COOH\end{array}\end{array}\right.}_{\text{Amido acetic acid or glycocoll.}} = \underbrace{C\begin{array}{l}\diagup NH_2\\ =NH\\ \diagdown NH.CH_2COOH\end{array}}_{\text{Glycocyamine.}};$$

$$\underbrace{C\begin{array}{l}\diagup NH_2\\ \equiv N\end{array}}_{\text{Cyamine.}} + \underbrace{\left\{\begin{array}{l}H\\ N(CH_3)CH_2COOH\end{array}\right.}_{\text{Methyl glycocoll or sarcosine.}} = \underbrace{C\begin{array}{l}\diagup NH_2\\ =NH\\ \diagdown N(CH_3)CH_2COOH\end{array}}_{\text{Methyl glycocyamine or creatine.}}.$$

The gradual substitution of hydroxy groups for hydrogen and the subsequent dehydration certainly demonstrates in an admirable manner the genetic relations existing between alcohols, aldehydes and ketones, and acids. The gradual substitution of the amido group for hydrogen and the splitting off of ammonia points out similar relations existing between amines, imines, amidines, nitriles, etc. Such a deductive treatment of a large field may serve as an admirable introduction to the more detailed study of the series, e. g. of oxygen or nitrogen derivatives of this particular series of hydro-carbons. It becomes almost self-evident that these series should be studied in the same succession in which they are derived. Nevertheless, it will be found at a glance over our more important text and reference books that this is not the case. Richter e. g. in his "Inorganic Chemistry" has arranged the material under consideration in accordance with the periodic system, as far as he evidently thought he dare. In so far he broke with traditions, and in each new edition he has new words of praise for the periodic system, not only as a chemical theory, but also as a didactic basis. Upon examination of the "Organic Chemistry," by the same author, such a basis for the adopted classification appears almost altogether wanting. This is particularly true e. g. of the nitrogen derivatives of the paraffin hydro-carbons. For the sake of illustration an abbreviated outline of the chapters may be given:

PARTIAL CLASSIFICATION OF THE PARAFFIN HYDROCARBONS AND THEIR DERIVATIVES ACCORDING TO

Richter.	*Victor Meyer.*	*Bernthsen.*
Monatomic alcohols (saturated and unsaturated). Ethers. Mercaptanes and Thioethers. Esters of the Mineral Acids. Amines: primary, secondary, nitro-amines, ammonium bases, hydroxylamine derivatives. Hydrazines, Diazo-compounds. Phosphines, Arsines. Metalorganic compounds. Aldehydes and Ketones. Monobasic Acids (saturated and unsaturated). Haloid anhydrides of the acids Cyanides of the acid radicles. Acid anhydrides, Thio acids. Esters of the fatty acids. Acid amides, Amide chlorides, Thio amides. Cyanogen-, Sulpho- and Amido-derivatives of the acids. Keto-acids. Cyanogen compounds: Dicyanogen. Hydrogen cyanide, Halogen cyanide, etc. Cyanic Acid, Cyanamic Acid, etc. Cyanides of the Alkyl radicles. Iso-cyanides or Carbylamines. Cyanamide, etc., Amidines, etc., Guanidine, etc.	1. Paraffin hydrocarbons. 2. Monatomic alcohols, $C_nH_{2n+1}(OH)$. 3. Alkyl compounds, the alkyl radicles of which are bound to halogen or oxygen. 4. Alkyl derivatives of sulphur (selenium or tellurium). 5. Alkyl derivatives of nitrogen: (a) Alkylamines, $C_nH_{2n+3}N$. (b) Quaternary ammonium compounds. (c) Hydrazine and tetrazone. (d) Alkyl derivatives of hydroxylamine. (e) Carbylamines (isonitriles or isocyanides). (f) Alkyl nitro compounds, $C_nH_{2n+1}NO_2$. 6. Alkyl derivatives of other metalloids (phosphines, etc.). 7. Alkyl derivatives of metals. 8. Transition to acids, aldehydes and ketones (Alkyl cyanides or nitriles of the fatty acids). 9. Fatty acids. 10 Derivatives of fatty acids. 11. Aldehydes and ketones.	1. Hydrocarbons (saturated to series C_nH_{2n-6}). 2. Halogen substitution products. 3. Monatomic alcohols. 4. Derivatives of alcohols: (a) Ethers. (b) Sulpho-alcohols and ethers. (c) Esters with inorganic acids and their isomers. (d) Nitrogen bases of alkyl radicles. (e) Compounds of phosphorus, arsenic, etc. (f) Metallic derivatives of the alkyl radicles. 5. Aldehydes and ketones. 6. Monobasic acids. 7. Acid derivatives: (a) Esters (b) Acid chlorides. (c) Acid anhydrides. (d) Thio acids. (e) Acid amines. (f) Amido- and imido-chlorides. (g) Thiamides. (h) Amidines. 8 to 11. Polyatomic alcohols and polybasic acids. 12. Cyanogen derivatives: (a) Cyanogen and hydro-cyanic acid. (b) Halogen derivatives of cyanogen. (c) Cyanic and cyanamic acids. (d) Sulpho-cyanic acid and derivatives. (e) Cyanimide and derivatives. (f) Appendix: Theory of isomerism in the cyanogen group.

A mere glance over these tables of contents, which reveal the system, or rather lack of system, of classification, will immediately make strikingly apparent the lack of uniformity. If, then, the raison d' être for the one or the other is looked for it fails to become apparent. If the periodic system is what Richter states it to be: if it not only places the elements and their derivatives in such position to point out their relations, but for this very reason may also serve as a basis for classification of chemical compounds for didactic purposes, why should it not be made serviceable in the study of carbon compounds as well as in the study of all other compounds?

The hydro-carbons are almost universally made the basis of study of the carbon compounds. A classification of them, therefore, becomes of fundamental importance. The best standard of classification seems to be that of the *degree of saturation* as expressed by the following formulas of saturation: C_nH_{2n+2}, C_nH_{2n}, C_nH_{2n-2}, C_nH_{2n-4}, C_nH_{2n-6}, etc. Each formula of saturation comprises one, several or even many *series* of hydrocarbons, which can be classified secondarily according to their non-cyclic or cyclic character. The classification of the hydrocarbons being accomplished satisfactorily, one of the principal difficulties of a comprehensive study of the carbon compounds is overcome. The order in which the derivatives of these hydrocarbons are to be considered is next in importance, and here, as well as in the fundamental classification of the hydrocarbons, writers on chemistry, as we have already seen, generally differ.

Those who follow the periodic system in general will e. g. upon reaching the fifth group, after a discussion of the elements nitrogen, phosphorus, arsenic, antimony and bismuth, take up their hydrogen derivatives, then their halogen derivatives, then their oxygen, sulphur, etc., derivatives, following the order in which these elements are generally studied, viz.: hydrogen, the halogens, the oxygen group (O, S, Se, Te), the nitrogen group (N, P, As, Sb, Bi). Why the same order should not be followed in the study of carbon-compounds it is difficult to understand. True it is that it is partially followed, but never consistently, at least not in the text or reference books.

If such a system of classification is carried to its logical conclusion it evidently leads to a study of nitrogen derivatives in the order outlined above. The amines and hydrazines will then be studied after, not before, aldehydes and ketones, the nitriles even later, and not before the fatty acids.

In conclusion the writer desires to state, in order to avoid misunderstanding, that such a system is not meant for the elementary student. The beginner in chemistry is not dosed with the periodic system or with any system. The elementary student is taught how to observe chemical phenomena, how to interpret them correctly, and how to draw generalizations from obtained facts. For this purpose the methods of instruction are as inductive as possible and the number of observations is naturally limited lest the student may fail to see the woods on account of too many trees. With the more advanced student, who reviews the subject of chemistry in order to obtain a more comprehensive view of the entire field, the method of treatment should differ accordingly. After the eminently successful application for more than twenty-five years of deductive methods in chemical research, it would seem that a more general application of deductive methods in teaching chemistry might not be uncalled for, i. e., in their proper place.

If such methods as outlined are already followed here and there in lectures and class-room work, the writer should be pleased to receive information of the fact. In a country, however, in which text-books are employed so fully as in ours, the writer may be pardoned, if necessary, for concluding that the treatment accorded the subject of chemistry in the class-room does not differ materially, at least in the largest number of instances, from that of the text-books.

The above is an expression of opinion, founded upon a substantial basis, as the writer believes, on a subject which has been seriously neglected. Within the last thirty years or more chemical thought has experienced no great revolutions. Theories have been formulated: some have again vanished, others are still being fought over. Yet within this time the benzol theory, and other more recent theories, have been so fruitful in their inventiveness that the chemist almost constantly finds himself so deluded with new material that he seldom, if ever, finds a breathing spell in which to sift and rearrange the new material he is trying to assimilate, as well as the old, according to new ideas. This is certainly strikingly apparent in our text and reference books. To call attention to it and indicate a way that will lead out of the difficulty may be worth the time spent in writing this short article.

Madison, Wis.

THE ANATOMY OF THE HEART OF CAMBARUS.

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WITH PLATES V AND VI.

The discrepancy that exists between the heart of the Crayfish, as usually described, and the actual condition as found by dissection, led me to make a careful study of the heart of our common Crayfish. In the carrying out of this work Mr. J. D. Madison, one of my students, gave me very material assistance, the mechanical part of the work being done by him.

It will be found on looking over the literature of the subject, that in nearly every instance in which a description of the heart of the Crayfish is given, it is taken directly from Huxley's work, or it is based on his description.[1] The form used by Huxley was Astacus, and although I have not had an opportunity to verify his results, I presume them to be correct. The common Crayfish with us is not Astacus but Cambarus. Huxley noted several points of distinction between the two forms, mentioning especially the reduction in the number of gills. As the result of my study, I have found that Huxley's account of the heart of Astacus can not be applied to that of Cambarus.

If a portion of the carapace of a live Crayfish be carefully removed from the mid-dorsal region, there is exposed to view a place where a regular pulsation may be seen; this marks the situation of the heart. Continuing the dissection of the tissues underlying the carapace, there is brought into view a cavity irregularly quadrangular in shape; occupying a considerable portion of this cavity will be seen a fleshy mass, much the same shape as the cavity but smaller, which contracts and dilates with a constant regularity. The cavity is usually called the

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[1]Anatomy of Invertebrated Animals, 1878.

An Introduction to the Study of Zoology, Illustrated by the Crayfish, 1879.

pericardium, the pericardial sinus or the pericardial chamber, while the pulsating organ is termed the heart.

The heart does not lie free in the cavity, but is attached to its walls by ligaments; while running out from the anterior and posterior ends are the blood-vessels (arteries), which penetrate the walls of the cavity and carry the blood into the general circulation.

A more exact nomenclature demands, it seems to me, that the cavity be called "auricle," and the pulsating organ "ventricle," as this corresponds more accurately to the functions of the parts.[2]

The blood brought from the branchiæ into the pericardial chamber passes at once into the pulsating organ, from which it is driven into the general circulation by its strong contraction.

"It will be observed that the branchiæ are placed in the course of the current of blood which is returning to the heart, which is the exact contrary of what happens in fishes in which the blood is sent from the heart to the branchiæ on its way to the body. It follows, from this arrangement, that the blood which goes to the branchiæ is blood in which the quantity of oxygen has undergone a diminution, and that of carbonic acid an increase, as compared with the blood in the heart itself. . . . The blood, therefore, which reaches the branchiæ has lost oxygen and gained carbonic acid; and these organs constitute the apparatus for the elimination of the injurious gas from the economy on the one hand, and, on the other, for the taking in of a new supply of the needful 'vital air,' as the old chemists called it. It is thus that the branchiæ subserve the respiratory function."

METHOD OF STUDY.

The heart may be fixed *in situ* by removing a small portion of the carapace immediately over it, and then plunging the still living animal into strong (95 per cent.) alcohol, hot saturated aqueous solution of corrosive sublimate, or 10 per cent. nitric acid. By either of these methods the firm carapace prevents

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[2] I shall, however, in the present paper use the term heart in its usual significance.

the wall of the pericardial chamber from collapsing and pressing the soft heart out of shape.

After fixation, the heart should be carefully removed, cutting the arteries which arise from it as long as possible, passed through alcohols of gradually increasing strength, and the hardening completed in 95 per cent. alcohol. As soon as this is accomplished (four to six days), the heart may be stained in any of the usual stains, embedded in paraffin and sectioned serially. Careful attention should be given to the dehydration, as I have found that it takes place quite slowly.

The sections used for study were cut .02 mm. thick, and at right angles to the long axis of the heart.

In order that the form and relation of the various parts of the heart might be easily grasped, use was made of Born's method of reconstruction of objects from serial sections.[3]

The wax plates were prepared by melting together four parts of best yellow bees-wax and one part resin, and pouring the liquid mass on the surface of hot water contained in a tank of given dimensions; when cool, this gave a plate of uniform thickness. Plates made by this formula I found much superior to those obtained from the dealers.

After the drawing on the plates was completed and the proper parts cut out, the plates that were to enter into the reconstruction were fitted together, and the whole fused by means of a hot tool; when this was accomplished, the model was cut into three parts. The cavity of the heart was treated in a similar manner to the outer surface.

As a control of the model, outline drawings of the heart previous to sectioning, as well as drawings of other hearts, were used.

A complete study of the vascular system was not made. The large arteries were followed sufficiently far to show their course and general distribution.

The vascular system may be studied by injecting the vessels with a solution of soluble Prussian blue in distilled water. The injection may be accomplished by inserting the needle of a

[3] Die Plattenmodellirmethode, Archiv f. mik. Anat., 1883, and Zeit f. wiss. Mik., 1888.

hypodermic syringe, which has been filled with the above solution, through the muscular wall of the heart into its cavity and making steady pressure on the piston. When this method is used, the carapace must be removed over the heart and the pericardial chamber opened. Successful preparations may be made by simply pushing the needle of the hypodermic syringe dorsally through the articulation between the cephalo-thorax and first abdominal segment, in a forward and downward direction, until it is within the pericardial chamber, and then pressing steadily on the piston.

The pulsation of the heart may be observed by opening the pericardial chamber of a live Crayfish; if this is kept filled with normal salt solution, the action of the heart may be watched for a considerable period.

FORM.

We will first consider the form of the heart as brought out by the reconstruction.

As will be shown later in the paper, the heart from which the reconstruction was made was in a contracted condition; this fact should be kept in mind while following the accompanying description.

Looking down upon the heart from the dorsal side, its form may be described as being saddle-shaped, the most prominent feature being the ridge, which runs from the posterior to the anterior border, increasing in prominence as it advances, and becoming distinctly rounded as it passes between the two dorsal openings. (Fig. 1, Pl. V.)

Viewed from the side, two openings into the heart will be seen, one placed behind the other. It will also be noticed that the dorsal surface of the heart projects some distance beyond the ventral, both anteriorly and posteriorly. The sides of the heart are concave dorso-ventrally. (Fig. 2, Pl. V.)

The ventral surface is the shortest; it has no openings into the cavity of the heart. It is slightly concave from side to side. (Fig. 3, Pl. V.)

In order that the heart may be conveniently studied, especially in regard to its cavity and the relation which it bears to the exterior and to the various openings, it has been divided into three parts, which will be spoken of as the anterior, middle and posterior thirds; each third is approximately of the same length.

ARTERIES.

From the anterior end of the heart five arteries are given off; three near the dorsal border and two but a short distance below them. (Fig. 4, Pl. V.) At the posterior ends of the heart only one artery is given off; this arises near the ventral border. (Fig. 2, Pl. V.)

Of the five arteries which arise from the anterior end of the heart, the three superior do not separate from each other immediately after immerging from the heart, but are bound together for some little distance; eventually they become distinct vessels and have independent distribution. (Figs. 1 and 4, Pl. V.)

The middle of these three arteries is the ophthalmic, often called by the German authors the unpaired "Kopfaorta." This is the smallest of the three; it runs directly forwards, over the stomach, and is distributed to the brain and eyes. The other two are the antennary arteries; they pass forward and outward around the stomach and are distributed to the antennæ.

The remaining two of the five anterior arteries are situated ventrally from the three just described, near the center of the anterior end. (Fig. 4, Pl. V.) They arise close to each other and separate soon after leaving the heart. They are the hepatic arteries. Their course is outward, downward and forward, being distributed, as their name implies, to the liver. In size they correspond with the antennary.

The single artery arising from the posterior end of the heart is the superior abdominal, or posterior aorta. It is the largest artery arising from the heart; it passes backward into the abdomen and is situated dorsal to the intestine. It gives off ventrally quite a large branch, the sternal artery. The superior abdominal arises from a funnel-shaped prolongation of the heart (Fig. 2, Pl. V), the artery forming the stem of the funnel. Following Huxley's description, the sternal artery is said, by all authors which I have consulted, to arise in common with the superior abdominal, from a bulbus-like enlargement of the posterior end of the heart. This does not hold true for Cambarus; the sternal artery is given off as a branch of the superior abdominal after it has become established as a distinct artery.

VALVES.

Each artery is provided at the point where it leaves the heart with valves, which prevent the blood from flowing back into the heart. These valves are from 0.25 mm. to 0.5 mm. in length. They consist of two loose folds passing parallel to each other from one side of the artery to the other; at the junction of the artery with the heart these valves are attached to the wall of the artery, the free extremity extending into the cavity of the artery in the direction of the blood current.

VALVULAR APERTURES.

There are no veins entering the heart of the Crayfish, but in their place we have six valvular apertures through which the blood enters the heart from the pericardial chamber. Two of these openings are dorsal and four are lateral. The two dorsal apertures are situated well to the anterior of the heart, quite near together, separated by the prominent dorsal ridge already described. (Fig. 1, Pl. V.) They are not placed parallel to the long axis of the heart, but they have a forward and outward direction, being more closely approximated posteriorly than anteriorly. The four lateral apertures are arranged in pairs, two on each side. They are, as a rule, situated in the middle third; their long axis does not correspond to that of the heart, but has a downward and forward direction. I shall call these two pair of lateral apertures "anterior lateral" and "posterior lateral." The posterior lateral apertures are situated in the median line on each side, while the anterior lateral apertures are situated quite near the ventral border. (Fig. 2, Pl. V.)

Each aperture is provided with valves, as shown in Fig. 7, Pl. VI, which is a transection of one of the lateral apertures. These valves consist of two flaps completely surrounding the opening, the free ends of the flaps projecting into the cavity of the heart. There is thus formed a "bicuspid" valve at each orifice. By referring to Fig. 7, Pl. VI, it will be seen that each curtain is club-shaped in longitudinal section, being much narrower at its origin from the wall of the heart than at its free extremity. Behind each valve there is a "sinus" similar in function to those found behind the semi-lunar valves of the vertebrate heart. Fig. 5, Pl. VI, shows a section through the dorsal apertures, and Fig. 6, Pl. VI, shows a section through the lateral apertures.

CAVITY OF HEART.

It will be remembered that the arteries arising from the anterior end of the heart are situated nearest to the dorsal border, while the single artery arising from the posterior end is nearest to the ventral border. The cavity of the heart conforms to this arrangement, being at the anterior end nearest to the dorsal and at the posterior end nearest the ventral surface. In the anterior third of the heart, the cavity is large and slopes upward towards the exit of the arteries. The dorsal valvular apertures open into this portion of the heart.

The anterior half of the middle third is much larger than is the posterior half. The anterior and posterior lateral valvular apertures open into this part of the heart. The narrowing of the cavity begins immediately behind the posterior valvular orifice.

There are no valvular apertures in the posterior third; the cavity does not slope down to the single arterial opening, but ends in the funnel-shaped extension which has already been described. (Figs. 2 and 3, Pl. V.)

The walls of the cavity (the ventricle) are made up of muscle fibres covered by a thick layer of epithelium. The muscle fibres are arranged in layers which run in various directions, interlacing with each other. Two quite prominent layers may be noted, one longitudinal in direction and one circular; the longitudinal is the most external. The epithelium covering the muscular wall is composed of several layers of large irregular-shaped cells. Fig. 7, Pl. VI, gives a view of the cells and the relation which they bear to the muscle.

LIGAMENTS.

As was stated early in the paper, the heart does not lie free in the pericardial chamber, but is attached to its walls by means of the arteries and certain band-like structures, called ligaments. The arteries have been described, and it remains for me to take up the ligamentous attachments.

Huxley describes six ligaments, three on each side, as being present in the heart of Astacus; of these three, two are attached to the anterior dorsal angle of the heart and one to the posterior. Dogiel[4] has recently described the ligaments of the heart of the same species as being made up of fine fibres which are attached to the entire surface of the heart. These fibres pass in different directions, interlace and unite to form broad bands, which are attached to the walls of the pericardial chamber.

As the result of numerous dissections, I find in Cambarus an entirely different arrangement, which may, perhaps, be said to be a combination of the views of Huxley and Dogiel.

Attached to each angle of the dorsal surface of the heart is a broad ligament; the two attached to the anterior angles have a forward, upward and outward direction, while those attached to the posterior angles pass backward, upward and outward to be attached to the walls of the pericardial chamber.

Besides these, I find a broad band attached all along the ventral border of the lateral surface, which extends directly outward to be attached to the wall of the pericardial chamber. The place of the attachment of this lateral ligament to the heart is indicated in Figs. 5 and 6, Pl. VI.

ACTION OF THE HEART.

Each pulsation of the heart consists of a stage of strong contraction, termed its systole, followed by a stage of dilatation or diastole. During its systole the heart becomes shortened and much narrower; this is due to the contraction of the longitudinal and circular muscle fibres already mentioned.

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[4] Beitrag z. verglich. Anat. u. Phys., d. Herzens. Arch. f. mik. Anat., 1894.

The action of these muscle fibres is antagonized by tbe several ligaments; these contain a considerable number of elastic fibres, and are put on the stretch by the contraction of the heart. As soon, therefore, as the action of the muscle fibres cease, the ligaments pull the heart back again to its original position and form. When the heart contracts, the cavity is in like proportion made smaller, the force of the contraction closing the valvular apertures of the heart and forcing the blood out through the arteries into the general circulation. The contraction being ended, the ligaments, by their elasticity, cause the heart to again dilate; the backward pressure in the arteries causes their valves to close. Now the valves of the apertures open, and by a decided suction the cavity is filled with blood from the pericardial chamber, to be again expelled by the contraction of the heart. This pumping action can be easily demonstrated by opening the pericardial chamber and using normal salt solution as indicated earlier in the paper.

As has been stated, the heart which was modeled was in a state of contraction; in proof of this statement it can be asserted that only during the stage of contraction can the prominent ridge, Fig. 1, Pl. V, be seen; it entirely disappears during the diastole of the heart. Moreover, those sections which pass through the valvular apertures show the folds of the valves closely applied to each other, (Figs. 5, 6, Pl. VI.) while the arterial valves are widely open.

In regard to the rapidity of the heart's action, no method was found by which it could be observed under perfectly normal conditions. Such observations as were made gave an average of seventy-two beats per minutes.

SUMMARY.

The heart of our common Crayfish, Cambarus, differs from the accepted description of Astacus in the following particulars.

(1) While both forms have the same number of valvular apertures (six), their arrangement is different. In Astacus there are two dorsal, two ventral and two lateral; in Cambarus there are two dorsal and four lateral, the ventral apertures of Astacus being absent. In Astacus the dorsal apertures are

placed almost central, while in Cambarus they are placed some distance anterior to the center.

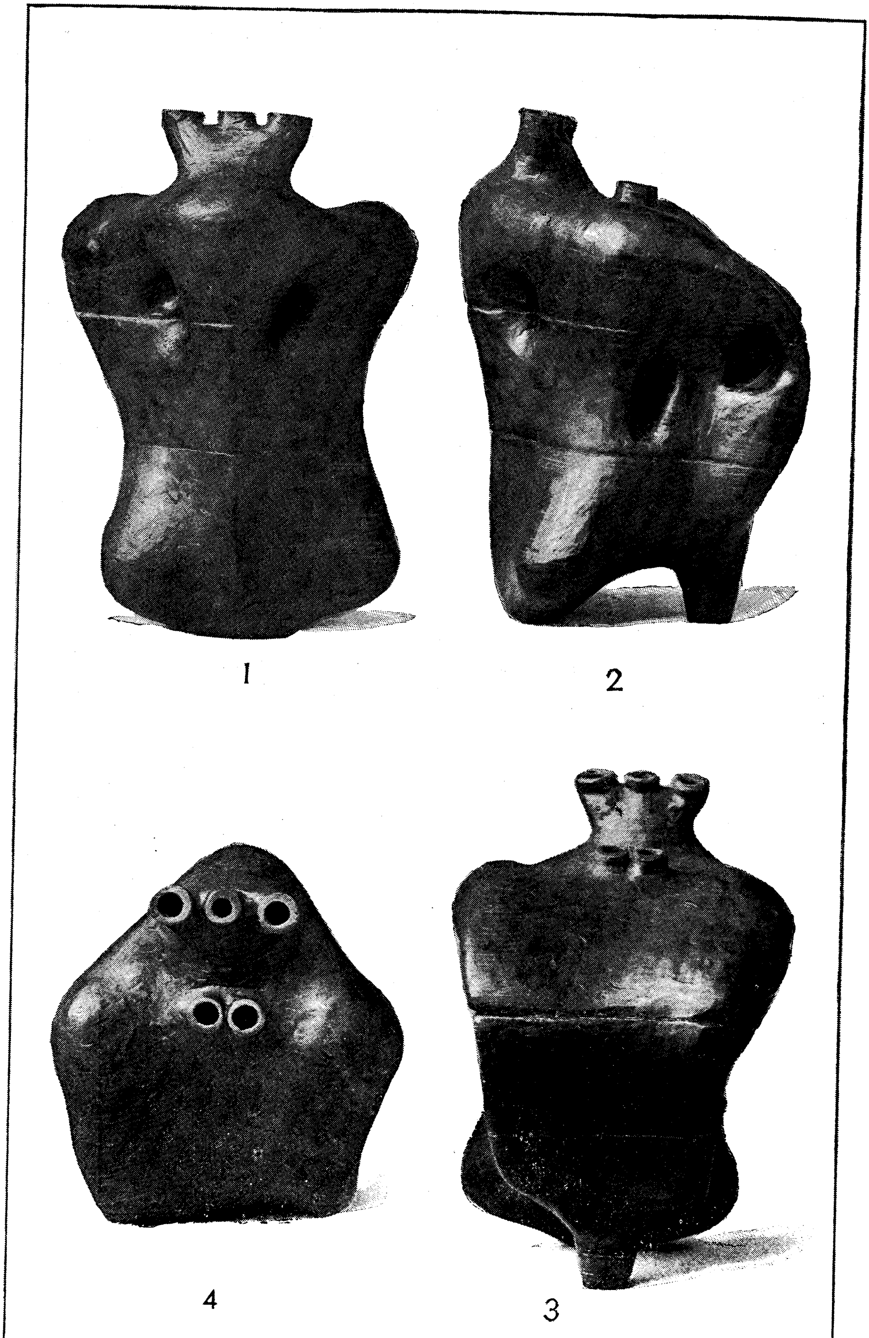
(2) The hepatic arteries arise much nearer to each other in Cambarus than they do in Astacus.

(3) In Astacus the heart is attached to the pericardial chamber by ligaments extending from the anterior and posterior cornua, while in Cambarus not only are ligaments found attached at these points, but there is also present on each side a strong lateral ligament extending along the entire ventral border.

(4) In shape the two differ widely from each other. The heart of Cambarus is longer, narrower and less rounded posteriorly than is that of Astacus.

Madison, Wis.

NOTE.—The species of Camberus for this locality have not been determined. Probably there are three species found in our waters. The foregoing description of the heart holds good for all the species.



MILLER ON HEART OF CAMBARUS.

EXPLANATION OF PLATE V.

Fig. 1. Dorsal view of the heart of Cambarus as shown by reconstruction. The prominent ridge in the center, the openings of the two dorsal valvular apertures, the common origin of the antennary and ophthalmic arteries and the round shoulder-like projections at the anterior and posterior angles are well shown.

Fig. 2. Same heart viewed laterally. The two lateral valvular apertures, the right dorsal aperture and the funnel-shaped origin of the superior abdominal artery are to be especially noted.

Fig. 3. Ventral view. Note the absence of valvular apertures; the common origin of the antennary and ophthalmic arteries; the hepatic arteries and the superior abdominal artery. The concave surface and the border along which the band-like ligament is attached are also shown.

Fig. 4. View of anterior end of heart, showing the relative position of the five arteries which arise from this portion of the heart.

EXPLANATION OF PLATE VI.

Fig. 5. Outline of a section taken through the center of the dorsal valvular apertures. × 20.

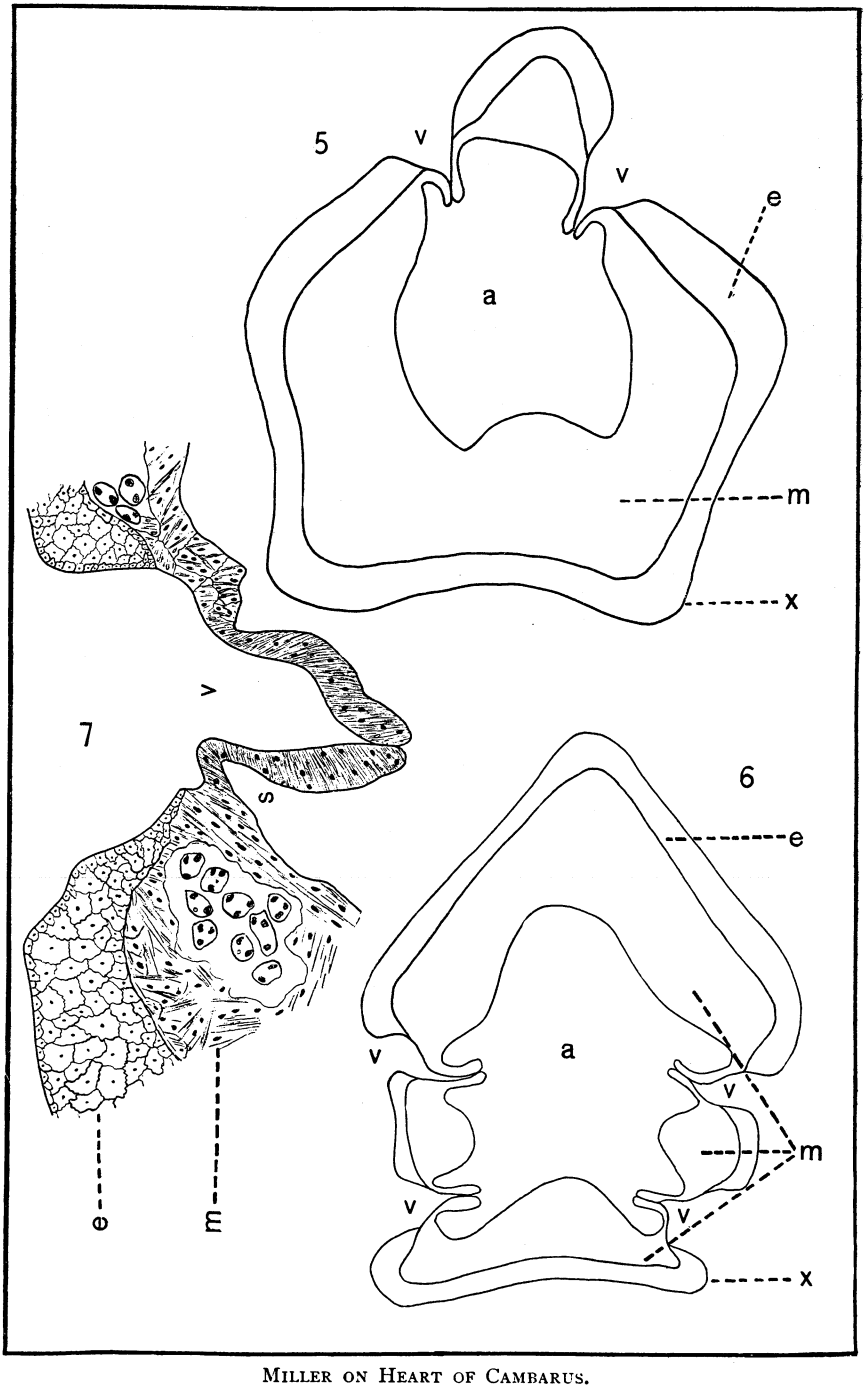
A. Cavity of heart.
V. Valvular apertures with valves.
E. Layer of epithelium.
M. Muscle of heart.
X. Point of attachment of ligamentous band.

Fig. 6. Outline of a section through the four lateral valvular apertures. × 20.

A. Cavity of heart.
V. Valvular apertures with valves.
E. Layer of epithelium.
M. Muscle of heart.
X. Point where ligamentous band is attached.

Fig. 7. Section through a valvular aperture. × 100.

V. Aperture with valve.
E. Epithelium.
M. Muscle.
S. Sinus behind the valvular fold.



MILLER ON HEART OF CAMBARUS.

THE EROSIVE ACTION OF ICE.

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It was originally intended in this paper simply to record some observations made in various parts of the country, bearing on the question of the power of moving ice to corrode its bed. Finding that the literature of the subject was somewhat abundant, it was decided to incorporate some of the views of others in this paper. This has been done to such an extent that the former intent has been quite overshadowed and the paper as now presented is simply a resume of previous publications on the subject with comments on some of the views expressed and with my own observations correlated so far as may be with those of the various writers from whose papers abstracts have been made.

The literature examined covers the period from 1862 to the present. It was thought that a development of ideas on the question of glacial erosion might thus be traced, which would perhaps be comparable to the general advance of the science of glaciology as a whole. This has been found to be the case in a measurable degree, yet from the first there seems to have been two classes of opinions, quite opposed to each other; and most of the authors consulted fall readily and decidedly into one or the other class.

Considerable positiveness has been manifested by a large proportion of the authors, (who are not all geologists), only a very few taking decidedly conservative ground. A few have changed their views, but these changes, with some notable exceptions, have been not to a middle ground between the two extremes, but from one side squarely over to the other.

It is interesting to note that the men who have been most conservative in their expressions of opinion, are the ones who would probably be now named as first in the list of authorities on all glacial questions.

Perhaps the majority of geologists regard the presence of such great numbers of lakes in the glaciated districts of the world as strong evidence of the power of ice to excavate rock. Particular mention is often made of the Alpine lakes, as well as of those of Scotland, Scandinavia and northern North America. Indeed it seems to be on this point — the origin of lake basins — that the question of glacial erosion chiefly turns.

The one party confidently refers to these lake basins as of undoubted glacial origin; and the other party as strenuously asserts the utter incapacity of the ice to do any such work.

The English geologist, Ramsay,[1] was among the first if not the first, to take the ground that the lakes above referred to are of glacial origin, i.e. lie in rock basins which were excavated by ice. He believed that the greater number of the Scottish tarns lie in rock basins, formed by the grinding of glacier ice, whether in valleys, on rough table lands, or on the water-sheds of passes. Some basins were formed by reason of local softness of the rock, but more generally he supposed them to be due to the greater thickness of the ice on particular areas.

"The theory of the glacial origin of many rock-basins, must, I feel convinced, be extended much beyond such mountainous districts as Switzerland, Wales and the Highlands of Scotland where they first attracted my attention."

In regard to the great alpine lakes he says of Lake Geneva that (1) it does not lie in a simple synclinal basin; (2) it is not due to special subsidence; (3) it is not due to a fracture of the rock; (4) it is not the result of water erosion, since water cannot possibly scoop out a hollow nearly a thousand feet deep.

The only other agency to which he can appeal is ice, and the Rhone glacier is the agent which he believes excavated the basin of Lake Geneva.

In a similar manner he accounts for Lakes Neuchatel, Thun, Brienz, Zug, Lucerne, Constance, Zurich and Wallen.

Lake Zurich has its waters held at their present level by a moraine, but he thinks the main basin is excavated in the rock.

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[1] Quart. Jour. Geol., Aug., 1862.

Notwithstanding the abundant evidence of pre-glacial erosion in the region of Lake Constance, which is fifty miles long and fifteen miles wide, and lies in Miocene strata, he concludes that since the falls of the Rhine are more than 800 feet above the bottom of the lake, the lake must lie in a rock basin which was excavated by the Rhine glacier.

He considers the great depth of the Italian lakes, Maggiore, Lugarno and Como, as sufficient evidence that they lie in rock-basins which were excavated by ice. As confirmatory evidence, he notes the fact that the deepest part of Lake Maggiore is at the place where the enormous glacier of the Val de Ossola joined the great ice-stream that was formed by the united glacier drainage of the valleys above Bellinzona and Locarno. Where these glaciers united there the lake begins; and where the ice was on the largest scale, there the lake is deepest.

That he may have taken cause for effect here does not seem to have occurred to him, at least he does not hint at such a possibility. Yet it is quite certain that if the valleys had been formed before the advent of the ice, the disposition of the ice-flow would have been the same as described, i. e., where the valley was deepest the ice would have been thickest.

In all these cases of alpine lakes he does not believe in the possibility of buried outlets; nor does he seek to combine the single causes which are considered by him as separately inadequate.

The North American and Scandinavian lakes are similarly disposed of, but with less discrimination, as the writer had of course not had opportunity for personal observation of the North American lakes. He quotes Sir William Logan, then director of the Canadian Geological survey, as fully agreeing with him and as even thinking that the Great Lakes, Michigan, Huron, etc., may be accounted for in the same way.

A remarkable change seems to have come over his views within the two following years. His theory had been much discussed and sharply criticised. In reply he published in November, 1862, the following:

"No better proof could be required that *in great part the valleys of the Alps were approximately as deep before the glacial epoch as they are at present* (italics mine); and I believe, with the Italian geologists, that all that the glaciers as a whole effected was only slightly to deepen these valleys and to materially modify their general outline, and, further (a theory for which I alone am responsible) to deepen them in parts more considerably, where, from various causes, the grinding power of the ice was unusually powerful, especially where, as in the lowlands of Switzerland, the Miocene strata are relatively soft."

This is certainly a very conservative view in comparison with his published opinion of two years before.

Dr. Falconer[2] attacked the views of Ramsay as to the origin of the alpine lakes and called attention to the mechanical difficulties which he thinks were quite overlooked by the followers of Ramsay. He referred to lake Maggiore, in which, after the ice has plunged down to the depth of nearly half a mile, it comes sliding up again at the rate of one hundred and eighty feet to the mile.

He thought the lake basins in the Alps were caused by the upheaval of the mountains, that rivers ran into them and had begun to silt them up when the glaciers came and re-excavated them, and carried on past them the large drift deposits which would otherwise have filled them.

In the Himalayas, on the southern slopes, the basins were thus filled and there there are no lakes, while on the northern slopes the ice extended farther and so carried the drift beyond the basins, and on that side lakes abound as in the Alps.

There is food for thought in this latter suggestion, but it is not easy to see how the mechanical difficulties suggested in the case of lake Maggiore are any more easily overcome on Falconer's hypothesis than on Ramsay's. Grant that the ice entered the basin and passed beyond it, and it makes no difference what agency formed the basin; the ice must "plunge" down and "slide up" just the same in either case.

In 1869 Sir Archibald Geikie read a paper before the Royal Society of Edinburgh, in which he maintained the glacial origin of the Swiss lakes, and dwelt upon the intimate connection between the alpine lakes and the innumerable rock-basins of the northern hemisphere, intimating that these two are of glacial origin. In his Text-book of Geology, 2d ed., he maintains the

[2] **Proc. Royal Geog. Soc., Jan., 1864.**

same views but suggests in a foot note (p. 401) that preglacial weathering may have formed the basins before the ice came, so that all the ice had to do was to sweep out the decomposed rock.

In the latest edition of the same work he reiterates his former views which are essentially those of Ramsay, but seems to open the door of possibility a little wider than before for the chance entrance of other modes of origin for the rock basins.

Geikie would seem to belong rather to the conservative class on the question of glacial erosion, but he is still claimed by the Ramsay school, as a supporter of their views.

Prof. J. D. Dana[3] affirms the power of the ice to break off rock masses and thus to make boulders and gravel in large quantities for transportation. He thought the gravel and boulders were incorporated into the ice mostly in the lower one thousand feet and largely in the lower five hundred feet.

He suggests that the fjords of Maine may have been begun before the ice age.

In his Manual of Geology he accepts the possibility of the formation of lake basins in soft strata, and thinks the ice would rise on encountering harder strata, thus forming the rim of the basin.

Le Conte[4] believes that all the Sierra lakes that he has seen are of glacial origin, with the possible exception of lake Tahoe. He has been led to modify his views on this question by observations in the Sierras.

He concludes that a glacier by its enormous pressure, and resistless onward movement is continually breaking off large blocks from its bed and bounding walls. Its erosion is not only a grinding and scoring but also a crushing and breaking. It makes not only rock meal but rock chips. It is constantly breaking off blocks and making angular surfaces, and then grinding off the angles both of the fragments and the bed, thus forming rounded boulders and moutoneèd surface. Its erosion is a constant alternation of rough-hewing and planing. Which of these processes predominates depends on the thickness of the

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[3] **Am. Jour. Science, vol. 5, p. 200, 1873.**

[4] **Am. Jour. Science, vol. 10, p. 126 et seq., 1874.**

ice and the texture of the rock. If the rock be full of fissures and the glacier deep and heavy the rough hewing rules. If the rock be very hard and solid and the ice be not very thick, the planing will predominate over the rough-hewing and a gentle smooth billowy surface is the result.

Although he does not say so directly, the inference is that Le Conte considers the rough-hewing to be efficacious in the making of rock basins.

Prof. N. S. Shaler[5] accounts for the formation of rock basins with characteristic ingenuity. He says that owing to the accumulation of the ice, the isogeothermal lines will rise in the earth and will ultimately invade the lower part of the ice to such an extent that melting will ensue in the deepest portions. The water thus formed, being under great hydrostatic pressure will be forced out, thus deepening the basin and cutting down the rim where it escapes. He also thinks that as a result of this washing, the ice would slide toward the center of the basin thus increasing its size by wearing.

To account for the basins in which this work goes on, Shaler supposes very slight original differences of level and very decided differences in the relative conductivity of the rocks, so that the isogeotherm of 32° would reach the ice in its ascent, not at a uniform level, but at points at different elevations. Contiguous ice masses, therefore, although lying at approximately the same level would be differently affected. The base of one might be invaded by the melting temperature while the other remained free from such invasion.

He applies this reasoning to the New England region to account for the great number of lakes there. He regards it as more than probable that these lake basins have again and again been filled with ice, so that, as we now see them they represent the accumulated wearing of many glacial periods.

Prof. T. C. Chamberlin[6] gives his view of ice action as follows:

'The proper conception of its action as we view it, is that of a very stiff viscous liquid, into the base of which is incorporated rocky fragments and earthy debris, which act upon the

[5] Proc. Bos. Soc. Nat. Hist., vol. 10, p. 358 et seq.

[6] Geology of Wis., vol. 1, p. 265.

rock floor not as a rigid plane but as a flexible rasp scratching it with the coarser and polishing it with the finer material, at the same time detaching and bearing away rock fragments which in turn score the surface beyond."

Of the effects of this action on pre-existing topography he writes as follows:[7]

"Two general stages may, however, usually be well distinguished, the first, in which the pre-glacial features are entirely dominant and the effect of drift erosion and covering is merely to soften and subdue the earlier surface expression; the second in which the pre-glacial rock contour has been thoroughly subdued (1) by cutting off projecting peaks, shoulders and spurs, and the filing of the whole down to a system conformable with the demands of glacial flowage . . . and (2) by the filling up of the valleys in various degrees according to situation and attitude toward the glacial movement; so that while the main ridges and valleys remain the same as in pre-glacial times and even many minor features still find expression, the whole aspect is very markedly changed and has assumed a parallel linear arrangement and a softened expression quite in contrast to the dendritic arrangement of ridges, and valleys, and the rough abrupt contour lines of the pre-glacial erosion type."

There is nothing here indicating a belief in the excavation of rock basins by ice, yet Prof. Chamberlin is sometimes claimed by the believers in that hypothesis as favoring that view.

L. P. Gratacap[8] notes that in a fresh advance of the glacier of La Brenna in 1831 it attacked a promontory in its path with such vigor as to shatter it with fissures and compel the removal of a chapel upon its crest. This would be strong evidence if we knew that previous to the advance of the ice, the promontory was not already fissured by other agencies, and so ready to fall an easy prey to the advancing glacier. No such statement is made by this author and we cannot therefore attach much weight to this evidonce.

The same writer says that lake Wakatiper in New Zealand by the most indisputable proofs has been dug out of the rock by ice to the depth of fourteen hundred feet. It is unfortunate that he did not state the evidence constituting this indisputable proof.

[7] Third Annual Report U. S. Geol. Survey, p. 305.

[8] Popular Science Monthly, Nov., 1878.

[9] Popular Science Review, 1879.

Rev. J. Clifton Ward[9], speaking of the tarns of Cumbria, believes them to be of ice origin for reasons precisely like those given by Ramsay long before.

Isaac Kinley[10] thinks glaciers have excavated the basins of large numbers of our North American lakes.

Prof. N. H. Winchell[11] thinks that Green Bay and Great Bay de Noquet were excavated by ice.

Dr. Robert Bell[12], of Canada, thinks Great Slave lake, Athabaska, Winnipeg, Georgian Bay and Ontario lakes were excavated by post-tertiary glaciers.

Rev. J. G. Bonney[13] does not believe that any of the great alpine lakes were primarily formed or have undergone any great secondary modification by glacial action. He would account for the lakes by local crust movements.

Prof. J. W. Judd[14] does not believe that any basin that can be called a lake at all, can be attributed to glacial action as a primary cause.

Mr. Carr[15] said: "The moulding power of ice upon hard granite possessing a strong physical structure, is comparatively slight. In such regions, glaciers do not so much mould and shape, as disinter forms already conceived and ripe."

Prof. Whitney in "Climatic Changes" said:

"The most important work of a glacier is the scratching and grooving of surfaces . . . the only glacial lakes are those where pre-existing valleys have been closed by morainic matter."

Hugh Miller said, that if glaciers can excavate at all, they can more easily enlarge a lake than start one.

Dr. F. Pfaff[16] after experimenting on the Aletch glacier, argues against the theory of the formation of valleys by glacial erosion.

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[10] Pop. Sc. Monthly, July, 1887.

[11] Am. Jour. Sc., 3d series, vol. 2, p. 17.

[12] Quoted by Pop. Sc. Monthly, July, 1389.

[13] Quarterly Jour. Geol. Soc., vol. 25, pp. 479–489.

[14] Geol. Mag., dec. II., vol. 3, pp. 523–525.

[15] Overland Monthly, May, 1874.

[16] Pogg. Ann., vol. 151., pp. 325–336. Sitsungsberichte Phys. Med. Soc. Erlangen, Heft VI, Seiten 34–44.

Tyndall on the other hand says:[17]

"I say nothing of lake basins; but it is a physical certainty that, given time enough, glaciers *must* scoop out valleys. A glacier with a thickness of a thousand feet will press on every square yard of its bed with a weight of 486,000 pounds. Such a weight with a motion derived from a pressure from behind *must* excavate."

Dr. Von Haast[18] describes a valley on the west coast of New Zealand in which the ice advanced over beds of gravel without destroying them to any appreciable extent.

McGee[19] observed many cases in Iowa in which deposits of till of moderate thickness have been made above residuary clays. In some cases the clay was disturbed somewhat, in others it was not, and the clays were not compacted more than is the lower till below the latest glacial drift.

Two generations of Hugh Millers have recorded the finding of beds of boulders over which the ice has passed, striating and grinding their upper surfaces without moving them.

The moving of ice over beds of till, of gravel, and even over a meadow without destroying the turf is recorded by Neumayr in his "Erdgeschichte."

In most of the cases like those above referred to the observations were made near or at the ice front. Many other similar cases have been noted by various observers.

A few instances have come under my own observation in regions far remote from the front of the ice in its most advanced position.

The first of these was seen near Big Stone City, South Dakota, soon after the grading of the railroad at that place. Several long and tolerably deep cuts were made which exposed the structure of the till beautifully.

At the base of the section was sixteen feet of older till, red, quite compact and with few boulders apparently. The upper surface of this till was a nearly level plain. The ice of a later advance had overrun the earlier till and had cut off a portion, how much I have no means of knowing, and had "glaciated" the

[17] Hours of Exercise in the Alps, pp. 238–247.

[18] Geol. of Canterbury and Westland.

[19] Am. Jour. Sci., vol. 18, pp. 301–303. 1879.

surface as though it were a rock mass instead of a bed of till. On this glaciated surface rested ten or twelve feet of newer, more bouldery till, which was in turn covered by six or eight feet of gravel containing rounded cobbles and boulderets up to eight or ten inches in diameter.

The three strata of drift were perfectly distinct and the sections were at that time (1888) perfectly fresh. The section showing the plane of separation between the old and the new till was an eighth of a mile in length and the plane itself was as marked as that between a bed of granite and a bed of schist.

During the summer of 1893 two similar cases were observed on the Big Fork river in northern Minnesota. The best case is about seven miles above Big Falls on the left bank of the river. In an air line the distance is about forty miles from Rainy Lake river. The till was compact blue clay resting on gravel. It was not very bouldery. Its upper surface has been planed off smooth by ice. It is covered by ten feet of sand.

Fifty miles farther south on the same stream a bed of boulders was seen over which the ice had moved striating the upper surfaces in a common direction.

These three cases are mentioned because they were observed so far to the north. It would seem that the ice must have moved over the region for many centuries at least.

J. Ruskin said:

"Try to saw a piece of marble through (with edge of iron for saw, and sharp flint sand for feldspar slime) and move your saw at the rate of an inch in three quarters of an hour, and see what lively and progressive work you will make of it.

"The Glacier Du Bois has not done more these 4,000 years against some of the granite surfaces beneath it, than the drift of desert sands have done on Mt. Sinai."

Mr. Wurtemberger[21] observes that the falls of the Rhine at Schaffhausen did not exist in the glacial era. The river (bed) at the falls is cut out of the upper Jurassic limestone, and its right bank is covered by well characterized drift.

Along a course cutting off the present bend in the stream, there is no trace of the limestone and only deposits of pebbles

[20] Am. Jour., vol. 40, pp. 98-99. 1865.

[21] Jahrb. Min., 1871, p. 582.

indicating the site of an old N. N. E. and S. S. W. valley of erosion, nearly in the direct course of the stream. The glacial deposits evidently filled this ancient valley, and thus forced the stream from its course, giving it a bend around south and west where by a fall of about eighty feet it regains its old channel.

A. Helland[22] states that the fjords of Norway are deeper in their middle portions than at their mouths where they are traversed by old moraines. The same is true of those of Scotland; and if the land should rise the fjords of these countries as well as those of Greenland would become lakes similar to Lake Maggiore and other lakes of the southern Alps.

In common with Nansen and some of the other Scandinavian geologists, Helland believes in the glacial origin of the fjords.

Professor W. M. Davis,[23] in his paper on the classification of lake basins, gives glacial erosion a minor place among lake forming agencies. He says it is certainly possible for glaciers to cut out rock basins but thinks the number and size of such basins have been greatly exaggerated.

He gives a discriminating review of the works of the various earlier writers on this subject and says in a brief summary that the difficulties that lie in the way of accepting a glacial origin for the large lakes are, in addition to the inefficiency of glacial erosion, first, that the necessity for the acceptance is not proved, as many of these lakes have other and sufficient causes; second that the distribution or location of rock basins is not sufficiently controlled by glacial but rather by orographic conditions.

He thinks Norway and Sweden undoubtedly possess many true rock basins of glacial erosion, but questions whether drift barriers may not explain the greater number of lakes there as they do in Finland.

He emphasizes the lack of exact data for lakes supposed to lie in rock basins and the overlooking of drift barriers, etc., as competent causes.

The formation of a lake is sometimes a simple, sometimes a complex affair.

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[22] Œfoers K. Svenska Vet. Akad. Förhandl., No. 4, pp. 13 33.

[23] Proc. Bost. Soc. Nat. Hist., Jan. 18, 1882.

Professor Pumpelly[24] in a paper on secular rock disintegration remarks that the plane marking the boundary between disintegrated rock and still hard rock must be an exceedingly irregular one. If we could imagine the loose, altered rock removed where this process has been active in depth, the surface exposed would present a remarkable topography, one in which the hardness of the material would play no causative part. The *prominences* would consist of those rocks most resistant to carbonic acid, e.g., soft clay slates and mica schists, as well as the hard quartzites and sandstones.

The *depressions* would represent rocks more or less easily acted upon by carbonic acid, water and oxygen, and to some extent all rocks carrying feldspar in abundance.

These depressions are largely *closed basins* . . more or less filled with the decayed rock until emptied by ice, wind, or some other agency.

He regards this disintegrated material as the chief source of the glacial drift and says he would measure the excavating power of the continental glacier, in solid rock by only a small portion of the finest part of the glacial debris.

[It is proper to state here that Professor Chamberlin has always held that the mechanical origin of the till was clearly indicated by the presence of carbonates in it. Residual clays are notably free from carbonate.]

One of the strongest advocates of the great erosive power of ice was the late Professor Newberry. He believed that ice was a much more effective agent than rivers.

Some of his latest papers were devoted to this subject. It was his belief that even the great American lakes had been largely formed by ice action.

Of late years quite a number of geologists have spent considerable time in studying the work of living or present glaciers.

Of these may be mentioned Professor J. W. Spencer, who thus writes of his observations on the Norwegian glaciers:

"Many of the glaciers are advancing and are seen to arch over from rock to rock, leaving sub-glacial caverns into which the explorer can go long distances.

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[24] Am. Jour. Sci., vol. 17. 1879.

"Numerous boulders are to be seen lying on the glacier bed of crystalline rock. Some of these are rounded, some sub-angular. The ice flows around them without stirring them. Even the boulders resting on the loose, soft morainic material over which the glacier is advancing are able to channel the ice as it moves over them.

"No blocks were seen in the act of being torn up from the subjacent rock, nor were loose stones being picked up.

"A large rounded boulder was being rolled along under the ice, not shoved, at the same time it was being crushed.

"A tongue of ice (about a cu. yd.) hanging from the roof of an ice cavern was seen pressing against a boulder that a man could have moved. The stone was not moved, and the ice was bent back in a curve (nearly a right angle). Scratched stones were rarely seen among those falling from the bottom of the glacier and in many places the rocks were scarcely if at all scratched. Although occasionally highly polished, the subjacent rocks even where scratched, showed genenally surfaces roughened by weathering or with only the angles removed.

"The upper layers of ice were seen to bend and flow over the lower wherever low barriers were met with in place of the lower strata being pushed up by an oblique thrust.

"A glacier was advancing into a morainic lake, and in part against the terminal barrier. In place of ploughing up the obstruction, the ice was forced up into an anticlinal, along the axis of which was a fracture and a fault.

"At several places where glaciers are advancing over moraines, they are leveling them and not plowing them out. This leveling process is by the dripping of the water from the whole under surface.

"The fall of a great ice avalanche from a high snow field, down a precipice of a thousand feet, to the top of a *glacier remainie* was seen. These falling masses bring down frost-loosened stones from the sides of the mountains, upon the glacier. . . It is this material which furnishes mud to the sub-glacial streams, and not the rocky bed of the valley, worn down by glacial erosion.

"One does not find that the glaciers, *per se*, are producing rock hummocks. These are the results of atmospheric agencies and aqueous erosion. They are only polished and scratched by the ice.

"The effects of glaciation in removing angles and in polishing surfaces is small compared with atmospheric erosion upon the same rocks." [25]

This is a most interesting series of observations. It must be borne in mind, however, that they were made at or near the ends of the glaciers, where the ice is yielding to the forces

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[25] A. A. A. Sci., vol. 36, pp. 218-220.

which destroy it, and where by common belief it is least effective in erosion.

Prof. W. H. Niles[26] at the close of his interesting paper on the relative agency of glaciers and subglacial streams in the erosion of valleys says:

. . . "the observations of three summers among the glaciers of the Alps have led me to estimate the relative agency of glaciers and of subglacial streams in the erosion of valleys as follows, viz.: the subglacial streams are of primary importance in working in advance of the ice, in deepening and enlarging these valleys. The glaciers abrade, modify, and in a measure reduce the prominent portions left by the streams, and give them the well known glaciated surfaces."

Long continued observation in the Alps has given Edward Whymper[27] a very similar view as to the erosion accomplished by glaciers. He says:

"Moraines are largely composed of matter which falls upon the glacier, or is washed down the sides of the mountain, and only to a very limited extent of matter that is ground, rasped, or filed off by the friction of the ice. Moraines illustrate the transporting power rather than the erosive power of ice."

It is evident that by moraine he means terminal or end moraine. Mr. Douglas Freshfield said:[28]

"For the last twenty five years I have had constant opportunities for observing glaciers at work in the Alps and elsewhere. The period has been one of retreat, following one of advance. What have some of the thickest — the Brenna, Lower Grindelwald, left behind? Not hollows, but hummocks.

"Burnishing I have seen glaciers often; scraping or pushing back soft protuberances in their path sometimes; but scooping or excavating, never."

He doubts that the thicker the ice the swifter its base will travel, and is of opinion that shearing will occur as a result of the increased friction on the bed, so that while as a result of the increased thickness the surface may move with accelerated velocity, the basal layers may not be affected in the same way or to the same degree, yet he agrees that the erosive power is increased by added thickness.

The studies of Dr. Albrecht Heim of Zurich, on the glaciers of

[26] Proc. Bost. Soc. Nat. Hist., vol. 19, pp. 330-336, Mar. 1878.

[27] Scramble Among the Alps, pp. 101-102.

[28] Proc. Royal Geog. Soc., Dec. 1888, pp. 779 et seq.

the Alps are the most thorough, comprehensive, and complete of all that have come under my notice. His results are embodied in his "Handbuch der Gletscherkunde," Stuttgart, 1885.

It is often stated by writers on the subject of glacial erosion, that the amount of sediment carried down by glacial brooks and rivers is much greater than that carried down valleys of equal area in which there are no glaciers; the obvious inference being that ice is much the more effective form of water so far as erosion is concerned.

That such statements are very misleading will be apparent on a little reflection. In the first place the measurements on which the estimates usually quoted, are based, were invariably made during the time when the rate of melting of the ice is at its highest.

Secondly, no deduction is made for material brought into the glacial stream by other means than the action of ice; a large factor or rather several factors of error thus find their way into the problem as commonly presented for solution, and the answer can but be erroneous.

Heim points out these factors distinctly.[29]

An oft-quoted example is that of the stream flowing from the Unter Aar glacier.

In 1841–5 Dolfuss determined the weight of sediment in the stream to be 1-7,040th of the weight of the water. But Heim states that these measurements were made in July and August, and that the average amount for the year cannot at most be more than 1-20,000th of the weight of the water. This is a reduction of nearly two-thirds from the widely published figures, yet it by no means tells the whole story. There are still other corrections to be made. It will be noticed *first* that the precipitation is fully as great on this valley as upon an equal unglaciated valley. The wash of this rain water from the valley sides and from the surface of the moraine covered glacier makes a very large addition to the sediment of the glacial stream. Again the *Schmelzwasser* itself, armed with the fine sand it carries is a powerful erosive agent, and the results of its activities are added to the total which goes out from the front of the glacier

[29] op. cit. p. 363.

and is there made to do duty as a measure of the amount and rate of *glacial* erosion. In many cases, also, springs come out in the valleys under the ice and add another factor to the problem.

In view of these evident and palpable sources of error affecting the most careful measurements that have thus far been made it seems clear that little confidence can be placed in any conclusions as to the rate of glacial erosion, which are based on such measurements.

Still less weight attaches to the opinion of those who only see the turbidity of the glacial stream and draw their conclusions hastily. On this point Heim says (p. 364):

"Those who see the glacial stream continually turbid in summer, while other streams run clear, who go into the mountains only in fine weather, such may with Penk[30] be led through these momentary superficial glances, to the false conclusion that a more intense erosion takes place under the glacier than in valleys not glaciated. (The glacial sediment, owing to its exceeding fineness, produces a relatively strong optical effect.) Those who see the wild mountain torrents during heavy rain-storms will come to quite different conclusions."

He further says:

"A system of unglaciated valleys furnishes its drift only periodically, in one day accomplishing more in the way of drift transport than the same area of a glaciated mountain in a year.

We already possess a number of measurements which show us that the ordinary alpine torrents whose united area is only one-tenth that of the Unter Aar glacier, by the annual floods, which in the natural course of things occur, carry into the valley in one or two days from 10,000 to 100,000 cubic meters. And the cases are not rare in which such torrents, in a few days remove one, two, and even three million cubic meters from the drift hills to the principal stream or into lakes."

[Compare this with the measurements of Dolfuss on the stream from the Unter Aar glacier, 60 cubic meters in a July day, and remember the corrections to be applied which reduce this amount to from ten to twenty meters per day.—C.]

According to Heim the annual transport by the Unter Aar glacier is only 6,000 cubic meters or 1-20,000th part by weight of the water in the glacial stream.

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[30] Mitt. d. Vereine fur Erdkunde, Leipzig, 1879, p. 16.

On the other hand the content of fine sediment in the ordinary flood stage of mountain streams averages about 1-100th part.

The coarse material, disregarding the fine, was found to be 1-2,500th in the case of the Reuss and 1-1,500th in the case of the Linth. Contrasting the two Heim says:

"Der Gescheibe und Schlammtransport der Gletscherbache ist also sehr viel geringer, geradezu verschwindend gegenuber demjenigen der gowohnlichen Bache and Flüsse."[31]

Regarding the making of lake basins by ice-action he says (p. 379): "The sweeping out of an old river bottom (Alluvionsboden) to a small lake basin, has never been observed in existing glaciers, much less the digging out of such a basin in hard rock."

He further says that the contrast between ice action and the ordinary forces of erosion is so great that valley making comes practically to a standstill when ice takes possession. This he says (p. 389) is not a theoretical deduction but a matter of observation.

He considers the ground moraine to come from the following sources (pp, 400, 401):

1. In the case of many glaciers it comes in great part from the surface moraines (Obermoranen).

2. A second source is found in the accumulated products of weathering.

3. The wear of the ice on the firm rock produces in most cases nothing but fine sand and rock flour (Schleifschlamm).

The cases are very rare in which rock fragments are broken off by the ice from its bed.

Heim's position on the main question is expressed as follows (p. 400):

"The slow sweeping out of a mass of sediment from a valley by a glacier [De Mortillet] I hold as not impossible from the facts, which we gather from existing glaciers although an actual occurrence has not yet been proven; likewise, some widening of deep valleys in soft sandy rocks, and the grinding out of shallow troughs also in hard rock I hold as conceivable, although direct proof is lacking, and the indirect has never been given without sharp qualifications."

"The grinding out of large lake basins in rock by glaciers

[31] Handbuch der Gletscherkunde, p. 365.

(Ramsay), I consider unproven. From the direct observations of myself and others on the insignificance of glacial agencies, I cannot accept the hypothesis. I find it however worth further examination.

"On the other hand, the attributing of cirques, valleys, and fjords to glacial action [Tyndall, Helland], I consider as a striking failure to appreciate the occurrence of the working of different agencies, as erosion, weathering, glacial agencies, faulting, etc."

During the past year (1893) the discussion on the subject of erosion by ice has again become somewhat active especially in England.

So far as can be gathered from journals and reviews the discussion in England is at present narrowed down to two opposing views or hypotheses. The one is the Ramsay hypothesis practically unchanged, and the other accounts for the lake basins by orographic movements.

Mr. A. R. Wallace [32] is a prominent defender of the Ramsay hypothesis. He writes as follows:

'The first essential to lake erosion is a differential action, caused locally either by increased thickness of ice, a more open and level valley floor, or a more easily eroded rock, or by a combination of these . . . In a narrow V-shaped valley the ice might rest wholly on the lateral slopes and hardly touch the bottom at all.

"On a tolerably wide and level valley bottom however, the ice would press with its fullest intensity; and its armature of densely packed stones and rock fragments would groove and grind the rocky floor over every foot of its surface."

In explaining the absence of a large lake in the Dora Balthea valley, where a glacier produced the great moraine of Ivrea opposite its outlet into the plains of Italy, and which forms a chain of hills fifteen miles long and fifteen hundred feet high, he says the most important point is the extreme narrowness of the lower part of the valley above Donnas, and again near its entrance into the valley of the Po. The effect of this, he says, would be that the glacier, probably 2,000 feet thick or more, would move more rapidly in its upper layers, carrying out its load of stones and debris to form the terminal moraine; while the lower strata, choked in the defiles would move very slowly, thus producing little erosion.

[32] Fortnightly Review, vol. 60, p. 750 et. seq. Dec. 1893.

His explanation of the well known fact that a glacier often passes over till and even sand and gravel without removing it, is that the material is so soft and incoherent that the stones in the bottom of the ice would press into the yielding mass which would close up behind the on-moving stones and leave no result.

In this simple way also he disposes of the theory that the lake basins were pre-glacial in origin and filled with the debris of weathering so that all the ice had to do was to sweep out this material. This, for the reason he has just given, it could not do.

He quotes Dr. A Helland as stating that about 800,000 square miles of northern Europe is covered by Scandinavian drift to the depth of one hundred and fifty feet. As the area of the region from which it came is much less than the area covered, at least two hundred and fifty five feet must have been eroded from that region to supply the needed drift.

Add to this what was lost by shipwreck in crossing the Baltic and North seas and what the streams have carried off since, besides that which still remains in the lowlands of Scandinavia and we have, he thinks, as much as five hundred feet removed by the ice from Scandinavia during the glacial period. This supposed enormous erosion is offered in proof of the effectiveness of ice in such work.

Without possessing any personal knowledge of drift phenomena in Europe the present writer still feels unwilling to accept such figures as those just quoted. It is an established belief, if not an established fact, that here in America the drift of any region is from 75 per cent. to 90 per cent. local in origin. This statement refers to the newer drift.

Considering crust movements to be the only alternative mode of the formation of lake basins, Mr. Wallace adopts the following criteria to discriminate between the two: Basins of erosion are characterized by, first, the absence of submerged ravines or side channels; second, the basin forms of the lake bottoms and the frequent occurrence of two or more separate basins even in small lakes; third, the simple form of surface contour. He further notes that basins of erosion often have side valleys lying at higher levels than that of the main basin, the streams falling by cascade into the lakes. These are criteria of well recognized value; but they do not seem to the writer to possess the diagnostic potency with which Mr. Wallace has invested them. The same author believes that all existing lakes must have been formed at about the same time, and that a recent one, corresponding approximately with that of the glacial period.[33]

If we accept earth movement, as the cause of lake basins we must explain why these movements took place only in regions glaciated. He suggests that such movement might possibly result from the loading with ice.

But he thinks that if there had been a subsidence of the ice-loaded areas the streams flowing out from them would have kept pace with the movement and would have cut their beds down sufficiently to have prevented the formation of lakes.

He seems here to have overlooked the fact that at that time the streams were overloaded with sediment and were not eroding at all but on the contrary were filling their valleys.

Like many of the English writers on this controversy he ignores the patent fact of the blocking up of valleys by glacial debris. He is so fully persuaded of the fact that glaciers are mighty engines of erosion that he forgets that they not only cut down but fill up; and he does not seem to be at all aware of the fact that it is far easier to prove the efficacy of ice in this latter capacity than in the former.

The Duke of Argyle[34] considers glaciers incompetent to form lake basins and attributes their formation to orographic movements, but concedes some importance to the damming up of valleys.

Professor T. G. Bonney[35] represents perhaps the other view among English writers on this subject.

He does not believe in ice action as a cause of lake basins. He refers to the Caspian and the Dead sea and other similar instances in which ice could have had no hand.

He thinks the Alps furnish typical results of ice action and the sum of their evidence is, the rough places have been made

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[33] Nature, vol. 49, pp. 43–78. March 9, 1893.

[34] Nature, vol. 49, p. 389.

[35] Nature, vol. 49, pp. ——. 1893.

smooth, the rugged hill has been reduced to rounded slopes of rock (like the rounded backs of plunging dolphins). But the crag remains a crag, the buttress a buttress, and the hill a hill. The valley also does not alter its leading outlines; all that the ice has done has been to act like a gigantic rasp; it has modified, not revolutionized; it has moulded, not regenerated.

No sooner do we come to study in detail the effects of the ancient glaciers in the upper valleys of the Alps, than we are struck by their apparent inefficiency as erosive agent. The result of prolonged personal study of the Alps may be summed up in these words:

"Valleys appear to be much older than the ice age; and to have been but little modified during the period of maximum extension of glaciers.

"Extensive valley tracts have been uncovered by the recent retreat of the Alpine glaciers, but nowhere has evidence been found of excavation as distinguished from abrasion. No signs whatever that the glaciers were able to break off or root up blocks of rock from their beds, were seen. The ice seemed to wear off prominences only. Cases were observed where the ice had flowed over large blocks of loose rock and had striated them on top and on both sides but had not moved them."

He points out that the alpine lakes are near the ends of the ancient glaciers, not farther up where the ice must have been thicker and lasted longer.

He notes also that the Italian lakes have radiating arms which indicate other than glacial origin.

He concludes that rock basins are original valleys of erosion modified by earth movements.

No mention is made by Professor Bonney of the blocking up of valleys by drift although it is clear that the amount of crust movement (subsidence) necessary to account for the alpine lakes would be much less on the supposition that the ice borne debris had choked the valleys to some extent near the ice front.

A review is given by Prof. Bonney in Nature vol, 47, p. 5, of a most important work, perhaps the most important of all yet undertaken, in relation to the question in hand, during the last thirty years. The work reviewed is volume one of a monograph of Lake Geneva by Prof. F. A. Forel.[36]

[36] Le Leman, Monographie Limnologique; F. A. Forel, Tome Premier (Lausanne, F. Rouge, 1892.)

In this volume Prof. Forel rejects the hypothesis so long ago put forth by Ramsay, that the basin of Lake Geneva was excavated by the old Rhone glacier. He finds instead that the lake basin is an extension of the old Rhone valley. This valley was defined at a very early period in the uprising of the Alps. Its excavation progressed with their growth. It was practically completed at a time when they were higher by 1,000 meters than they are at present. Then followed a subsidence of the mountain region, the lowland being comparatively unaffected.

This formed the lake. The movement in the disturbed region may have been differential, but Prof. Forel does not consider this supposition necessary to account for the facts.

It is by such work as that of Prof. Forel, of which this brief mention gives but a glimpse, that the question of glacial erosion will be settled.

Prof. C. W. Hall says[37]:

"The lakes of Minnesota are conveniently divided into three classes: first, rock bound lakes; second, silted river lakes; third, glacial lakes.

"The first class occur chiefly in the northeastern part of the state. They occupy the troughs in the crustal folds that have contorted the surface, or the depressions where excessive faults have broken and considerably tilted the strata. These as a rule are long, narrow and deep. By far the greater number of lakes in Minnesota are those occupying the depressions in the unevenly distributed morainic matter deposited during glacial times.

"They were all evidently formed in the same general manner, by the washing down of fine silt from the highlands into the bottom, thus gradually filling the interstices in the gravels and sands beneath them, making water tight bottoms to hold the water."

There is here no reference to glacial erosion to account for any of the 10,000 lakes accredited to Minnesota.

The observations of the writer on the lakes of north-eastern Minnesota are quite in accord with the views here expressed by Prof. Hall.

The same statements may be made with reference to the lakes of Wisconsin and of the Dakotas. In none of these states has a lake been found which can be shown to owe its origin di-

[37] On the formation and deformation of Minnesota lakes, Science, vol. 21, pp. 314-315.

rectly to glacial erosion. Probably nine out of every ten lie in hollows in the drift.

Dr. Andre M. Hansen[38] thinks he has proven the Pleistocene origin of the Norwegian fjords. He maintains that it is impossible for an inland ice sheet coming from the highlands of Scandinavia to pass the row of close set fjords that deeply indent the coast of Norway. He says that in the last advance of the ice, the boulders of highland origin which it brought were left at considerable heights until the inner ends of the fjords were reached, when they suddenly drop down to the level of the old sea beaches.

On the east the same advance of the ice carried boulders into Prussia. But the western coast of Norway has been glaciated up to 1,800 feet above sea level. Hence he concludes that, since this could not happen in the presence of the fjords, it must have been done before they were excavated. This he thinks, demonstrates the *origin of the fjords in Pleistocene time* and he infers also their ice-made character. The writer has never seen the coast of Norway, but without such special information as would come from a study of the region it seems to him that, in view of the facts that (*a*) the fjords are excavated in hard rock, and (*b*) that Scandinavia has long been and still is in a state of oscillation, and (*c*) that the boulders mentione by Dr. Hansen halt at the old sea beaches, the most simple and natural explanation of that fact would be the submergence of the peninsula up to the level of the old sea beaches at the head of the fjords in late Pleistocene time. This submergence certainly took place at some time and what time more opportune than when Scandinavia carried a great and presumably uncomfortable load of boulder-clad ice on its back from which dirty water was constantly trickling down its face.

Dana, Upham, and others have shown pretty conclusively that the fjords of New England are of Tertiary age and that the continent stood then many hundreds of feet higher than it id in glacial times. The fjords were thus the work of the very rapid streams which this continental elevation produced.

Reasoning from analogy we might infer that the Norwegian

[38] Nature, vol. 49, p. 364.

fjords had a similar origin both in the matter of time and also of the excavating agent.

But such reasoning is no more conclusive than that of Dr. Hansen. Although it is far too commonly indulged in by geologists when discussing regions which they have never studied, the writer wishes to avoid the fault, and so while he doubts very much the capacity of even such very industrious ice as that of Scandinavia is said by Helland to have been, to excavate such deep passages as the Norwegian fjords in such hard rocks as their walls are said to show, yet he must confess that he really knows very little about it, and perhaps Dr. Hansen is right after all.

CONCLUSIONS.

From such study as he has been able to make of this subject the writer has been led to the conclusion that the efficiency of ice as an eroding agent has been very greatly exaggerated in the past.

The claims made for the erosive power of ice have been based on many observations. The chief of these claims are here specified:

1. The fact is undisputed that the lakes of the globe are practically confined to the regions that have been glaciated. Some of these lakes were apparently found to occupy rock basins. The conclusion was thus reached that the lakes for the most part had been furnished with beds by glacial erosion. It has since keen shown that in this country a very large majority of the lakes lie in drift hollows, still others lie in drift obstructed valleys, others have been formed by differential uplift. A few lie in folds in the rock and a very few lie in what seem to be true rock basins the origin of which still remains in doubt.

2. Lakes have been observed to discharge their waters over a rocky rim the lowest visible point of which was many feet above the deeper portions of the lake bottom.

The assumption has usually been in such cases that the lake occupies a true rock basin which could not have been made by water and hence must have been made by ice.

It has been shown however that in some cases an old outlet at a much lower level has been blocked up by glacial debris causing the lake to rise and find a new outlet.

3. The great depth of the lakes has been thought to be sufficient proof of their glacial origin, but the fact that in some of of these cases the depth can be shown to be due to differential uplift and in others to drift obstructions at the outlet, is sufficient to throw doubt upon this conclusion.

4. The fact that ice has once occupied a basin has been often assumed as proof of the ice-made character of the basin. If ice could cut out such a basin, still more easily could it enlarge and deepen one which is found ready made. Let us examine theoretically, such a basin lying in the path of a large ice stream. Let the ice fill the basin and flow on beyond to any distance. What takes place in the basin? First. let us assume that the only check upon the rate of movement of the ice is that due to the increase in mass. It is like a lake in the course of a river. The current in the lake is inversely proportional to its size as compared with the river. If it is a large lake the current is imperceptible. In the case of the ice-filled basin, if the ice mass be ten times that of an equal length of the ice stream, its motion will be only one-tenth as rapid. This is the most favorable assumption that can possibly be made, yet even under this supposition, differential wearing could not take place, as the added power due to greater thickness in the basin is more than compensated for by the retardation of motion, since part of the expansion is lateral [i. e., the ice is not ten times as thick in the basin as it is outside]. It seems clear that the basin could not be deepened by the ice although it might suffer some wear.

But this writer is of the opinion, whether it be well founded or not, that the supposition just made is not the true one, and that the real case is even less favorable to the theory of ice erosion.

The ice in the bottom is urged on by the weight of the ice on the lee slope, *minus* the friction on that slope.

Its passage out of the basin is resisted by the weight of the ice on the stoss slope *plus* the friction on that slope. If the two slopes are equal the weights of ice will be equal but the resistance of friction is all on one side and opposes the movement of the ice. It thus appears that the retardation of motion is more than that resulting from the expansion of the ice.

In the deepest portion of the basin the ice is of course thickest and presses most heavily on its bed. It is upon this undoubted fact that the chief argument for differential erosion is based. Let this be examined closely.

The reduction of motion due to vertical and horizontal expansion has already been noted, as has the further retardation due to friction on the slopes.

The increased pressure of the thicker part of the ice greatly increases the friction on that part of the bed, but does not increase the tendency to onward movement. The only force urging the ice onward is the pressure of the ice on the lee slope. This is more than balanced by the resistance already noted, and if the ice were a perfectly rigid body I do not see how motion would be possible. As it is, differential motion must inevitably result which still further reduces the motion of the lower layers of ice if indeed actual shearing does not occur with resulting stoppage of the bottom portion of the ice.

If this reasoning is correct the ice in a rock basin must be regarded as moving very slowly at the surface, and with increasing slowness toward the bottom where it may possibly cease to move altogether. If this be granted the result so far as erosion is concerned must be to cut down the rim of the basin faster than the bottom, so that, without the filling which is known to occur in scores of cases, the tendency of ice-action is rather to destroy than to create rock basins.

5. The great excavating power of ice is thought by many to be proven by the thickness and great extent of the glacial drift. This material was evidently deposited by the ice; it must have been transported by the ice; therefore, the probability is great that it was torn up and furnished for transportation by the same agency. That the till might be composed largely of pre-glacial accumulations of decomposed rock was early suggested. To this it was replied that the presence of carbonates in considable quantities in the till was proof that it could not be composed of residual material, since such soils are always and every-

where nearly free from carbonates. To the present writer it seems that this question has not received the thorough investigation which its theoretical importance demands. There are other ways of accounting for the presence of these carbonates besides the one inplied above. But first of all the actual amount of such carbonates should be determined over a large area in till of all types and at various depths.

If it be argued that the amount of till is too great to be accounted for in the way here suggested, i. e., by pre-glacial rock disintegration, it should be borne in mind that the region from which the ice moved is the oldest part of the world. Its rocks are quite susceptible to the forces of decay, and it is simply impossible that they should not have yielded to those forces in all the millions of years since they were formed. Nor is it reasonable to suppose that all the results of decay were washed into the streams and carried to the sea to form the beds of Paleozoic and later rocks. It is incredible that there should not have been a residuum of decomposed rock comparable in most respects to that now found in the Archaean regions south of the glaciated area. But there is now no such residuum in the northern region, the rocks have been swept clean and the material carried southward by the great ice sheet.

To this material was added whatever the ice could break off or rasp off from the bed over which it flowed. I believe that this load of sub-glacial debris would be forced into depressions and, filling them up, protect them from the glacial wear, while the prominences would feel the full force of the glacial rasp. The effect would be, not to make rock basins, and so strengthen the relief, but by filling depressions and cutting down prominences to lessen relief.

6. The undoubted great transporting power of ice has not been carefully discriminated from its eroding power. The huge blocks which it has transported are usually spoken of as having been torn from the rocky bed of the glacier by the same force that transported them. A ledge of rock weakened by weathering, fissured by crustal warpings and standing squarely in the way of a powerful ice sheet would probably fall an easy

prey to it. But a solid hill of sound rock is quite another matter. So is a smooth surface of undecayed rock.

7. Finally, it seems to be a fact after all these years of discussion and investigation, that not a single case of a lake basin which can be proven to have been made by ice action has been discovered.

Perhaps as near an approach to proof as any is the case of Cayuga lake as reported by Prof. Tarr. But the fact of a considerable uplift of the region to the north of this lake, with the further fact of a drift filled outlet shown by borings to be at least 300 ft. deep, goes very far to discredit the evidence furnished by the lateral valleys referred to by Tarr. Like many that have been discussed before, it is a case not proven.

Stevens Point, Wis.

ON THE ACTION OF ALUMINUM CHLORIDE ON SATURATED HYDROCARBONS.

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The reaction discovered by Friedel and Crafts and called by their name, is one of the most widely applicable methods of synthesis used. By it can be built up from simple hydrocarbons of the benzene series derivatives belonging to almost all of the classes known. As an example a simple case may be given: When acetyl chloride and benzene are brought together no reaction takes place, but if to the mixture a little anhydrous aluminum chloride is added, there is a rapid evolution of hydrochloric acid and a tarry mass is left which by the action of the water is changed to aluminum chloride and a ketone, acetophenon. Leaving out the intermediate steps, the reaction may be interpreted by saying that under the influence of the aluminum chloride one hydrogen atom of the benzene and the chlorine of the acetyl chloride have formed hydrochloric acid and the residues before joined to the hydrogen and chlorine have joined to form our new ketone. In the same way any organic compound containing chlorine can be made to give up its chlorine in favor of an aromatic hydrocarbon residue.

In using the Friedel and Crafts reaction for the synthesis of aromatic compounds it is sometimes desirable to use a solvent either to bring solid substances into solution or to dilute liquid substances in order to prevent too great intensity of action. Carbon bisulphide and petroleum ether are the solvents used by chemists and recommended in the text books and laboratory guides. It is to raise objection to the use of the latter solvent that this note is presented. If the reaction takes place readily and at a low temperature petroleum ether may in some cases be used with propriety, but it should not be used in all cases.

Gustavson, a Russian chemist, has shown that aluminum bromide reacts on many substances of the fatty series, including petroleum ether, when a stream of hydrobromic acid is passed in or when ethyl bromide is present. But so far as can be ascertained from the only source available, viz., the Russian correspondence of the Bulletin de la Société Chimique of Paris, he does not note any reaction taking place between aluminum bromide and petroleum ether when they alone are present, nor does he mention any reaction of aluminum *chloride* on petroleum ether or paraffin hydrocarbons.

When aluminum chloride is brought into petroleum ether and the temperature is raised to 40° or 50°, there is evolution of hydrochloric acid and of combustible gases. This reaction takes place even at ordinary temperatures, but more slowly. The contents of the flask after the reaction is over is in two layers, the unchanged petroleum ether and a brown horn-like substance insoluble in petroleum ether, but soluble in chloroform. It probably corresponds to the substance $C_4H_8AlBr_3$ which Gustavson found as a product of many reactions in which $AlBr^3$ acts on fatty compounds. On account of its hygroscopic character it would be very hard to bring it into form to analyze, and no attempts have been made in this direction. When the substance is treated with water much heat is evolved and a brownish liquid results which floats on water. Repeated fractional distillations even under diminished pressure fail to separate any product of even approximately constant boiling point. The range of temperature shown by the fractions is from the boiling point of the petroleum ether up to 350° and beyond. At 200° there is evidence of decomposition. The higher fractions which are brown or yellowish tars have a pleasant peculiar odor.

Petroleum ether is a mixture of hydrocarbons principally of the paraffin or saturated series. It is the common idea that the parraffin hydrocarbons are extremely stable and not acted on except by the halogens. The reaction described is of interest, since it is the action of a simple salt on these supposed stable compounds. In order to study it more carefully some of the so-called turpentine of the California digger pine was obtained and from this, by treatment with sulphuric acid and distillation pure heptane C_7H_{16} of a constant boiling point of 98°–98.1° was obtained. Aluminum choloride acts on this pure saturated hydrocarbon in the same way as on the petroleum ether. At ordinary temperatures slowly, and at higher temperatures more rapidly, hydrochloric acid and combustible gases are evolved, and a product remains in the reaction vessel which is precisely like that obtained before, and no more attractive for further study since no definite products can be isolated.

It is hoped that by modifying the conditions some more light may be thrown on the course of the reaction, at least so far as the gaseous products which are evolved are concerned. The gases given off at ordinary temperatures may be determined by gasometric methods, and perhaps by letting the reaction go on under diminished pressure a sufficient amount of a lower volatile hydrocarbon may be collected to be analyzed. Some preliminary work has already been done in these directions.

So far these observations may call attention to the practical objection to the use of petroleum ether in this reaction, and to emphasize the idea that chemical stability is a term which can be used in reference to a certain substance or class of substances only when the reaction to which these substances are subjected is definitely stated.

Madison, Wis.

THE RELATION OF ECONOMIC CRISES TO ERRONEOUS AND DEFECTIVE LEGISLATION,

WITH ESPECIAL REFERENCE TO BANKING LEGISLATION.

EDWARD D. JONES, B. S.

INTRODUCTION.

Commercial crises are socio-economic phenomena, and as such they direct attention to the character of the economic relations which individuals, and other economic units, bear to one another. Despite the diversities which, for the purpose of analysis, it is necessary to emphasize, we must recognize the existence of a wonderful uniformity in the character of these relations. This uniformity is partly maintained by the more or less emphatic assertion of the social will through legislation, custom, etc. In so far as actions have a social bearing, the social will has a right, directly or indirectly, to control their character. The wisdom with which this control is exercised must obviously be of the greatest moment. The elaboration and evolution of civilization is constantly increasing the importance of the social relations; and nowhere is this tendency, at present, more marked than in the economic field. When now it is said that in the present century, for the first time in history, the course of business is being marked into distinct periods by an intensifying series of industrial convulsions and depressions, the economic importance which social solidarity is giving to law and public opinion must be apparent.

The present paper attempts only to deal with the first of these two means of control, namely, legislation, and that only from an historic point of view. Judging from the importance of the connection existing between crises and economic legislation, we should expect considerable attention to have been devoted to the subject. And, indeed, much has been done but a study of the principal work presents a review of what is at best but an irregular and fragmentary outline. It is as connected with the larger subject of the theories of crises that the work contained in this paper has been attempted, and in following the development of these theories, it has come about that so large a part has been devoted to banking legislation, and that in connection with this the presentation centers about the privileges of the Bank of France and the Peel Bank Act of 1844.

It has been said that every question has its legislative side, and this side it is which, very often in the history of discussions on crises, has occupied the minds of the writers in whose memories the events described were still fresh, to the exclusion of almost every other consideration. The business machinery which has been wrecked is considered as the origin of disturbance[1] and whatever laws have created or maintained that machinery are suspected and condemned as erroneous and defective. Proposals for new laws and for revisions and improvements of every description appear in plentiful crops after every severe commercial panic. A specific cure, a simple addition to, or change of, legal provisions is often all that is prescribed to rectify what is conceived of as a specific abuse.

As an economic crisis always involves the serious disturbance of the mechanism of exchange[2] we find that many discussions have centered themselves upon the provisions governing the currency at the particular time and place concerned. The evil effects of a depreciated paper money are evident in the experiences of Austria in 1873.[3] The inflexibility of the system

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[1] Bowen has enumerated two theories of commercial crises. One theory explains them from the mismanagement of banks and an unnecessary expansion of the currency. The second regards the banks as passive and finds the characteristic feature in a great extension of the system of credit. The first view he rejects. "American Political Economy," 3d ed., 1863, p. 437.

[2] "D'ailleurs, une crise commerciale est toujours une crise monétaire, puisque c'est la réduction de la réserve metallique des Banques qui donne le signal de l'explosion." Say's "Dictionnaire," Art. "Crises Commerciales" by Juglar, § 2.

[3] "Die Frage nach den Geldkrisen mit allen ihren Folgen in Oesterreich die Valutafrage zum ersten Ausgangspunkte habe, *dass die Geldfrage in der Valutafrage liege* und dass das Mittel dagegen nur in der Herstellung der vollkommen freien Geldbewegung zwischen Oesterreich

of bank note issue introduced into England in 1844 and the contest over the privileges granted to the Bank of France, have given rise to as important discussions as any in the history of money. From these have come a most valuable part of the body of knowledge in existence upon that subject.

In the following section therefore under the heading of Banking Regulations are ranged the theory of a single bank of issue, and the directly opposing one of competing banks of issue, also the discussion which arose as to the operation of the Peel Bank Act in England.

The second heading, devoted to general legislative provisions effecting business, in so far as these have been involved in the discussion of economic crises, embraces such topics as the validity of contracts, corporation and joint-stock businesses, the legal status of the stock-exchange, bankrupt laws, etc.

BANKING REGULATIONS.

I. *A Single Bank of Iissue.*

When Napoleon became first consul of the provisional government set up upon the overthrow of the directory at the close of 1799, he proceeded, at once, and in so far as his authority gave him opportunity, to carry out a general plan of internal reform. After the peace of Lunéville and Amiens and the formation of the Concordat, he summoned to his councils the ablest men in all departments of knowledge. A thorough reconstruction of

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und dem übrigen Europa gefunden werden könne." Dr. Lorenz v. Stein in "Der Tresor" (weekly newspaper), June 12, 1872.

Speaking of a normal flow of money from country to country, and the maintenance of a general level of prices Neuwirth says: "Von diesem heilsamen Prozesse, ohne welchen die Wiederkehr von Krisen im allgemeinen, namentlich von solchen localisirten Charakters, eine ungleich häufigere wäre als wir thatsächlich zu beobachten Gelegenheit haben, sind wir in Oesterreich-Ungarn völlig ausgeschlossen, die Ausgleichung localen Geldbedürfnisses durch internationale Dazwischenkunft kömmt uns nicht, wie den Anderen zustatten." "Speculationskrisis von 1873," p. 373.

NOTE.—Throughout this paper the italics occurring in quotations are those of the original writer.

the finances and administration of government and of the judiciary was the result.[1]

The conditions of banking were not far advanced at this time in France. There were private banks issuing notes subject to redemption but privileged only within the cities in which they were located. On the 13th of February, 1800, Napoleon founded the Bank of France.[2] It had no special privileges and although its capital stock was large for the time, 30,000,000 francs, it was merely a competitor among other Paris city banks. Of the 30,000 shares of stock for sale at 1,000 francs per share, the government bought 5,000. A general assembly was constituted to consist of the two hundred largest shareholders, every five shares conferring one vote, but no one person or corporation to have more than four votes. This assembly chose the officers of the bank consisting of fifteen directors and three supervising censors.

In 1803 an apparent change of policy was made and the bank was given the monopoly of note issue within the walls of Paris. Its capital stock was increased to 45,000,000 francs, and the charter was continued to 1818. This capital, however, was too large for the business and the bank, becoming involved in the operations of the French treasury, was allowed, by legislative enactment in 1805, to restrict its redemptions to 600,000 francs per day. The law of 1803 also provided that no one could have more than one vote in the general council of the bank.

Notwithstanding that the capital employed was already too large, it was again increased in 1806 to 90,000,000 francs. The amount actually sold in 1810-11 was between eighty-one and eighty-two million, and by redemption was brought down to 67,-900,000 francs, where it remained until 1848. This legislation

[1] Victor Duruy, "Hist. of France." Trans. from 17th Fr. ed. N. Y. (Crowell), p. 586.

[2] As general references upon the history and constitution of the Bank of France, consult, article "Banque" by Leon Smith and Neymarck in Say's "Nouveau Dictionnaire d'Economie Politique" Tome I; Max Wirth, "Grundzüge der National Oekonomie," Bd. III; Alphonse Courtois, Art. "Renewal of Privilege of the Bank of France," Banker's Magazine, N. Y., vol. 46, 1892, also by same author "Historie des Banques en France," 2nd ed., Paris, 1881; Tooke, "Hist. of Prices," vol. VI, § 11-16 incl. pp. 44-74.

(1806) at the same time brought the bank more closely under the control of the government. The governor and two assistants were to be chosen by the Emperor. The dividends were limited to 6 per cent. with the privilege of dividing two-thirds of the surplus remaining above this. In 1834 the undivided surplus was limited to 10,000,000 francs. Since 1874 this has stood at 8,002,314 francs. According to the law passed in 1808 the bank was allowed to establish branches, and between 1817 and 1838 nine such were founded in various cities of France. The recognized connection of the bank with the public finances led to considerable distrust when the invading armies entered France in the winter of 1813–14. A restriction of redemptions to 500,000 francs daily was allowed but full payment was resumed in April, 1814.

In 1820 the 67,900 shares then in existence were fixed not to be changed in quantity except by law. The charter which had been renewed in 1806 to extend to 1840 was in the latter year continued to 1867.

In 1848 there came, however, the legislation which marked an era in the history of the bank. The revolution had pressed heavily upon the Bank of France and its branches as well as upon independent private banks in various parts of France. The provisional government was obliged to consent to a restriction of specie payments. The issue of 100-franc notes was authorized, the smallest denomination allowed before being 200 francs. The privilege of this issue was given to the provincial banks in common with the Bank of France, but their several notes were to be receivable, though outside the city, yet only within the department, in which the bank was situated. The inconvenience of this showed itself so powerfully that in April and May decrees were issued which finally absorbed the nine independent banks, then in existence, into the Bank of France, adding these to the fifteen branch establishments already connected with the bank. The issue of notes in France was then definitely made the exclusive right of the bank. The capital stock was again increased

[1] These were the independent banks-of-issue at Rouen, Lyon, Havre, Lille, Toulouse, Orleans, Marseille, Nantes, and Bourdeau. cf. Wirth, 'Grundzüge," Bd. III., p. 99.

and a million and a quarter added making it 91,250,000 francs. Not only did the revolution involve the bank in difficulties, compelling a suspension of specie payments until 1850, but the smaller discount establishments which had grown up as apparently necessary links between the informal demands of trade and the strictly ruled Bank of France, were entirely swept away. The distress was so great that the government advanced funds to aid in establishing "Comptoirs d'Escompte." In 1852 the Crédit Foncier and Crédit Mobilier were established.[1] From this date on the business of the bank increased so rapidly that in 1857 the government doubled its capital, requiring, however, the investment of 100,000,000 francs by the bank in government 3 per cent paper. The privileges of the bank were then extended to 1897.

A petition presented in 1865, by a number of manufacturers of Lyons and Paris, for an inquiry into the nature and management of the Bank of France led to the famous Bank Enquête. The result of this examination was entirely to exonerate the bank and to record the opinion of a majority of the financiers of Europe in favor of confining the issue of notes to a single central establishment, under private control, but privileged and regulated by law.[2] The bank at present enjoys the greatest freedom in the matter of regulating discount and extending its issues[3] within the maximum limit of four milliards of francs. It is required that

[1] Authorized in December, 1852. "Le Crédit foncier, qui prête sur les terrains, se contente d'un interêt modesté et consent à être remboursé du capital lui-même en une série de trente annuités. En novembre de la même anneé, se fonda le Crédit mobilier, qui prête sur des valuers mobilières." A. Rambaud "Histoire de la Civilisation Contemporaine en France," 2d ed. Paris, 1888, p. 703. The Comptoir d'Escompte was founded in 1848, Credit Lyonais, in 1863, and the Société Générale, in 1864, besides numerous private banks.

[2] Max Wirth op. cit., p. 187.

[3] "Depuis 1848, la Banque de France a seule la faculté d'émittre des billets payables en espèces au porteur et à vue: depuis 1857 elle a seule le droit d' élever le taux de ses opérations au-dessus de la límite poseé par la loi de 1807 en matiére d' interêt de l'argent, et de faire varier les conditions de l'escompte suivant la situation du marche." Wolowski in Art. "Débats sur la Banques" in the "Revue des deux Mondes." Fev. 1, 1865, Tome 55, p. 664.

its legal tender notes shall be redeemed in specie,[1] and that a safe and conservative policy shall be maintained. Interest upon deposits is not allowed and advances are made for three months only and upon securities attested by three persons of known solvency.[2]

During the Franco-Prussian war the bank was again obliged to restrict the redemption of notes, taking it up again in 1877. But throughout this war the management distinguished itself in the most highly credible manner, and has thereby earned the praise and confidence of the French people. This financial institution stands to-day not only as the largest of its kind, but as one of the best models of banking mechanism in existence.[3]

Let us now consider briefly the arguments of those writers who hold that competition in bank-note issue is the source of commercial convulsions, and that the best protection against them is to be found in the existence of a single authorized bank of issue.

The discussion of the freedom of bank issue has been modified in France, to a greater or less extent, by political and historical connections. The year 1848, in which the monopoly of bank issue was completed, and the period of the Franco-Prussian war, during which the management of the bank awakened

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[1] "Die Bank besitzt das ausschliessliche Privilegium, Noten auszugeben, welche sie stets auf Verlangen gegen bares Geld einzulösen hat. Diese Einlösung erleidet aber in den Zweiganstalten der Bank in den Departments einige Einschränkungen, so dass dieselbe eigentlich nur in Paris unbedingt einlöst." Max Wirth, op. cit., pp. 100–101.

[2] "La Banque de France fait des avances:

1° Sur les effets publics français et sur les obligations de la ville de Paris, jusqu'a concurrence des $\frac{4}{5}$ de leur valeur d'apres leur cours coté au comptant la veille du jour où l'avance est faite;

2° Sur les actions et obligations des chemins de fer français d'apres une quotité laisseé, pour chaque titre, à son appréciation;

3° Sur les obligations du Credit foncier, de villes françaises et de départements français sur les obligations émises par la société général algérienne, et sur les dépôts de lingots ou monnaies etrangères d'or ou d'argent qui lui sont faits." Art. "Banque" in Say's "Dictionnaire," by Neymarck.

[3] Max Wirth, op. cit. p. 219, also A. Wagner, Lectures on Banking, Summer Semester, 1894.

general admiration, mark the chronological boundaries within which the discussion was carried on. The change from republican to imperial government, which took place in 1852 and 1853, was thoroughly supported by those of the merchant and monied classes who were in dread of ultra-republicanism and felt their only safety to be in Louis Napoleon. The monarchistic party and its sympathizers were willing to see the government strengthened, and the part which the Bank of France had been made to play for Napoleon I was not an insignificant one. The growth of centralization was a marked tendency in politics at this time.[1] It was felt that a single central bank with which the finance department could have direct relations would add to the strength of both. Certain it is that the government itself steadily exhibited a prejudice in favor of such an institution.[2]

The record of the Bank of France was pointed to and the great immunity which France had always enjoyed from commercial panics. The disadvantages of the system of local banks had been felt both before and during its short trial in 1848, and the bar it had placed to the transaction of business between one part of France and another was felt to be happily removed by an issue, good in all places, and regulated at numerous points by branch establishments in close connection with the central bank.[3]

A very integral part of the discussion upon the freedom of banking is the connection it had with the doctrine of free competition. The orthodox school of economists, who nowhere held sway with higher hand than in France, believed in the so-called "economic harmonies." Those who advocated a monopoly of note issue took good care to admit the general rule of competition and to fortify themselves for claiming this exception to it.[4]

[1] Hellwald "Culturgeschichte," Band II, 2 aufl., pp. 561–2.

[2] Courcelle-Seneuil "Traitê des Operations de Banque," p. 217.

[3] G. du Puynode "De la monnaie, du credit, et du l'impot," 2d ed., Tome I, p. 354.

[4] Wolowski frequently fortified himself by an enumeration of those writers whose views corresponded more or less closely with his own. In Journ. des Econ., Tome 41, 1864, p. 165, footnote, he mentions Sir Robert Peel, Rossi, Blanqui, Leon Faucher, Lord Overstone, François Bartholony, d'Eichtal and Victor Bonnet. In Journ. des Econ., Tome 3, 1866, p. 363, he adds Adam Smith, J. B. Say, Sismondi, Ricardo, Torrens, Norman and Gladstone. Elsewhere he repeats parts of these lists.

Wolowski, the most prominent champion of the privileges of the Bank of France, held that competition in bank-note issue had no more place than in the coining of metallic money.[1] And this latter it was the duty of the state to regulate for the same reason that it provided one law, one measure, and one weight.[2]

The system of a single bank has the great advantage of resting responsibility in a definite place.[3] It puts an unmistakable duty upon those in whose hands the course of monetary affairs rests, and makes impossible the shifting and neglect of it which is inevitable among a multitude of competing banks. In this way public opinion and publicity of accounts is enabled to exercise a powerful influence when concentrated upon one management.

The very independence of a bank with monopoly privileges removes from it all necessity, from competition with rivals, of extending its advances beyond the limit of safety. The struggle to earn dividends is removed, and such a bank may order its policy for the public welfare. A competing bank, it was urged, must outdo competitors in order to obtain trade, and it must therefore be in sympathy with, and to an undue extent subordinated to, the demands made upon it.[4] The essence of the competitive spirit is to increase the business done upon a given capital to the greatest possible extent, and not only this, but the tendency of competitive banking is to calculate more closely the average balance of deposits-on-call and extend still further the issue of notes relying upon the constancy of this balance. To increase their issues, banks are often willing to divide

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[1] Cf. his article "Question des Banques," Journ. des Econ., Fev., 1864, Tome 41, p. 163.

[2] Wolowski, op. cit., p. 163, says: "*Une loi, une mesure, une poids, une monnaie*, tel a été le voeu séculaire de la France, accompli aujourd'hui; quand il s'agit de preserver le toute atteinte cette précieuse conquête, loin de sacrifier le droit individuel, l'etat le couvre d'une utile garantie; il féconde le travail, en assurant la circulation facile et l'echange sincère des produits; il accomplit ainsi la haute mission sociale qui lui est dévolue."

[3] E. Nasse. Art. "Banken" (Bankpolitik) Conrad's Handwörterbuch Bd. II., p. 32. Also S. J. Loyd, "Reflections suggested by a Perusal of the Pamphlet of Mr. Horsley Palmer." London, 1837, p. 52.

[4] Edinburgh Rev., vol. 65, Apr., 1837, p. 85.

their profits and offer interest on deposits.[1] When then, from any reason, an unusual demand is made upon the deposits of such a bank or when notes are presented for redemption, the funds are insufficient to float the great issue which has been reared upon them. Distrust spreads the demands to other banks and the system, honey-combed by competition, falls together. Crises, suspension of banks, stringency of the money market, and a depreciated paper are the results. Each bank endeavors to save itself, at whatever cost to its competitors,[2] and no bank is strong enough to extend assistance and command confidence. Here again the champions of the monopoly bank urge the advantage of the power and sufficiency of a single great establishment. Its connection with the government gives it position and solidity, and the ability to inspire such unquestionable credit as is the object of all search in times of crises.[3] Then it is, pre-eminently, that a single great bank can put forth its power, or, as has been the case in the history of the Bank of England, it may re-establish confidence by the mere prospect of its assistance.

II. *Competitive Banks of Issue.*

A large school of French writers have held views directly opposed to those we have just considered, and have maintained that the cause of economic crises lies in the abuse of power on the part of privileged banks.

The successive moves, shortly sketched in the preceding section, which created out of the Bank of France a great monopoly in 1848, were by no means looked upon with favor by all classes who were interested in financial matters. There has always been a large public to welcome the reopening of the discussion re-

[1] The law governing the Bank of France forbids the paying of interest on deposits. Note issue in the United States is no longer allowed on deposits as formerly, but upon capital only.

[2] Leon Smith, Art. "Banques" in Say's "Dictionnaire."

[3] E. Nasse, Art. "Uber die Verhütung der Productions-Krisen durch staatliche Fürsorge," in "Jahrbuch für Gesetzgebung," etc Bd. III., N. F. Also A. Wagner, "Geld und Credittheorie der Peel'schen Bankacte," p. 193 et suiv.

garding the privileges of the Bank of France.[1] From within the bank itself also, came a strong objection to the additional control which the government assumed in connection with the legislation of 1848, and this was accompanied with a bitter protest against the general centralizing tendency manifesting itself in France.[2] A governor and two assistants were to be appointed by the Emperor following the law of 1806. These officers, it was noticed, took oath to *govern* the bank, and in this way it was felt that the power of the directors was liable to diminish to a merely supervisory one.[3] Three at least of the regents were to be chosen from the treasury agents of the government, located in the provinces. This insured a strong and constant representation for the state within this council of the share-holders.[4]

It was never forgotten that the bank was the creature of Napoleon I,[5] and it seemed to many that it embodied too much of

[1] Laveleye, Rev. d. d. Mondes, 1865, p. 433.

[2] In a discussion in the Chamber of Deputies, in 1847, over the smallest denomination of note issue, Alex. Clapier said: "The real interest of the measure is not an immediate discount interest; it is an interest of the future. The Bank of France cherishes a plan which it does not conceal; it wishes to absorb within itself all the provincial banks, and to attain this result it tries to attract to its vaults all the money of the country. For my part I think this would be an immense danger. I have heard it said, upon a recent occasion, that one of the dangers, one of the inconveniences of our political situation was this excessive centralization which puts in the hands of power all the places, all the offices of the country, and it was said that the power, which can dispose of all the places and all the offices, holds in its hands all the votes, all the consciences. Well, I say that there is a concentration more dangerous than that of the places and offices; it is that of fortunes and credit. An establishment holding in its hands all the country's credit would hold more than all the country's votes; it would hold the existence of every body. There must be one of two things; either this establishment would be in the government, or it would be outside of the government. If it were outside of the government, it would be the stronger and would crush it; if it were in the government, the government would be stronger than anything else and would crush us." Banker's Magazine, vol. 46 March, 1892, p. 701. Original French in Courtois' "Historie des Banques en France," p. 167, note.

[3] Courtois in Banker's Magazine, vol. 46, pp. 540-541.

[4] Palgrave "Dictionary of Pol. Econ.," vol. 1, p. 97.

[5] For examples of this see E. Fournier de Flaix "Revue d'Economie Politique," Tome V, p. 205, also Courtois, op. cit. p. 540 and 706.

the same principle that he had carried out in the army.[1] Many considered the forced absorption of the provincial banks [2] into a privileged private company at the seat of the capital [3] as an evidence of both private and sectional favoritism.[4] Not only was this felt but an oligarchical character in the organization was pointed out.[5] The shares were in sums of 1,000 francs, but even at this a voice in the general assembly was limited to the two hundred highest shareholders.[6] The lowest notes of issue were from 1803 fixed at 500 francs, with 250 francs as the minimum for the branch departments. In 1847 this was reduced to 200 francs for the central bank, and in the following year 100 francs was established for both the central bank and its branches.[7]

The profits of note issue might, it was urged, have served as an inducement to the founding of banks which would have given the accommodations of credit to large classes of people in all parts of France. The bank had indeed tried to found successful branch departments, but the restrictions laid upon its business methods were found too great to allow of close connection with trade.[8] It was a banker's bank and so strictly limited that institutions sprang up, as occasion offered, to occupy the field.[9] The competition was just enough to prevent the bank from supporting the supplementary institutions as it should have done, and not enough to offer any check upon the business methods of either.[10]

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[1] Gustave du Puynode, "Journ. des Econ.," vol. 26, p. 218. Courtois, op. cit. p. 540.

[2] Courtois, op. cit. p. 784.

[3] Hellwald "Culturgeschichte" Bd. II, p. 562.

[4] The provincial stock-holders were almost entirely without representation. E. Fournier de Flaix, op. cit. p. 203. The three provincial officials in fact represented only central and government interests.

[5] Courtois, op. cit. p. 607.

[6] Fournier de Flaix, op. cit. p. 203.

[7] Tooke, "Hist. of Prices," vol. VI, pp. 45–46.

[8] Courtois, op. cit. pp. 608 et suiv. Fournier de Flaix, op. cit. p. 203. The bank was likened by J. B. Say to an insurance company which would only insure where there was no risk. Du Puynode, op. cit. p. 227.

[9] For general program promulgated by the Crédit Mobilier. See Tooke, op. cit. vol. VI, pp. 106–109 and 115.

[10] Tooke, op. cit. vol. VI, pp. 133-134.

Out of the close connection between a controlling bank and the government of a country it was shown that additional evils might arise. If the government was often strengthened the bank was as often weakened. Such an institution, owing its position to the favor of the law, is not independent and can oppose less resistance to the exorbitant demands which the financial department of the state may make upon it than can any one of a number of independent competing banks.[1] Its strength will in this way be easily over-taxed and its solidity endangered. The connection is an unwholesome one as the state finds an easy means of obtaining money and the bank, with a reasonable claim to protection in case of financial difficulty, feels comparatively small concern.[2]

The course of the money market is then subject to the most violent agitations by whatever endangers public credit. The fact was cited that in the earlier history of the Bank of France, the government had persisted in making the capital of that institution too large, presumably with the intention of drawing together idle funds which should make the bank more willing to listen to the proposals of the government. When then from such or purely industrial reasons a crises comes, the bank, weakened by government demands or laxity due to a feeling of too great security, solicits the suspension of specie payment and the business knot is again cut instead of being untangled.[3]

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[1] E. Nasse. Conrad's Handwörterbuch, Bd. II, p. 32.

[2] M. Chevalier says in reviewing Horn's book, "La Liberté des Banques" in Journ. des Econ., vol. 3, 1866, p. 357: "Avec l'esprit d'analyse le distingue, M. Horn a recherché pourquoi les grandes banques privilégieés avaient été si souvent en défaut; il en constate, la cause, cause à peu près uniforme, il faut le dire, et qu'on retrouve identiquement la même dans les deux hemisphères. Cette cause, c'est l'immixtion du gouvernement dans les affaires des banques; pour parler avec plus de précision, ce sont les complaisances que les gouvernements ont demandées aux banques, les avances exorbitantes qu'ils se sont fait faire par elles, tandis qu'en principe une banque ne devrait faire des avances qu'au commerce. Les banques privilégiées n'ont pu refuser ces complaisances, parce qu'elles etaient privilégieés." Cf. Horn, "La Liberté de Banques," p. 395.

[3] A. Wagner "Lehre von den Banken," p. 15, argues that if the state always came to the rescue of competing banks with a grant of legal tender powers in case of financial difficulty as is done with privileged

Illustrations of such a course of events were obtained from the history of the Bank of England and of France.[1] The power intrusted to a single establishment, as in the case of the banks referred to, may easily be a disastrous one to the credit of the public outside of itself, for as Lord Overstone said, a private banker, if he mismanage, must suffer the penalty and be bankrupt, but if the Bank of England mismanage it can save itself at the expense of the entire country.[2]

A large portion of the influential school of economists who argue for the advantages of freedom in trade, have applied this principle throughout, to every department of industrial activity.[3] Competition it is thought can as effectually check unsound and dangerous practices in the issue of bank notes as in any other form of business enterprise. Chevalier thought those who opposed the freedom of banks also opposed the construction of railroads and the freedom of exchange.[4] A single bank of issue tends to rest its credit upon the deposits lying in its vaults. Competitive issue will, however, confine the extent of note emission to capital stock and legitimate resources.[5] A monopoly bank, attempting to force as large an issue as possible into circulation, cheapens the price of credit. While this directly tends to promote speculation, it throws some portion of the money of private capitalists out of employment. This money flows into the bank, and the latter, unwilling that it should lie idle, increases still farther its advances to the public. Thus a process of displacement goes on during the progress of which an enor-

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banks, it would not be difficult for them in like manner to bring back their finances to a state of order.

[1] Bank of France in 1805, 1814, 1870–71. Bank of England, 1797, 1803, etc., Cf. Chas. Gide "Prin, of Pol. Econ." (Trans.) Boston, 1892, p. 310.

[2] Report of committee of H. of C. on commercial distress, 1847–48, N. 5192.

[3] The school of free competition would remove the issue of legal tender notes from the category of state functions. The tendency at the present time is, however, in the opposite direction. Some form of the privileged bank system exists at present in Holland, Belgium, Austro-Hungary, Russia, Denmark and Norway as well as in France and England.

[4] Wolowski, "Journ. des Econ.," vol. 41, 1864, pp. 165-166.

[5] Coquelin "Rev. d. d. Mondes," vol. 24, 1848, p. 459.

mous paper currency is erected upon an uncertain balance of deposits. The end of this progression is always a financial crises. Then to the growing inequality in the distribution of business profits, a total break-down of the credit system is added.[1]

Under a system of free banking these evils are avoided. Every attempt to realize undue profits in the issue of credit will attract new capital and increase competition until the same level of profits is reached for money and talent invested in this as in any other branch of competitive industry.[2] The circulation of notes of private issue is dependent upon the extent to which they will be received by other bankers. Each institution, therefore, must keep watch upon the others.[3] The motive of self-interest will lead to the immediate exclusion of the notes of such institutions as depart from the true principles of trade, and attempt to introduce dishonest and dangerous methods.[4]

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[1] Coquelin, op. cit. pp. 447–457.

[2] Coquelin, op. cit. pp. 457-470. Precisely the same theory and explanations are to be found in H. C. Carey, "Credit Systems," pp. 57–58 and 66. Coquelin recognizes Carey's work and recommends it very highly.

[3] The report of the "Banque Enquête" of 1866 advances this. Cf. Leon Smith in Say's "Dictionnaire," Tome I, p. 159; also Garnier "Traité d' Économie Politique."

[4] Courcelle-Seneuil though by no means extreme in his views (see "Journ. des Econ.," Tome 43, p. 163), has thus described the advantageous working of competition: "On peut supposer, il est vrai, l' existance d' un banquièr de fantaisie, leger, sans prêvoyance et sans scrupule, disposé à user pour ses dépenses personnelles du crédit qu' il obtinent du public. Ce banquier pourra abuser sans doute des èmissions de billets comme de toutes les autres formes du crêdit; mais il sera surveillé dans ce cas comme dans tous les autres, par la péfiance des interessês. Or, quels seront les plus interessês à ne pas prendre de mouvais billets? Justement les autres banquiers qui sont, ainsi que lui, les caissiers gênéraux du commerce, et se trouvent parfaitement plac pur être renseignês sur la nature de ses opérations, et, en dêfinitive, sur la solvabilité. On comprend, en effet, que le jour òu les banquiers cessent de recevoir les billets d 'une banque, ces billets ne peuvent plus resters en circulation, parce qu'ils remplacent la monnaie et que le mouvement naturel des èchanges amène sans cesse la monnaie de toute sorte dan- la caisse des banquiers. Le public á donc, quant aux emissions de billets dont a contre-valuer aurait, êtê consommée, des garanties au

In this way under the regime of "laissez faire" a tendency to the gradual employment of methods which must inevitably lead to a crisis is checked in its first development by a stronger opposing force; the self-interest of competitors. Such in outline are the arguments that have been employed, in France, in the discussion of the privileges enjoyed by the bank of France.

The experience of the United States has furnished material to both sides in the discussion of the question of bank note issue. Coquelin writing in 1848, cited New England as having a large number of banks and yet being particularly free from the disturbances that trouble the rest of the world.[1] Juglar in answering Coquelin's argument in 1891, affirms that financial crises in America have not only been as frequent as elsewhere but of even greater violence.[2]

A most valuable means of securing to a system of numerous privileged banks, such as exists in the United States at present, the advantages of the power and confidence of a single great bank, in times of crises, lies in voluntary combination. This has been effected in this country, by the grouping of a number of important banks, through clearing house associations. In New York such unions were effected in 1873, 1884, 1890 and 1893. During the last panic this method of union was also successfully adopted in Boston, Philadelphia, Pittsburg and elsewhere. The importance of these experiments for the future of financial prosperity can scarcely be over-estimated.

The financial conditions of this country during the crises of 1857 have been made the subject of thorough study by European writers. In his message to the thirty-fifth congress President Buchanan denounced in the strongest terms the "extravagant and vicious system of paper currency and bank credits, exciting the people to wild speculations and gambling in stocks." [3] The charge here made of reckless bank-note issue has not been sus-

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moins égales à celles qu'el rencontre dans le commerce pour les autre op rations de credit." Journ. des Econ., vol. 42, pp. 173-174, Art. "De Liberté des Banques."

[1] He in particular mentions Rhode Island which, in 1830, had 47 banks or one for every 2,064 of its inhabitants, op. cit. pp. 448, et suiv.

[2] Art. "Crises Commerciales," § 2 in Say's "Dictionnaire."

[3] Sen. Exec. Doc. No. 11, 35th Cong., 1st session, Wash., 1858, p. 4.

tained, and, although there were numerous abuses, a general over-issue of notes was by no means of the most importance among them.[1] The chief fault lay in another branch of the banking function, namely, in the discount department. The banks invested their money too eagerly in speculative enterprises and to increase their funds offered high rates of interest, only to turn deposits so secured, and which were subject to instant removal, into various forms of fixed capital.[2] But to detect a sympathetic movement in banking management, responding to that which exhibits itself in other business lines, is far from discovering the originating cause of both, though the mistake has often been made.

Upon the whole it seems that too much attention has been directed to the particular form in which the abuse of credit has manifested itself.[3] Crises have occurred under systems of free

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[1] Schäffle says upon this, "Man hat die Botschaft (Buchanan's) warhaftig nicht als ein Meisterstück der Gündlichkeit und Aufrichtigkeit anzuerkennen. Gewiss, die Banken haben gesündigt; aber wie wir nach gewiesen, ihre Hauptsünde lag, namentlich bei den grösseren Stadtbanken New Yorks, Bostons, u. s. w., weniger im Missbrauch der Notenausgabe, als im Darlehens-und Depositengeschäft. Hier aber sind sie von dem spekulirenden Volksgeist und der drängenden Geschäftswelt ebenso geschoben worden, als sie diese geschoben haben. * * * Der Präsident verschweigt, dass man mit 100 Millionen Pfund Sterling europäischen Kapitals in amerikanischen Bahnspekulationen wirthschaftete. * * * Was ist gegen dieses eine Vermehrung der Notencirkulation der Vereinigten Staaten um 70 Millionen Dollars während fünf Jahren ungeheurer Verkehrsausdehnung? Es ist Klar, die Ausdehnung der Notencirkulation ist es weder allein, noch hauptsächlich, welche das Zeug zu der unerhörten Schwindelei geliefert hat," Art "Die Handelskrisis und das Bankwesen" in "Deutsche Vierteljahrsschrift," 1858, heft I, pp. 307–308. In harmony with this see Laveleye "Le Marché Monetaire," Paris, 1865, pp. 112–113.

[2] A. Wagner, in discussing banking in the United States at this period, says: "Vielmehr erwies sich gerade das Depositengeschäft für Publicum und Banken als gefährlicher, obwohl man es bisher neben der Zettelausgabe kaum beachtet hat. Die Entwicklung, welches es in neuerer Zeit genommen, nemlich durch Gewährung *hoher* Zinsen auf *stetsfällige* Depositen viel Capital zur *dauernden* Anlage an sich heranzuziehen, wurde mitunter schädlich." "Die Geld und Credittheorie der Peel'schen Bankacte," pp. 261–262.

[3] Cf. Schäffle "Deutsche Vierteljahrsschrift," Heft I, 1858, pp. 416–417.

banking and under various degrees of state control and monopoly. The banks of necessity follow and partake of the general spirit which pervades business.[1] Comparative study indicates this to be the correct conception rather than that in the defects of particular banking systems are to be found the sources of industrial convulsions. A deeper cause must be sought. Strong and significant indications of it are to be found in the lack of general moral integrity and solidity in the spirit of a people.[2]

III. *The Peel Bank Act of 1844.*

The period from 1797 to 1821 has been called, in England, "The Bank Restriction Period" because, during that time, the Bank of England was relieved, by government authority, from the necessity of redeeming in coin its issue of notes. The causes for the restriction of specie payments in 1797 seem to have been mainly political.[3] The war with France was again renewed at that time, and with it came new demands of the government upon the bank.[4] In 1795 the government had forced the bank to an increased issue of notes.[5] Upon receipt of the news of the French expedition to Ireland the reserve fell rapidly, amounting in February, 1797, to only £1,186,170. Following upon the restriction, the government authorized an examination of the condition of the bank, and a meeting of London merchants declared themselves willing to receive its notes at par to any required amount. When this order was issued it was intended to

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A. Wagner in Rentzsch "Handwörterbuch," p. 534; also "Peel'schen Bankacte," p. 261. Juglar "Crises Commerciales," etc., 1st ed., Preface, p. 9.

[1] Leon Smith, op. cit., p. 161.

[2] Cf. Schäffle, op. cit., pp. 375–376. The quotation chosen by Adolph Wagner as the motto of his book, "Lehre von den Banken," is: "Free trade in banking is *not* synonymous with free trade in swindling." (Probably adopted as the negative of a sentence occurring in Tooke, op. cit., vol. 3, p. 206.) The two things compared are by no means co-extensive, and the latter shows itself under a bewildering multitude of different forms.

[3] Ricardo, "Prin. of Pol. Econ.," p. 289. (London, 1881.)

[4] Sidney Dean, "Hist. of Banks and Banking," p. 73.

[5] Max Wirth, "Handbuch des Bankwesens," pp. 246–248, being Bd. III of "Grundzuge."

endure but for a few weeks. It was, however, continued from time to time, and although the bank made some moves toward a resumption in 1799, a second outbreak of foreign hostilities put an end to this, and it was not until 1819 that a law providing for a gradual resumption of payments was promulgated. The end of the restriction period practically came on May 1st, 1821. The provisions of the enactment had allowed the directors considerable discretion, with additional time and a gradual method of approach to the final standard of equality of notes to gold coin.

At this time there were private banking concerns in England, and also joint-stock banks having not over six members and under the principle of unlimited liability.

The first disparity between gold and the bank notes showed itself in 1800, continuing to 1802. From that year to 1808 the difference was comparatively small but, beginning with 1809, the depreciation increased considerably, reaching thirteen and fourteen per cent. and even going above this.[1]

Before the period of restriction, the regulation of the currency had been a subject to attract little public attention. The principles laid down by Adam Smith in the "Wealth of Nations" had been widely received, but beyond this admirable exposition there existed very little work of value upon that subject.[2] The uncertainty of the vlaue of money served again, as it had done before in the history of political economy, to arouse the greatest attention to financial conditions. The policy of the bank, and the circulation of coin and paper became the subjects of the liveliest contention. These questions, and the "currency" theory in particular, brought into prominence the balance of trade, and consequently whatever influenced it. As is well known, a very exceptional importance was given to the discussion of foreign trade during the period covered by the contentions over the Bullion Report and the Act of 1844. The English "Corn Laws" were brought more and more into prominence, and

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[1] Wagner "Lehre von den Banken," p. 77 ,and "Peel'schen Bankacte," p. 39. The crisis of 1816-17 closed 89 provincial banks and destroyed their notes. The increased demand for Bank of England notes brought their value nearly to par.

[2] Tooke, vol. iv., p. 83.

passed through a long and trying stage of alteration to final repeal in 1846.[1] These causes may be deemed of some importance in explaining why the bank discussion became finally a subordinate part of the wider one on international trade. The latter was advancing to soon become the question of paramount im portance to Great Britain.

The subject of depreciation was first fairly presented in Mr. Ricardo's pamphlet, published in December, 1809, entitled; "The High Price of Bullion a Proof of the Depreciation of Bank Notes."[2] As the discussion grew more and more important, and the reason for it became more obvious, the "Bullion Committee" was appointed by the House of Commons in 1810 to investigate the monetary conditions.[3] The report which they presented was not adopted, although it affirmed in the clearest terms an existing depreciation of the bank notes in circulation. On the contrary, Parliament adopted resolutions to the effect that there was no depreciation.[4] In addition to this, but a curious commentary upon it, a law was passed in 1811 making it illegal to deal in coins of the realm at any other than their normal ratio to the notes of the bank. The effect of this legislation was to disguise all such transactions, and so to afford an appearance of reason to the arguments of those who held that no difference of ratio existed.[5]

The Bullion Committee, adopting the views of Mr. Ricardo,

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[1] Agitation for free trade was prominent during the period covered by the restriction, and almost continuous during the period following it. The laws were altered in 1773 and 1791, and in 1804 a sliding scale was adopted, which considerably increased fluctuations. An attempt at legislation was made in 1814, change was secured in 1815 and 1822. In 1828 a new sliding scale was adopted, another in 1843. The end of the corn laws was practically in 1846. This continual alteration brought about the greatest uncertainty and distress. As manufacturing England prevailed over the agricultural interest, the disturbance of the conditions of foreign trade became more distressing. Cf. Sydney Buxton, "Finance and Politics," vol. 1, ch. iv; also McCarthy, "Hist. of Our Own Times," vol. 1, ch. xiv and xv.

[2] Tooke, vol. iv, p. 98.

[3] Members were Horner, Huskisson and H. Thornton

[4] Tooke, vol. i, p. 316.

[5] Wagner, "Peel'schen Bankacte," p. 42.

held that the cause of depreciation was an undue increase in the issue of the bank. They recommended as a remedy the return to a system of redeemable notes. So long as the notes in circulation could not be exchanged for gold, they explained, there could be no regulative connection between them and the course of exchange. The entire theory of the Bullion Report centers in the idea that the price of money, irredeemable paper in this instance, depends upon its quantity.[1] Some regulative of its quantity must then be established in order to prevent a fall in its price. Such a regulative is only to be found in a constant convertibility.[2] To make the bank paper redeemable in coin is to restore the proper and natural control of its amount. The theories of money which grew out of the principles here laid down were of the greatest consequence in the discussion which followed. They prepared the way for more than the resumption of payments.

The history and condition of English foreign trade had been meanwhile made the subject of careful study by Thomas Tooke in his "History of Prices." This author, incomparably the clearest thinker of his time, agreed entirely that there was a diminution in the value of paper in circulation. He found the reason of it, however, in the unfavorable balance of trade which had been caused by English war expenses.[3]

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[1] Wagner, "Lehre," pp. 81 and 82. But absolute accuracy was scarcely to be expected. Wagner says: "Allerdings muss man einräumen, dass der Report ausdrücklich zugiebt, der numerische Belauf der Banknoten könne nicht das einzige Kriterium abgeben, zu verschiedenen Zeiten, *je nach der Lage des Handels*, sei eine verschiedene Menge Noten für den Verkehr nothwendig. Allein trotzdem weicht er selbst bereits von diesem Gedanken ab und will durch Verminderung der Notenmenge vornemlich eine Preiserhöhung derselben bewerkstelligen und noch mehr wird in Folge von den Anhängern der Theorie der Einfluss anderweiter Umstände ausser Acht gelassen, so dass man sagen kann, nach dieser Meinung war der *numerische Belauf der Noten sogar ganz allein der Betimmer ihres Preises.*"

[2] That Ricardo was not at the standpoint of the currency school is proved, for one thing, by his belief that the law requiring country banks to redeem their notes in the notes of the Bank of England was sufficient to prevent any abuse of their privileges. See "Recardo's Works" (McCulloch ed.) p. 301.

[3] Tooke, IV, pp. 132–142.

The Bullion Report, however, grew in favor, and its doctrines also prevailed largely in the business world. There always existed as in France a feeling of opposition to a favored bank. And in the case of the Bank of England this might have been increased by the stringent measures it had at times been compelled to take. Any distress therefore was most naturally coupled with some defect or abuse connected with the bank.[1]

In 1819, parliament appointed the "Bank Committee." It was in connection with the report brought in by this committee that arrangements for the re-establishment of gold redemption were finally made.

A distinct school of theorists was now gradually growing up who, in reasoning upon the currency, started from the idea of a general level of prices brought about by the action of international trade upon a purely metallic currency. Each country naturally attracts that portion of the money of the world which corresponds with the amount of business done within it. The fluctuations of such a currency, it was held, are the natural ones, and such as are necessary to effect a continual self-regulation of prices. If now a paper currency be introduced it is necessary that changes in its amount shall be made to exactly coincide with those in the bullion as effected by the balance of trade. To insure this harmonious variation the mere convertability of notes to coin was not considered as sufficient. The fact that the Bullion Committee had advocated in their report a return to specie redemptions as a sufficient measure to re-establish normal conditions in England, shows that there existed a difference between the theory there contained and that of the "currency" school. There is in both, however, the same tendency manifested, to an exclusive consideration of the quantity of money in a country, as the determinant of its value. The theory laid down in the Bullion Report, and the tendencies contained in it, could only logically develop into a pure quantity theory. The influence of the restriction period is seen in the application of a theory, loosely drawn from experience with an irredeemable paper

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[1] Wagner, Peel'schen Bankacte, pp. 15-22, also 257-258, and Tooke, V, p. 527.

currency, to a currency exchangeable for gold.[1] This involves one of the chief assumptions of the Peel Bank Act; namely, that an issuing bank has the power to increase or diminish the amount of its issues at pleasure.

Another assumption contained within this arises likewise from the continually emphasized importance upon prices, of fluctuations in the amount of money, whether these be düe to the settlement of international balances or any other cause. Clearly the idea held was that the immediate and full effect of such subtractions from, or additions to, the currency is immediately communicated to all prices. That is to say, all money is conceived to be employed in trade, and to be in constant circulation. If gold is shipped from the country, it is drawn from the circulation.[2] The existence of hoards, whether in private hands or in banks or other institutions, is entirely left out of consideration.[3] The money accumulated in the vaults of banks can only

[1] "Es ergiebt sich aus der Darstellung der Currencytheorie, dass dieselbe ein Ausfluss der frühern Theorien Recardo's und des Bullion reports ist. Der Unterschied besteht vornemlich darin,dass die frühern Lehren über die Wirkung einer Aenderung in der Menge der umlaufenden Noten auf Waarenpreise und Wechselcurse, während diese Noten uneinlösbar sind, auf die Zeit übertragen wurden, wo sie wieder einlösbar waren, also von der Zeit eines uneinlösbaren Papiergeldes auf die eines gemischten Geldsystems." A. Wagner, "Lehre," p. 99.

[2] "It is universally admitted, by persons acquainted with the monetary science, that paper money should be so regulated as to keep the medium of exchange, of which it may form a part, in the same state, with respect to amount and to value, in which the medium of exchange would exist, were the circulating portion of it purely metallic. Now it is self-evident, that if the circulating currency were purely metallic, an adverse exchange causing an exportation of the metals to any given amount, would occasion a contraction of the circulating currency to the same amount; and that a favorable exchange, causing an importation of the metals to any given amount, would cause an expansion of the circulating currency to the same amount. Therefore, when the directors of the Bank of England allow, not their circulation, but their deposits, to contract and expand under the influence of the foreign exchanges, they depart from the only sound principle upon which paper money can be regulated." Robt. Torrens, "Letter to Lord Melbourne," p. 29. Cf. same work, pp. 39-43, and Tooke, IV, pp. 220-222.

[3] An explanation of the nature of these under a system of metallic

have been subtracted from the circulation, and must of necessity have been replaced by paper, if prices were not influenced. If then such money is exported in the course of trade, the level of prices will not respond to the equalizing influence which international trade is supposed to bring about, unless a corresponding amount of notes be withdrawn. The coin which they represent is gone; but, in this case, gone only from the bank, as its place in circulation is occupied by a paper substitute.[1] Unless, therefore, the latter is likewise withdrawn, prices will not feel the unfavorable balance and no hindrance remains to check the export from continuing to such a point that a depreciation of the notes of issue takes place. If these notes cannot be exchanged for metallic money there is no limit to the depreciatior which may ensue. But, even if they be steadily redeemable, although depreciation can then only exist within narrow boun daries, it may yet be sufficient to lead to disastrous convulsions in trade.

This misconception of the conditions governing the withdrawal of notes from circulation under a system of redemption, was, as we shall see, the basis upon which Mr. Peel harmonized his measure of 1819 with those of 1844. He was quite at the standpoint of the currency school in this particular, though his confusion is perhaps more profound than that of any other member of it.[2] The same argument was advanced by Sir Wm. Clay,[3] Colonel Torrens,[4] and others. This is the crucial point in the theory responsible for the Peel Bank Act, and its importance for the purposes of this paper is that it formulates a theory of economic crises, and that in connection with it, one of the chief aims of the Peel Act of 1844 is to prevent the recurrence of such convulsions.

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circulation is given in Tooke, IV, pp. 224-227. For Ricardo's view, Wagner, "Lehre," p. 100. He criticises Ricardo (Ed. McCulloch), pp. 77-78 and in general, ch. 7. Cf. Fullarton, "Regulation of Currencies," pp. 71-74; quoted also by Mill, Prin. of Pol. Econ., Bk. III, ch. 24, § 4.

[1] Wagner, "Lehre," p. 98.

[2] Wagner, "Lehre," p. 99.

[3] Torrens, "Inquiry into * * * Renewal of Charter of the Bank of England," pp. 10-15 and 45-50, et suiv.

[4] Tooke, IV, pp. 178-179.

The authority of first importance connected with the currency school is Lord Overstone.[1] His assumptions were drawn from practical experience in banking, and show the influence of generalization which, though incorrect for even the restriction period, was applied to conditions fundamentally different.[2]

We have seen that Peel was instrumental in bringing about resumption in accordance with the recommendation of the Bullion Report. In 1844 he introduced legislation providing such additional regulations for securing parallel fluctuations between the amount of paper money and the in and out flow of bullion as were advocated by the currency school. It would seem that a change had taken place in his own mind; but he expressly emphasized that he considered the act of 1844 as but a completion of the work begun by the resumption of 1819, and he attempted to harmonize the two in the following way. Under a system of strict convertability Mr. Peel held that it was possible for a gradual diminution to take place in the purchasing power of notes as compared with that of coin. An exportation of gold may reduce by insensible degrees the amount of coin in circulation; and its place may be taken by added issues of notes. In the speech introducing his bill, he explains: "The difference may not be immediately perceived; nay, the first effect of undue issue, by increasing prices, may be to encourage further issues; and as each issuer, when there is unlimited competition, feels the inutility of individual efforts of contraction, the evil proceeds until the disparity between gold and paper becomes manifest, confidence in the paper is shaken, and it becomes necessary to restore its value by sudden and violent reductions in its amount, spreading ruin among the issuers of paper, and deranging the whole monetary transactions of the country."[3] So

[1] Other adherents to the "currency theory" were Norman, Colonel Torrens, McCulloch, Morris & Prescott, bank governors in 1848, also the governors in 1857–1858, etc.

[2] "Lord Overstone weiss seine gewissen Lehrsätze und prajudicirenden Schlagworte und "Schlagsätze" mit seltener Fertigkeit eines geschulten Dialectikers zu gebrauchen und legt dabei mitunter eine souveraine Geringschätzung ihm entgegengehaltene Thatsachen und Erfahrungen an den Tag, wie man sie bei den geschmähten Theoretikern nicht häufig findet." Wagner, "Geld u. Credittheorie," p. 9.

[3] Speech, p. 27. Tooke, IV, p. 187; Cf. Tooke, V, pp. 507–512.

gradual and imperceptible may be this movement, that a considerable discrepancy may take place before attention is called to the fact, or a sufficient motive is offered to effect the exchange of notes for money at the bank.[1] When, however, this

[1] Torrens, in his answer to Mr. Tooke, explains thus: "Now the increase of a convertible currency would produce the same identical effects, through the same identical process, which would be produced by the increase of an inconvertible currency," and later: "The nature and character of the effect would bo the same, whether the increased quantity of currency should be convertible or inconvertible, though its extent and degree in the two cases would be different. In the case of the inconvertible paper, the effect would be unlimited; in the case of the convertible paper, the effect would be confined within narrow limits;" etc. "Inquiry," pp. 48–50. In another place he says: "The increase in the quantity of convertible paper is limited by the power of the holder to exchange it for gold, as soon as from the increase of its quantity its value in relation to gold begins to decline. If the increase in the quantity of convertible paper had no effect in lowering its value in relation to gold, the holder could have no motive in exchanging it for gold." In comment upon this Mr. Wilson says, "Now, really, this is a special case of wonderful refinement! Every case of an optional exchange of equivalents must be considered an evidence of depreciation! It is certainly an evidence of some preference, or greater applicability for the purposes immediately required. But let us ask this ingenious reasoner — Two men go to the bank counter on two successive days; one has received a remittance of a fifty pound note from the country, which is of no use to him until he has converted it into coin, and he presents it for payment; the other man has *fifty sovereigns*, but wishes to make a remittance to the country, and he receives a note in exchange for it. The one has a 'motive' for exchanging the note for gold, the other for exchanging gold for the note; the one had a preference for the gold sufficient to take him to the bank, the other had a preference for the note sufficient to take him there. Now, we ask, which had depreciated,—the coin or the note? for in one case there was more coin in circulation, and less paper, than the convenience of the public required for circulation, and there existed, therefore, a '*motive*' to convert coin into paper; in the other case there was more paper and less coin in circulation than the public convenience required, and there existed a '*motive*' to convert it into coin. But enough. We will grant Colonel Torrens that bank paper may be depreciated in relation to coin to the extent of supplying a 'motive' to step to the bank and exchange it; but he, too, must grant that sovereigns also may be depreciated to the extent of supplying a similar motive to exchange them. But when all the ingenuity of this most ingenious writer on these subjects has been able to

exchange has begun, the depreciation necessary to bring it about forms an excuse for general distrust of the issuing bank and its circulation. In the sudden rush which succeeds, we have all the elements which combine to produce the keenest financial distress.[1]

Here, then, we have an explanation of crises offered by the currency school, and to prevent the return of these the famous Peel Bank Act of 1844 was conceived.[2]

In the same year with the passage of the bill, Colonel Torrens wrote of it; "I believe that it will fully accomplish its object (i. e. the perfect assimulation of our currency to the metallic model), and that it will effectually prevent the recurrence of those cycles of commercial excitement and depression of which our ill-regulated currency has been the primary and exciting cause."[3] And previous to this he had argued, that a disturbance which caused the bankers to abandon the rule of restricting the paper to correspond with the fluctuations of bullion, could only arise through a neglect of it in the first place.[4] Sir William Clay practically agreed with this.[5]

Lord Overstone and a few others seem to have exercised more discrimination, and held that the regulation of the currency could only prevent such crises as were due to a mismanagement of the same. But in so far as this was the cause, the attempt

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give no better evidence of the liability of convertible bank paper to depreciation, *what are we to think of the minister who gravely effects to found a great bank measure on such a principle?*" James Wilson, "Capital, Currency and Banking," pp. 58-59; also Tooke, vol IV, pp. 189-191.

[1] The reason explaining the origin of such fine-spun artificialities as this is to be found in the ingrained idea of a quantatitive theory of money. To bring appearances into harmony with the theory accepted often imposed a severe tax upon ingenuity.

[2] This explanation of crises was more or less exclusively held, but, when other causes were admitted to have any influence, the mismanagement of the currency was still considered as co-operating and distinctly tending to increase the violence of the general disturbance. Cf. Wagner "Peel'schen Bankacte," p. 45.

[3] "An inquiry into . . . the charter of the Bank of England," etc., p. 100. See also Tooke, IV, p. 282.

[4] "Letters to Lord Melbourne," pp. 39-43.

[5] Tooke, IV, p. 284.

to soften, and if possible, prevent crises, still remains an ultimate aim.[1] John Stuart Mill said, in summing up the aims of the legislation in 1844, "I think myself justified in affirming that the mitigation of commercial convulsions is the real, and only serious, purpose of the act of 1844."[2] This object was clearly placed in the foreground by Sir Robert Peel in the speech in which he introduced his bill into the House of Commons.[3]

The act provided for a separation of the Bank of England into two distinct parts; one entitled the Issue Department, the other the Banking Department. The first of these alone was to have the power of issue. The creation of this Department of Issue necessitated some transfer of money and securities. It was conceived that there existed a certain minimum below which the circulation of bank notes would never go in England. This sum was judged, from experiments since 1840, at £14,000,000.[4] It was therefore allowable, according to the theory of the promoters of the act, for this amount of notes to be in circulation, without there being a corresponding sum of gold in the bank to insure redemption.[5] The Banking Department was required, therefore, to transfer to the Issue Department securities to the amount of £14,000,000. Of this sum the larger part consisted of government bonds which comprised that part of the public debt advanced by the bank (£11,015,100). Additional sums were also to be transferred consisting of such gold coin and gold and silver bullion as the Banking Depart-

[1] Loyd "On the Management of the Circulation," p. 105 (Tooke, III, p. 248), but also see "Thoughts," p. 8 (Tooke, IV, pp. 281-282). Cf. Opinion of the Chairman of Parliamentary Commission of Inquiry, contained in its report, 1848.

[2] "Prin. of Pol. Econ.," Bk. III, ch. 24, §3.

[3] "Some apprehended that the proposed restriction upon issue will diminish the power of the bank to act with energy at the period of monetary crises, and commercial alarm and derangement. But the object of the measure is to prevent (so far as legislation can prevent the recurrence of those evils from which we suffered in 1825, 1836, and 1839. It is better to prevent the paroxysm than to excite it, and trust to desperate remedies for the means of recovery." Peel's speech, May 20, 1844.

[4] Increased to £15,000,000 in 1866.

[5] Cf. Wagner "Lehre," pp. 145-146.

ment could release. In return for this the Issue Department paid to the Banking Department an amount of bank notes equal to the entire deposit of securities, coin, and bullion made in it.[1] Although a decrease was allowed, no increase of issue above the amount so transferred was to be made, except in exchange for gold bullion at the ratio of £3 17s 9d the ounce. The only way in which gold could be removed, was in exchange for notes. These regulations bound the Issue Department strictly in its dealings with the Banking Department. A single exception which permitted of an increase of issue was in case a country bank should retire its notes. Upon permission of the government, the Bank of England might then increase its issues upon security by a sum equal to two-thirds of the country notes withdrawn. The remaining sections of the act restrict the note emission of country banks in numerous ways. The general tendency shows a desire to consolidate the issue of notes as largely as possible in the hands of the Bank of England as reconstituted and restricted.[2]

Under this system of organization the Bank of England is today working, but its introduction brought about a distinct revolution in the methods of that institution.

While the conditions of note issue were most rigidly determined, the banking department was seriously weakened and practically left to its own resources and devices.[3] The reason for this may be found in the motives which brought about the law.

The purpose for which the Peel Bank Act was conceived was

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[1] Entire transfer to Issue Department £28,351,295, of which £14,000,000 was in securities, £12,656,200 in gold coin and bullion, £1,695,095 in silver bullion, which was never to exceed one-fourth part of the gold coin and bullion held. The Banking Department received £8,175,025 in notes, £20,176,070 being in circulation. It retained £857,765, beginning business therefore with £9,032,790.

[2] The provisions of the act may be found in H. V. Poor's "Money and its Laws," 2nd ed., pp. 297–298; also in "The English Manual of Banking," by Arthur Crump, 4th ed., London, 1879, pp. 286–289.

[3] Lords' Report of 1848, p. 48, Schäffle in "Deutsche Vierteljahrsschrift," 1858, heft I, p. 358. As Sir John Lubbock said, this legislation might rather be called the "Bank Note Act" than the "Bank Act." "Essay on the Bank Act of 1844." Addresses, p. 26.

to put into actual working the theories of the "currency" school. Their exclusive view of the conditions of a metallic currency, of an unfavorable balance of trade as only caused by unnecessary foreign expenditures, and of money as including only gold or notes in circulation, led them to concern themselves only with the Department of Issue. Their expectations were most sanguine, but were balanced on the other hand by Tooke, Wilson, Fullarton and others with the most distinct predictions of disturbances which might be intensified, to a most distressing degree, through the operations of the act. And these conditions were not long in coming. In 1847, within three years of the institution of the new order of things, the reserves of the Banking Department had been seriously reduced, the bank had been forced to suddenly increase its rate of discount, this had been followed by a disastrous crisis, and the government had seen the necessity of temporarily suspending the operation of the act.[1]

We have seen that the purpose of the framers of the act was, through an attempt to regulate the amount of notes in circulation, to effect a contraction in circulation coincident with the diminution of the bullion; and, what was inseparably bound up with this in their minds, to prevent, or at least check at an early stage, financial crises, and so reduce them to insignificant fluctuations. Their mistake was in supposing that commercial distrust affected only the notes of the bank, and that, therefore, a reduction of the reserves of the bank would never take place, except through a presentation of notes for redemption. The real course of events showed itself to be different. If for any reason connected with the operations of trade, gold was demanded in considerable quantities for shipment, the Banking Department was compelled to replenish its reserves by withdrawing notes from its stock to present at the Issue Department for gold.[2] The combined influence of the shipment, and

[1] The Austrian copy of the Peel Act underwent the same fate. Herkner in Conrad's Handwörterbuch, Bd. IV, p. 903.

[2] The quick and severe check which the operation of this act put upon the export of gold was adapted only to the case when such a drain was the result of increased prices due to speculation or over issue of notes cf. Mill op. cit., Bk. III., ch. 24, § 4. Tooke, IV., pp. 389-392.

contraction of notes, could not fail to seriously affect trade. The disturbance thus caused, or arising from any other reason whatsoever, displayed itself most quickly, not in a depreciation of notes, but in the amount of credit in use which supplemented, and in part dispensed with, the need either of gold or notes. When any considerable part of this credit, therefore, was destroyed, the demand came, not for gold alone, be it observed, but for gold or notes. By the provisions of the act, however, notes could only be issued, in 1847, (above the sum of £14,000,000), in exchange for gold. For all the securities, coin, and bullion turned over by the Banking to the Issue Department; the former had received only £8,175,025 in notes, the remainder being already in circulation.

When, therefore, in 1847, the demand came for accommodation at the bank, the stock of notes was speedily depleted. And, in addition, yet another thing happened that had not been contemplated by the theorists of the "currency" school; the drain transferred itself to the gold in the Banking Department without bringing in a corresponding amount of notes, which might be presented to the Issue Department for coin to replenish the gold balance. This was done in the most natural way by a presentation of checks calling for deposits.[1] Had the bank been free to temporarily increase its note issue this call for gold would have been averted,[2] but no notes were to be gotten, even to meet the most temporary demand, without a like sacrifice of the already rapidly disappearing gold.[3] This condition of things speedily became intolerable. The discount was raised to practically prohibitive rates. Mr. Tooke had predicted that under the undisturbed working of the act, discount might rise as high as 20 per cent.[4] What had been foreseen took place; the ministry suspended the act, or rather took the responsibility of the bank's disobeying it. The effect of this

[1] Macleod "Banking," Vol. II., pp. 342-343.

[2] In 1825, upon the issue of notes, the gold immediately flowed back into the vaults of the bank, showing that what was wanted was a medium of exchange in which everyone could trust. Baron Ashburton, "The Financial and Commercial Crises Considered," pp. 11-13.

[3] Cf. J. S. Mill in "Westminster Rev.," June, 1844, p. 596.

[4] Tooke, Vol. II., ch. IV., pp. 179-181.

was immediate. All that was wanted appeared to be the assurance that reasonable accommodation could be had. The issue of notes did not exceed the legal limits that had been temporarily removed.

As is the custom in England, committees were immediately appointed by Parliament to inquire into the causes of commercial destress, and the operation of the Bank Act.[1] The committee of the House of Lords criticised the act. That of the Commons, under the influence of Peel, saw no reason for modifying any of its provisions.[2]

It was the crisis of 1847, therefore, that reopened the discussion of currency and banking in England. The act remained unrepealed, however, and again in the stringency of 1857, it was suspended and discounting allowed at 10 per cent. At this time the permitted issue of notes slightly exceeded the legal limits. During the third suspension in 1866, no infringement was found necessary.

In the Parliament of 1847, Sir Robt. Peel frankly admitted that the prevention of panics, which was one of the objects of the act, had not been accomplished.[3] All the former adherents of the measure were, however, not so willing to admit defeat. There can be noticed a considerable shifting in the aims attributed to the Act, by its supporters, after its break-down in 1847, from those claimed for it immediately before and after its passage. In 1844 the theory leading to the Act was concisely stated, by

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[1] Committees that have concerned themselves more or less with the operations of the Bank of England were appointed in 1819, 1832, 1840, 1841, 1847 and 1857. The condition of joint stock banks was investigated by the committees of 1836, 1837, and 1838.

[2] Reports from committees of both Houses of Parliament, Sess. Nov. 18, 1847, Sept. 5, 1848, Vol. VIII, parts 1, 2 & 3. Cf. Tooke, V, pp. 487-491.

[3] "The bill of 1844 had a triple object. Its first object was that in which I admit it has failed; namely, to prevent, by early and gradual, severe and sudden contraction, and the panic and confusion inseparable from it. But the bill had, at least, two other objects, of at least equal importance: the one to maintain and guarantee the convertability of the paper currency into gold; and the other to prevent the difficulties which arose at all times from undue speculation being aggravated by the abuse of paper credit in the form of promissory notes." See Poor, "Money, its Laws and History", p. 305.

Torrens, to be to bring the effect of sudden withdrawals of gold, whether for foreign shipment, (which alone was considered) or otherwise, to immediate bearing upon the money in circulation through a like withdrawal of bank notes.[1] Through this, the depreciation of the notes and commercial fluctuations were to be prevented. After 1847, when the impossibility of always reducing the amount of notes to correspond with the bullion was proven, the assumption was made, that the chief object of the act had never been other than to secure the convertability of notes, and prevent their depreciation.[2] Thus the suspension of the act was held to be in strict harmony with the spirit of the same.[3]

Convertibility had, however, never been endangered by the crises occuring between the resumption of 1819 and the act of 1844.[4] The period of most danger was obviously in times of crises, but precisely at such times were the provisions of the act suspended, and the issue of notes left to the discretion of the bank, the rate of discount being fixed.[5]

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[1] Col. Torrens "Letter to Lord Melbourne," pp. 29-30. See note, ante.

[2] In regard to the contraction of the note issue Wagner says: "Dieser Zweck der Acte wird nicht immer klar genug in Erinnerung behalten, und besonders von den Anhängern der Acte, als sich späterhin zeigte, wie wenig jener eigentliche Zweck erreicht worden sei, die Aufrecht-haltung der Einlösbarkeit der Noten als Hauptzweck hingestellt. Das ist aber entschieden Unrecht." "Lehre" p. 7. All did not lose sight of this fundamential "currency" school doctrine however; as for example, Morris, Governor of the Bank. Commons Rep. on Comm. Distress 1847-48, N. 3624.

[3] John Mills, "The Bank Charter Act," etc., p. 11; R. Torrens "Prin. of Robt. Peel's Act," pp. 105–106; J. S. Mill, op. cit. Bk. III., ch. 24, §. 4; Lubbock, op. cit. p. 35, and many others.

[4] Mill, after the quotation already given (see ante), says: "I think myself justified in affirming that the mitigation of commercial convulsions is the real, and only serious purpose of the act of 1844." "I am quite aware that its supporters insist (especially since 1847) on its supreme efficacy in 'maintaining the convertibility of the bank note,' but I must be excused for not attaching any serious importance to this one among its alleged merits. The convertibility of the bank note was maintained, and would have continued to be maintained at whatever cost under the old system." Bk. III, ch. 24, § 3 note.

[5] The regular recurrence of crises under the new law showed the error

As we saw in the discussion of competing banks, the time when a central bank can render most valuable service in maintaining credit is when fluctuations are greatest. But the restrictions of the bank act would have made it an engine of the greatest destruction to all outside of itself.[1]

Economic crisis was the rock upon which the artificial structure of the "currency" theory went to pieces. The act grew from a too exclusive view of abuses arising in connection with one particular form of credit.[2] Knowledge and integrity in the management of the Bank of England has, however, steadily increased, and its influence, without, or, perhaps in spite of legislation,[3] has correspondingly been a wholesome one.

MISCELLANEOUS LEGISLATIVE PROVISIONS.

The forms into which capital may be combined for the furtherance of business purposes are clearly of the greatest importance in estimating and explaining the tendencies manifested by business enterprise. Some of these forms have shown themselves fitted for certain classes of undertakings only, and through some of them over-speculative and dishonest business spirit has been able to work itself out much more easily than through others.[4]

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of the view that they were caused wholly or even principally by overissue of notes.

[1] "Sir George Lewis once said that Peel's Act did great good except for a week once in ten years, but in that week it did so much evil as almost to counterbalance the good it had done before." Sydney Buxton, "Finance and Politics," vol. II, p. 17, cf. Wagner, "Lehre," p. 11, also "Geld und Credittheorie," pp. 258–259.

[2] Mill, op. cit., Bk III, ch. 24, § 1. For a general review of the false assumptions of the Act, see James Wilson, "Capital, Currency, and Banking," p. 36, also Tooke, IV, p. 260.

[3] Schäffle quotes with entire approval Lord Ashburton upon the management of crises:—"Nothing can be more absurdly presumptious than to substitute machinery in such a case for human understanding." "Deutsche Vierteljahrschrift," 1858, heft I, p. 369, cf. Huskisson quoted by Torrens "Principles of Peel's Act of 1844," pp. 107–108.

[4] The juristic person is now too often used as the "persona" once was in Rome—as a mask to hide the true actors. Corporation methods would in many cases be immediately recognized as infamous if they

The attention of economists and statesmen was especially drawn to the abuses of joint-stock organization arising in Germany and Austria at the close of the war of 1870–71, and culminating in the Vienna crash of 1873. In Germany, at the middle of 1870, there were 410 join-tstock companies with a capital of 3,078 million marks. Four and one-half years from that time, at the close of 1874, the number had been increased by 857 new companies with a capital of 4,290 million marks. That the growth was abnormal was amply shown by the insolvencies of the following years.[1] One of the chief results of this crisis was to show the necessity of a reform in the laws controlling the conditions of joint-stock business.[2] The system in existence, of granting charters by special legislative enactments, proved to be inadequate, open to favoritism, and without proper uniformity in its operation.[3]

Thus numerous enterprises were permitted which had no other aim than the speculative one of throwing a quantity of stock upon the market for sale. Such companies were abandoned by their promoters who took good care to sever their financial connection with them at the most opportune moment.[4]

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were merely transferred to the sphere of private actions and relations. Cf. Report of Eleventh "Kongress deutscher Volkswirthe," 1869.

[1] Neumann-Spallart, "Uebersichten der Weltwirthschaften," 1879, p. 16. Cf. Herkner, op. cit.

[2] Neuwirth, "Speculationskrisis von 1873." Schäffle, "Zeitschrift für die gesammte Staatswissenschaft," Bd. 30, 1874, p. 2. Oechelhäuser in "Die Wirthschaftliche Krises," gives three reasons for the overtrading of 1873 The causes he finds are: 1, "in dem Missbrauch der neuen Actiengesetzgebung;" 2, "in der bisherigen Banknoten-Politik," and 3, "in den sozialen Bewegungen der Neuzeit." A new corporation law was passed in Germany June 28th, 1884.

[3] Upon this system Dr. Alexander Meyer wrote: "Das Erforderniss staatlicher Konzession zur Bildung einer Aktien-Gesellschaft is zu verwerfen, weil der Staat weder die Bedürfnissfrage, noch die Vertrauensfrage in ausreichender Weise zu prüfen vermag. Soweit die gesetzlichen Normativbedingungen nicht ausreichen, ist die Zurückführung der Bildung von Aktien-Gesellschaften auf das wirthschaftlich zulässige Maass lediglich der wachsenden wirthschaftlichen Einsicht anzuvertrauen." "Deutsche Vierteljahrsschrift," 1869, vol. 3 for that year, pp. 116–117.

[4] Oechelhäuser, op. cit., p. 34. It will be remembered that an enor-

The growth of legislation has, in most countries been toward fixing by legislative enactment, the general conditions which must control all joint-stock businesses, leaving then the establishment of particular enterprises to take place by registration under provision normal for all.[1] Such laws may restrict the joint-stock form to those businesses in which experience has proven it to be useful, and can provide such safe-guards as may be found necessary to protect against dishonesty on the part of promoters, or in the general conduct of business. As far as possible, it is desirable to remove any interest which would arise from the mere act of founding a company, unless that interest, whatever it may be, is clearly understood and formally stipulated between those who organize a company and those who invest their money in it. When an organizer is able to contribute valuable knowledge by the use of which profitable investments may be made, a compensation is of course legitimate, whether it is in the form of a single payment from the company at organization, in money or shares, or is a permanent interest in in the business, secured by means of royalties, etc. It is undeniable however that the latter course of proceedure has the effect to make organization rest more exclusively upon the prospects of a legitimate and continuous trade than does the former.[2]

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mous increase in the speculative grounding of stock companies, and even greater greed in swindling the public occurred under the system of special concessions in England in 1720, at the time of the "South Sea Company" and the "Bubble" mania. Cf. Mackay, "Popular Delusions," vol. I, pp. 51–62.

[1] Schulze-Delitzsch in the eleventh "Kongress deutscher Volkswirthe," 1869.

[2] According to the English "Companies Act 1862 to 1890," a memorandum must be filed by each company organized, stating its location, general purposes, capital and number of shares. Changes in this can only be made under the control of the court. Promoters may be sued for any profits gained by them in founding the company and not specified to the stockholders. And to prevent such profits being covered up in sub- and supplimentary contracts, promoters must specify in all circulars and prospectuses the names of the parties and the dates of any contract entered into by the company or its promoters or trustees. The prospectuses must not only contain a strict and scrupulous statement

So far as the principles governing the general management and organization of joint-stock companies permits of being expressed in a few words, the evils of mismanagement seem to originate from a more or less complete abandonment of the democratic principle. The concentration of very considerable discretionary power in the hands of directors, without an easy means of appeal and investigation being open to the stockholders, diminishes the feeling of accountability in the former, and hence their general efficiency. Private interests of those in control then inevitable assert themselves. Experience seems to show that a general active control of a large corporation by its stockholders is difficult, both to put in operation, and to maintain, and even when secured is only purchased through a great loss of flexibility and initiative enterprise to the business.[1] Because of the difficulty of controlling a business by means of concurrence in an assembly, it has been strongly urged that the joint-stock organization should be limited to such businesses as require a large proportion of fixed capital, and in which the profits do not depend upon speedy adaptation to changing circumstances, and thus upon more or less speculative ventures. The best results are attained when the business, once being founded, is in its management largely automatic.[2]

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of truth but no material fact, in the knowledge of the promoter, which would modify the character of the inducement offered may be omitted.—Vice-Chancellor Kindersly, 1 Dr. & Sm., p. 381. Differences between the memorandum and the prospectuses is a ground for throwing up shares and demanding a return of money. Campbell "Prin. of Mercantile Law," pp. 218—243.

[1] Oechelhäuser notices the tendencies to recklessness "Nicht alle Direktoren wirthshaften so sparsam und gewissenhaft für die Actionäre, als die Compagnons einer Handelsgesellschaft, als der private Gewerbtreibende, für die eigene Tasche. Eine gewisse Atmosphäre des Leichtsinns ist in der Leitung der Geschäfte durch die Direktoren (in deren Hand das Schicksal der Gesellschaften ruht) und in der Controle derselben durch die Aufsichtsräthe vielfach unverkennbar. Leider ist dabei das Organ der Gesammtheit der Actionäre, die General-Versammlung, erfahrungsmässig wenig geeignet, kräftig und rechtzeitig einzugreifen." "Die wirthschaftliche Krisis" p. 33. Cf. Neuwirth's proposed amendments to Austrian law of joint-stock companies. "Speculationskrisis von 1873;" p. 335.

[2] Dr. Meyer op. cit. thus explains: "Kurzum, das Anlage-Kapital einer

When the tendencies of organization are oligarchic, rather than monarchic, a corresponding set of evils are exhibited. Manipulations of the stock market take place, when a bare majority of stock gives control, in order to bring about such a consolidation of shares in a few hands. And when control is obtained, the voting majority can in innumerable ways take from the treasury of the whole to fill the pockets of a part.[1]

The greatest importance, however, still attaches to the responsibility imposed upon the individual stockholder. Formerly the entire private fortune of each shareholder was liable for any debt of the company. This was supposed to give the greatest possible security for prudent management and ultimate solvency. Gilbart pointed out that banks organized on the joint-stock principle, with unlimited liability, were less subject than others to runs. "Everybody knows that all the partners are liable for the debts of the bank to the full extent of their property."[2] But as the history of joint-stock companies in England has shown, under the indirect working of a regulation thus designed to increase the security of such organizations, this security was, in fact, very much decreased. Men of means and financial ability found it too much of a risk to place their entire fortunes in jeopardy

Aktien-Gesellschaft soll automatisch *arbeiten*, und, wo es das *nicht* kann, da ist die Form der Aktien-Gesellschaft, wenn auch rechtlich zulässig, immer eine *wirthschaftliche Lüge* und wir sollen uns bestreben, auf dem Wege der Gesetzgebung und der wissenschaftlichen Propaganda dahin zu arbeiten, dass es keine andere Aktien-Gesellschaft gäbe als eine solche, die *automatisch* zu arbeiten im Stande ist" p. 126. Cf. Schäffle "Tübinger Zeitschrift," 1869, p. 283.

[1] The distribution of voting power in the Bank of France will be remembered. In the first and second "Bank of the United States," the following scale was applied.

For every one or two shares — 1 vote.

For every additional two shares up to 10 — 1 vote.

For every additional four shares from 10 to 30 — 1 vote.

For every additional six shares from 30 to 60 — 1 vote.

For every additional eight shares from 60 to 100 — 1 vote.

For every additional ten shares from 100 up — 1 vote.

No person, copartnership or body politic to have more than 30 votes, First charter I., sec. 7, second charter I., sec. 11.

[2] "Hist. Prin. and Practice of Banking," 2 vols., London and N. Y., 1892. vol. I, ch. VI, p. 118.

from a management in which they had little or no control, by having invested a small amount in shares. The conservative element staid out of such undertakings. There was little advantage over private business in a stock company where the controlling interest was in one hand and a few shares only were distributed to various holders. The joint-stock organization, therefore, was left to such as had no fortunes to lose, and who invested in shares as a speculative venture, trusting to a lucky turn for success.[1] The same principle acted as a bar to union of capital and skill. Monied men would not risk themselves by supporting inventors, or by admitting the sale of a few shares to those seeking investment for their small savings. About the middle of this century the change from unlimited to limited liability was effected in England,[2] the new privileges being hedged about with numerous safeguards. The stockholder is today only liable for the unpaid portion of the capital stock represented by his shares.[3] The word "limited" must always be attached to the company's name and inserted in its contracts and prospectuses. Numerous additional provisions have been made by law. It is for example stipulated that the shareholders shall meet within four months of organization. No company may purchase its own shares[4] or sell them at a discount. If directors draw

[1] Wagner, Lectures on Money and Banking, delivered Summer Semester, 1894.

[2] In 1851 a committee was appointed to investigate the subject. Two years later it was referred to a Royal Commission investigating Mercantile law. The following year this body reported against any change. In 1855 a bill was introduced to limit liability in certain cases. In 1856, 1857, 1858, 1862 and 1865 the system of limited liability was fully established and developed, any seven or more persons being allowed to associate themselves in a company with limited or unlimited liability. Levi, "Hist. of Commerce," part IV, ch. VII.

[3] A shareholder's contract is completed by his letter of application answered by an allotment of shares. If the calls upon present shareholders are not sufficient to meet the debts of the company, recourse may be had against such as were shareholders within a year, but only to meet such debts as were contracted while they were still members. Campbell, op. cit., pp. 232–242.

[4] The lack of this provision in French law led to manipulations on the stock market in the interests of the "Union Général." This was shortly

dividends from capital stock they may be compelled to replace them at their own expense. Finally access may be had to the assets of a company for the payment of debt through a process, strictly prescribed by law and denominated "winding up." This may be instituted by the company, in which case it is voluntary, or by its creditors, being then involuntary.[1]

This brings us to the subject of bankruptcy in regard to which a few points may be noticed. It is obvious that a very great influence must be exerted upon the general conduct of business by those regulations which are designed to prescribe what shall be done when a person's assets are not equal to his liabilities. The character of these provisions will determine to an important extent how severely the effects of an economic crisis are felt by those immediately concerned in bringing it about, and through them, as one means, will be expressed the attitude of trade toward such practices as are considered to lead up to crises.[2]

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followed by its failure (1882) and a severe financial crisis was brought upon France; one of the few which that nation has suffered.

[1] A general summary of the advantages and disadvantages of the joint-stock business form is thus given by Schäffle, "*Vorzüge*:—*rasche* Bildung und Ausdehnung *grosser* Zwecke,—Theilung gefährlicher und umfassender Risicen,—Loslösung von der Zufälligkeit individueller Kapitalkraft und Betriebsamkeit,—Continuität des Grosskapitals,—umfassender und dauerhafter Kredit. *Nachtheile:* Hang zu maassloser dauernder verschuldung,— fortlaufende Abtretung der Kapital-erübrigungen an fremde Zwecke, Disposition der Betriebsleitung über grosses fremdes Vermögen ohne genügende privatwirthschaftliche Verantwortlichkeit,—Schwerfälligkeit in Ausnützung der Conjunctur und im Uebergang auf veränderte Unternehmungsgebiete,—Gründungsgefahren,—Vermengung der Privatgeschäfte und der Gesellschaftsgeschäfte durch Directoren und Verwaltungsräthe,—Schwierigkeit, eine wirksame Kontrole über die Verwaltung rechtzeitig zu führen, "Tübinger Zeitschrift" 1869, pp. 336-338, Cf. Conrad's Lectures, 3rd ed., (privately printed) pp. 67-68. Rogers, "Industrial and Commercial History of England," Series I, ch. VII. Roscher, "Nationalökonomik des Handels und Gewerbfleisses," 2 aufl., § 28, 29 und 30.

[2] "Private credit is always conditioned, and in a great many ways, by the situation of the whole nation's business; in other words, by their politico-economical situation. It is especially in the higher stages of civilization, that one bankrupt may easily drag numberless others down

The aims controlling legislation upon bankruptcy may be stated to be, as regards the creditor; a just, speedy, and economical distribution of the debtor's property, as concerning the debtor; either to restore him as far as possible to an independent position, or to administer punishment for neglect and fraud as the facts may indicate.[1] Sometimes one of these aims, sometimes another, has been the dominating one expressed by legislation. If a state of insolvency be merely considered as due to misfortune, the most fair and economic method of clearing the score for another chance in business is what is principally desired. If, on the other hand, it be looked upon as the result of negligence or dishonesty, a fair trial and suitable punishment should be provided.[2] Undoubtedly there is room for both of these elements in the correct conception, and the problem is in assigning them their relative importance. On the one hand injustice and hardship in individual cases is to be reduced to the smallest possible minimum, but on the other hand, the immense indirect social influence of legislation is ever to be kept in mind.[3] In general, the law will reflect the popular estimate of the bankrupt, obtaining among any people.[4]

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with him; and where the laws are bad or powerless, not even the wealthiest man can predicate his own solvency for any length of time in advance. One of the most important conditions of credit is the certainty that, if the debtor's good will to meet his obligations should fail, it shall be supplied by the compulsory process of the courts." Roscher, "Prin. of Political Economy," (Lalor's trans.), vol. I., § 91, pp. 274–275. See the whole of this section, also § 92.

[1] Judge M. D. Chalmers, Art., "Bankruptcy Law and Administration;" Palgrave, "Dictionary of Political Economy," vol. I., p. 116; Couder, "Dictionnaire de Droit Commerciale," Paris, 1877–81, Tome IV, Sec. I.

[2] Mr. Robbins, Report to New York Chamber of Commerce on the Bankruptcy Bill, Feb., 1882.

[3] "Any law will prove a disappointment"—that does not recognize that these proceedings are a trial of the merchant—"because the discouragement of insolvency is much more important than any economical or speedy settlement of insolvent obligations." "Nation," Feb. 9, 1882, vol. 34, p. 115.

[4] In France bankruptcy is considered a disgrace, and French law makes considerable provision for the reinstatement of the innocent bankrupts. Bankruptcy is an offense which may be punished by im-

The influence of the general point of view will betray itself in the determination of a great number of discretionary questions concerning the character of the legal proceedings employed. The acts which are to be construed as indicating insolvency must be carefully defined. The tendency is to establish both voluntary and involuntary bankruptcy proceedings, that is, to admit of petition either from the insolvent or from one or more of his creditors. If on the one hand too slight a cause for petition be allowed, the process may be abused as an ordinary means of effecting collections, while the opposite extreme allows the evil to accumulate and renders the creditor helpless to interfere at an early stage.[1]

The point of the greatest importance, in the ultimate bearing of bankruptcy upon crises, is perhaps, as to what prevents the discharge of the insolvent, together with freedom from all incurred obligations. The examining court in England is not limited by a few special provisions but may avail itself of any of the general methods prescribed by law for the detection and judg-

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prisonment from one month to two years. The tendency in the United States is perhaps too much in the opposite direction. Cf. Morrill, "Comparative Jurisprudence and the Conflict of Laws," Boston, 1886, p. 219, also Thorold Rogers in Art. "Causes of Commercial Depression," "Princeton Review" (N. Y.), Jan., 1879, p. 223, and in "Industrial and Commercial History of England," Ch. VII, pp. 144–145.

[1] In 1841, a United States bankrupt law was passed. Voluntary and involuntary bankruptcy were allowed, but on such favorable terms that a great many applications were made under it. The law became unpopular and was repealed in 1843. Two other attempts at a uniform law of bankruptcy have been made in this country. One was in 1800, which President Adams says "was condemned as affording too much encouragement to fraud, waste, and a rash spirit of adventure." The third law was passed in 1867. The United States Circuit and District Courts were made courts of bankruptcy, each having a prescribed jurisdiction under the terms of the act. This law was amended in 1874 and finally repealed in 1879. Since then numerous but unsuccessful attempts have been made to secure a federal law. The processes in the various states are fairly similar, resting, however, upon varying state provisions as to exemption. In the absence of a uniform law the state enactments are only limited by the provisions concerning the obligation of contracts contained in art. I, sec. 10, of the constitution.

ment of fraud.[1] The principal hindrances to discharge are, in France, extravagance in personal or household expenses, speculations or losses upon the stock market, the adoption of ruinous methods to delay bankruptcy, or attempt to unduly favor any creditor.[2] In the United States, under the law of 1867, evidences of fraud, or fraudulent gifts or conveyances were a bar to discharge; also losses through gaming, and the failure to keep proper books.[3] In case an estate did not yield 30 per cent. the concurrence of the majority of the creditors, both as to number and in value of claims, was to be secured[4] and in a second bankruptcy, no discharge was granted unless the estate yielded at least 70 per cent.[5] Ten shillings in the pound must be divided among creditors in England to insure the immunity of the debtor, thus making the minimum 50 per cent. instead of 30 per cent. as formerly in this country.[6]

The immunities afforded by bankrupt law may, in some cases, be most successfully used by debtors, but particularly by heavy debtors, as a menace to their creditors. And the greater the amount of the debts the more the interests of the creditors unite them in hoping for any favorable turn to lessen deficit before a final settlement. Thus bankruptcy may be compared in its action to a crisis. Insolvency is indeed a crisis for one business, while a general crisis is the simultaneous occurrence of many insolvencies. Bankruptcy like a crisis may then be a healthy check and a restorative when applied at an early stage, but delayed, it becomes a dreaded cutting down to actual conditions, being made worse by delay and ill founded hopes.

In addition to the classes of legislation that have already been mentioned there are many other provisions which exert the greatest influence upon the course of trade and exhibit how fundamental it is that the basis upon which free competition builds,—the bounds within which individual initiative may be

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[1] Bankruptcy law in England rests upon the enactment of 1883, as revised by the legislation of 1890.

[2] Morrill op. cit., p. 218.

[3] Sec 29, Rev. Stat., 5110.

[4] Sec 30, Rev. Stat., 5112.

[5] Sec 30, Rev. Stat., 5116 (Act of 1841, sec. 12).

[6] Chalmers op. cit., p. 118.

allowed to operate,—should be carefully and accurately determined.

A few of these provisions only can be enumerated. In England and in most of the states of the Union, acts have been passed to suppress speculative transfers in stock, either generally, or in some kinds of securities.[1] Speculation in government securities is illegal in England under the provisions of "Sir John Bernard's Act."[2] Another method of restriction has been to limit the relation of principal and agent, removing in some cases cognizance of law from the obligations incurred. The legal character of the obligation of contracts has been withdrawn, both in England and this country, from gaming and wagering contracts, by numerous enactments, thus withholding the enforcement of law when the taint of gambling can be established.[3] Contracts made with the end in view of establishing a "corner" on the market are void in this country. An even wider legislation is that in England against enhancing the price of stocks to the damage of the purchasing public. Adolf Wagner has shown that the taxation of stock-exchange "deals" and speculative transfers in general rests upon the same basis with an inheritance tax; that is to say, upon the principle which justifies the state in appropriating a part of those economic gains accruing to individuals, upon the basis of the present social and economic order, and which are only in a subordinate measure the result of the recipient's own productive exertions.[4]

The legal status of the stock exchange is somewhat anomalous, resembling that of an association or club. As it is not

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[1] Eng. and Am. Encyc. of Law, vol. 23, p. 737.

[2] This does not however apply to railway or joint-stock shares.

[3] The contract is void when merely fictitious, and when nothing more than a settlement of the differences between present and future prices is contemplated. In England the broker may hold his principal for losses paid at the latter's request. In this country the tendency is to leave the broker without recourse. Cf. Eng. and Am. Encyc. of Law, vol. 23, pp. 142, et. suiv. Cf. "Lawson on Contracts," §288. Bishop on Contracts (Large Ed.), Chicago, 1887, §529-535, inclu.

[4] Finanzwissenschaft," 2 Aufl., Bd. II, pp. 574-575. For the advisability of a tax to reduce speculation, p. 577, fine print. With regard to the methods of taxation which may be employed, p. 583, fine print.

usually incorporated, it does not issue stock, and the discipline of its members rests upon its own regulations.[1] These are therefore of the greatest importance. The means of binding the individual members may be secured in a number of ways. A deposit to insure conformity to the rules may be demanded, either of the candidates, as in France, or be pledged by those proposing a candidate for membership, as in England.[2] The establishment of a mutual life insurance, amounting, as it does in New York, to $10,000, exerts an obvious influence. The limittations upon membership, costs of the same, restrictions in its transfer, and conditions under which it may be forfeited, are important.[3]

In general, upon the topic of legislation, it may be said that in so far as unwholesome and dangerous tendencies manifest themselves in the industrial world, it is the business of the State to interfere. In other sections of the discussion, of which this paper forms a part, we have occasion to present explanations of crises, founded upon the increasing difficulty of forming correct business calculations, owing to the uncertainty of the market and the complexity of productive processes. In connection with this can be judged the importance of the establishment of an efficient department of public statistics, and the most prompt and general circulation of its information possible. In connection with theories founded upon tendencies leading to undue concentration of wealth are suggested a multitude of legislative

[1] Eng. and Am. Encyc. of Law, vol. 23, pp. 764–765.

[2] Three members must recommend a candidate to the London stock-exchange, pledging each £750 for two years against his possible failure.

[3] "Le nombre des agents de change est limité; il est de 60 seulement à Paris. Des obligations speciales leur sont imposées; ils doivent satisfaire à des conditions déterminées (être Français, âges de 25 ans accomplis, jouir des droits civils et politiques et avoir satisfait aux exigences de la loi militaire); en outre, ils ont à verser un cautionnement qui est à Paris de 250,000 fr. Ils sont soumis à des responsabilitiés particulières relativement aux titres négociés par eux. Enfin, par un engagement pris entre eux, ils sont solidairement responsables, mais seulement pour tout ce qui est qualifis *faits de change.*" G. François Art. Le Monopole des Agents de Change," Rev. d'Econ. Pol.— Tome 7, 1893, pp. 329–330.

provisions such as comprise the substance of factory legislation and insurance laws, and from that point of view the influence of taxation, of inheritance laws, of the attitude of the State toward natural monopolies, etc., will gain a new application.

The increasing complexity of modern industrial conditions requires the regulative interference of law at an increasing number of points, to prevent such as would not otherwise be deterred, from misusing the powers placed in the hands of each, and rendered more destructive against all, by the ever greater increase of social solidarity. While the need of proper legislation is more and more felt, a mistake made through it, like that of an individual in modern socicty, may work an increased amount of evil.[1]

Madison, Wis.

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[1] The scrutiny to which the individual legislator of the future must be subjected, with regard to preparation and capacity, must be brought into proportion with the far-reaching effects of his action. It will eventually be recognized that ability to accumulate a fortune, to become a successful public speaker, or even a celebrated lawyer, does not necessarily imply ability as a legislator. In connection with this application of the principle of the division of labor, lies one of the great problems upon the solution of which rests the future of a popular form of government.—Cf. Cohn, "Finanzwissenschaft," Bk. i, ch. vii, part 2, § 176-184. Bryce, "The American Commonwealth," part v, ch. 94, third and fourth of the faults pointed out. L. F. Ward, "The Psychic Factors of Civilization," Boston, 1893, p. 167.

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PLANKTON STUDIES ON LAKE MENDOTA. I.

THE VERTICAL DISTRIBUTION OF THE PELAGIC CRUSTACEA DURING JULY, 1894.

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INTRODUCTION.

The following paper is the result of the joint work of Mr. Mr. O. A. Olson and H. P. Harder, members of the class of 1895 of the University of Wisconsin, done under my direction, and with my aid, for graduating theses in the College of Letters and Science. The observations occupied about six weeks of the summer of 1894. The first ten days, beginning about July 5, 1894, were spent in preliminary work, experimenting with the dredge and with methods of counting. The last observations were made on the 4th of August, and the finishing of the counting of specimens occupied about another week. Messrs. Harder and Olson did most of the dredging, taking the observations, day and night, at regular intervals whenever the state of the weather permitted. The observations at 6 and 9 p. m. were ordinarily made by myself. The counting and the exceedingly wearisome computation of percentages and averages was also performed by them. In this latter work Mr. Olson was responsible for *Cyclops* and *D. pulicaria*, while Mr. Harder did the computing for *Diaptomus* and *D. hyalina*. Each, however, checked the work of the other, so that great accuracy has been obtained, both in counting and in computation. Mr. Harder was absent after the completion of the observations, while Mr. Olson has been in attendance at the University and has done much work during the college year.

The results of the investigation were written up and reported to me by Messrs. Harder and Olson, and have been re-worked by myself and put into final shape for publication. Each gentleman reported upon the species investigated by himself. A large amount of detailed work was done, especially by Mr. Olson, which does not appear in the following paper. No attempt has been made to offer the results of each set of observations. The value of statistical work of this kind lies rather in the average results obtained than in the record of each single observation. It is believed that the use to which this paper may be put does not warrant the printing of the very numerous detailed computations. They are, however, preserved, and can be referred to by any person who is interested in the subject.

The original purpose of the investigation was to determine the supposed diurnal migrations of the crustacea, but since the results in this direction have been entirely negative, the outcome of the work has been to give us a definite idea of the vertical distribution of the crustacea in the lake during the month of July. This may be called their summer position, for it should be expressly noted that this position is not a constant one during the different seasons of the year. The conditions of July apparently obtain through August and the greater part of September, but later in the year a totally different and more uniform scheme of distribution is developed. The conditions of the later spring and of June are not yet known.—E. A. B.

LAKE MENDOTA.

Lake Mendota, in which these observations were made, lies immediately to the north of the grounds of the University of Wisconsin, which extend for a mile along its southern shore. The greatest length of the lake is about 6 miles from east to west, and its greatest breadth is something under 4 miles. It is partially divided into two basins by points on the east and west shores, which leave between them a space of about two miles. The smaller or southern basin is about 3 miles in length. With the exception of these projections the lake is quite regular in form, being without islands and having only broad bays with wide mouths. The conditions of life, therefore, are substantially uniform throughout the lake.

No well developed elevation in the bottom of the lake marks the separation into two basins, of which mention has been made. From the southern shore the bottom slopes off gradually to a depth of from 15 to 19 meters. In passing from this depth to the farther basin of the lake, a shoaling of the water amounting to two or three meters is noticed in places. Whether this shoaling, indicating a slight elevation, is constant throughout the whole length of the lake is as yet unknown.

About ½ mile northwest from the University buildings the water is between 18 and 19 meters deep—the southern portion of the deeper part of the lake. Northeast from this point a depth of 22 m. is reached in about a mile, and beyond that the greatest depth of the lake is probably about 24 m. The greater part of the bottom of the lake, therefore, is almost a plain, and a very large extent of the water is from 16 to 22 m. in depth. This uniformity of depth secures uniformity of biological conditions. The control observations made at various times, in different parts of the lake have shown no noteworthy differences in the crustacean life.

The place of observation was less than ½ mile from the southern shore of the lake, and several miles from the northern shore. It was about ½ mile from the nearest land to the west, the end of Picnic Point. In spite of this one-sided location, the number of crustacea remained substantially the same, whether the wind blew off shore or toward the land.

THE DREDGE.

In the construction of the dredge employed in our work, it was our aim to provide an apparatus which could be lowered to any desired depth, opened and raised through a certain distance, and then closed again. It was necessary also to devise one which could be made by an ordinary tin or coppersmith. The instrument consists of four parts:—the frame, the net, the releasing apparatus, and the bucket. The general appearance of the apparatus is given in Plate VII, and a full-sized section through the frame and part of the cover in Plate VIII, fig. 1.

The Frame.— The frame consists of the frame proper, bearing the sliding cover of the dredge, with its supports and guides;

the weights for moving the cover, and the attachment for the net.

The frame is 44 cm. long by 23 cm. wide on the outside, 42 cm. by 20 cm. inside. It is made of brass tubing 1 inch square and 1-32 of an inch thick, split longitudinally so as to leave one flange — the top one — $\frac{5}{8}$ of an inch wide, and the other $\frac{3}{8}$ of an inch wide. (*A*, Pl. VIII, fig. 1.) The pieces are firmly soldered together so that the flanges project outward. At the corners are fastened ears, pierced for the four cords by which the frame is hung to the dredge line. A half-piece of tubing similar to that of the frame is soldered across the frame near the middle, so as to leave an opening at one end 20 cm. square. Beneath this opening is fastened the net, and this end is called the front of the frame.

To the top flange on the sides of the frame and across the front end is soldered a strip of sheet brass 1-32 of an inch thick, and about $\frac{1}{4}$ of an inch wide. (*B*) This is attached close to the outside of the upper flange. Above it is fastened a strip of thin spring brass — the guide (*C*) — of the full width of the top flange, leaving between it and the flange a deep narrow cleft open toward the inside of the frame. In this groove the cover slides. In the middle of each end of the frame is attached a pulley (*H*), over which pass the cords for moving the cover. Just above the front pulley is an eye of wire (*G*), through which passes the cord to the cover. Its purpose will be mentioned later.

The cover is a flat piece of thin spring brass. The sides and front edge are not modified at all. The rear edge is bent over, so that when closed the cover fits closely over the flange of the partition in the middle of the frame. Around the front and sides of the cover is soldered a strip of thin sheet copper $\frac{1}{64}$ of an inch thick, and $\frac{5}{8}$ of an inch wide. (*E*) The inner edge of this strip is folded on itself, and attached to the cover so that the free edge is parallel with that of the cover, leaving between it and the cover a deep, narrow groove, in which fits the guide of the frame. On the top of the cover are soldered two eyes (*J*) for the attachment of the weight cords. In a dredge which is to be worked from a large boat it is well to provide an air escape, in the form of a short brass tube attached to the center of the cover. To this can be tied a cloth tube long enough to fall over and close the opening in the cover when the dredge is raised. In a row-boat the cover can be slipped by hand to allow the air to escape.

Since the brass of the cover is so thin, it tends to sag in the middle of the front, although stiffened by the flange. It is well to fasten to the inside of the frame two or three short sloping guides (*M*), which will guide the front edge of the cover into its groove on the frame as it closes.

The attachment of the bag is a circular piece of stout copper, 20 cm. in diameter on the inside (*K*), with a stout wire turned into its lower edge on the outside. The net is held in place by a collar of sheet copper 2 cm. wide, having at the ends eyes of heavy wire, through which a bolt can be passed. The net is slipped over the frame, the collar placed upon it, and drawn tight by a screw bolt. This holds the net perfectly, without the use of eyelets or similar arrangements, and the net can be attached or removed in a minute. This collar is well shown in Pl. VII, fig. 1.

The net.—The net is made of fine muslin known as "India linen." The opening of the meshes, while, of course, not perfectly regular, measures about 0.1 mm. It permits the passage of water quite freely and is not affected by wetting nor does the coefficient change with time to an appreciable degree. A piece of stout muslin was sewed to the top of the net for attaching it to the frame. In the July observations the net was attached directly to the square frame. Later the method described above was substituted. There was no difficulty in washing the net clean when attached to the square frame, but it was much more difficult to shape and fasten smoothly.

The releasing apparatus (Pl. VII, fig. 1) is a modified form of one designed by Prof. C. Dwight Marsh, of Ripon College, Wisconsin. It consists of an oblong frame of stout sheet brass 13 cm. long, 11 cm. wide, 2.5 cm. deep, divided by a horizontal partition in the middle. In the center of the top, bottom and middle pieces is a hole one-fourth of an inch in diameter, through which passes the dredge line. A fork of stout wire passes through holes on each side of these plates. The upper two plates are pierced by the branches of the fork, and the stem passes through the bottom plate. To the stem below the frame is attached a side wire — the weight-pin — which passes up through a hole in a lateral projection of the bottom plate for about half an inch. This is the hook to which are hung the weights for moving the cover.

The fork for the opening weight is narrower and shorter than that for the closing weight. Its branches are 6 cm. apart, and project 2 cm. above the frame. The branches of the other fork are 9 cm. apart, and project 6 cm. above the frame. The top of each branch of the forks is bent at right angles across the frame, projecting inwards, so that the messengers which release the weights have something more than the ends of the wires to rest upon. Both forks are held up by rubber bands, stretched from the junction of the branches to the middle plate. They can be depressed just far enough to bring the top of the weight-pin upon a level with the plate through which it passes, and thus allow the weights to become detached. The messengers for releasing the weights are discs of lead, each with a slot in the side and a wire catch, so that it can be slipped on the dredge line from the side. The opening messenger is 7 cm. in diameter, and weighs 275 g. (10 oz.). The closing messenger is 10 cm. in diameter, is perforated with holes to sink more rapidly, and weighs 450 g. (16 oz.). The opening messenger is of such diameter that it passes between the ends of the closing fork and strikes the top of the opening fork, depressing it so as to release the opening weight. The larger—closing—messenger when it sinks rests on the broader closing-fork and depresses it, thus releasing the closing-weight.

The weights.—The weights used in working the cover of the dredge were at first made of ordinary lead fishing sinkers, weighing 4 to 6 ounces each. These were chosen because the total weight could easily be altered by adding or withdrawing sinkers, as was indicated by experience in using the dredge. When the weights had been adapted they were cast into one piece. The opening weight weighs 425 g. (15 oz.) and the closing weight 1025 g. (36.5 oz.). The closing weight has to lift the opening weight as well as close the cover. They are hung to the dredge by snap hooks, to each of which is attached two cords. The first of these is the cover cord, which passes through the pulley on the end of the frame, and is fastened to the cover. By it the weight opens or closes the dredge. The second cord is the releasing cord. This passes through the same pulley and is tied to the wire loop to which are fastened the cords supporting the dredge, and which attaches the dredge to the line. It is long enough to be slack when the weight is hanging at the full length of the cover-cord. Weight-hangers—stout fishing swivels — are attached to these cords at such a place that when they are hung on the weight-pins of the release, the weights are supported close to their respective pulleys, and both cover cords are loose. The opening weight is hung to the inner or narrower fork of the release, and the closing weight to the outer one. This arrangment of cords is well shown in Plate VII, fig. 1, where the weight-hangers are on the pins and the dredge is "set."

It will be seen that the cover-cord of the closing weight shows a large loop when the dredge is lowered with the cover closed. This loop gave much annoyance at first by becoming entangled, and thus preventing the dredge from opening. The difficulty was overcome by an elastic cord attached to the release-cord of the opening weight and having at the other end an eyelet, through which ran the cover-cord of the closing weight. This elastic cord is of such length that it holds up the slack loop of the closing cord when the opening weight is "set" by hooking its weight-hanger on the weight-pin of the release. When the opening weight is released the eyelet falls to the level of the cover, releasing the closing cord. It must not drop far enough to be shut in between the cover and frame when the dredge is closed. The eyelet is kept from being drawn into the closing pulley when the cover is drawn shut, by the loop of wire already mentioned (*G*, Pl. VIII, fig. 1) through which passes the closing cord just before reaching the pulley. This arrangement of cords reads as if it were complex. It is really simple. The cords do not become entangled, and need no adjustment. The weights can be set by a single movement—

hanging the weight-hangers on the weight-pins—which occupies hardly a second for each weight.

The bucket.—The bucket consists of three parts, the bucket proper and the two pieces by which it is attached to the bag. (Plate VII, figs. 2, 3.) Each is made of thin spring brass. The two attaching pieces are cylinders. The upper one fits into the lower, and is about 6 cm. in diameter and 5 cm. deep. It has a wire to stiffen it in the upper edge. This and all of the parts are lap-soldered, so as to avoid a seam. The second or lower cylinder is large enough to fit over the upper one, and to permit the net to come between them. Each is provided with three equidistant loops of wire, by which they may be fastened together, and the lower one has two pins on opposite sides which fit into the bayonet catches of the bucket. The dredge net is drawn down inside the upper cylinder and turned up over its exterior; the lower cylinder is slipped over it and fastened to the upper one. The mouth of the net is thus held firmly between the cylinders, and at the same time no projections are left to hold back its contents, nor are there any longitudinal folds, if the dredge-net is properly fitted to the cylinder. The bucket proper is a cylinder of thin brass 6 cm. in diameter and $7\frac{1}{2}$ cm. high, with four windows in its lower part, each $3\frac{1}{2}$ x 4 cm., covered with brass wire gauze of .01 inch mesh. The opening of each mesh is about 0.17 mm. (.007 in.) in diameter. In the upper edge are cut notches for a bayonet catch, by which it is attached to the middle cylinder. It slips over the middle cylinder for a distance of 3 cm., thus securing a tight joint, so far as the crustacea are concerned. The bottom is slightly conical, and leads to a conical tube filled by a rubber stopper, which is put in by a wire handle from the inside. There are three legs upon which the bucket may stand. In Fig. 2 the upper cylinder is supported by blocks upon the second one.

The dredge as described above is not to be considered as an attempt at a universal self-closing dredge. It was designed to meet the conditions of the special problem which we had proposed and was found to meet those conditions admirably. The advantages of the dredge appear to me to be as follows:

(1) It is simple, easily worked, and reliable.

(2) It is operated by weights, which work positively, and does not depend upon springs or wheels, whose action is more or less uncertain.

(3) It is tight, so far as the crustacea are concerned. The coarseness of the wire mesh of our bucket does not permit us to assert that it is equally tight to *Peridinium* and similar minute creatures. It would not be difficult, however, to construct a dredge on a similar pattern whose cover should be entirely secure against the entrance of any organisms when the dredge is closed.

As disadvantages of the dredge may be mentioned:

(1) The amount of the weights required for working the cover. This, however, is not much greater than is necessary to cause the dredge to sink promptly and rapidly through the water.

(2) The resistance offered by the cover in drawing up the dredge, and the time required by the messengers in descending to open and close it. These are, however, of comparatively slight moment in water so shallow as ours.

(3) A more important objection lies in the fact that the dredge must be used as a vertical dredge only. The boat from which it is worked must be practically stationary, and preferably should be anchored. If the boat is drifting through the water, the pressure of the water on the cover of the dredge so hinders its sliding that a weight which works it perfectly when the dredge is vertically suspended fails to open or close it. Further, if the dredge line is not vertical, a messenger which ordinarily is amply heavy for releasing the weights may fail to sufficiently depress the weight-pin.

METHOD OF USING THE DREDGE.

The mode of working the dredge is as follows: The dredge is hung to the dredge line, and the opening and closing weights are hung to their respective supports. The weight-holders are hung to the pins of the release, so that the weights are supported by the release cords. The cover is slid into place, and the dredge lowered. When it has reached the proper depth the smaller or opening messenger is sent down the line. It strikes and depresses the short fork, releases the opening weight, which, as it falls, pulls back the cover and opens the dredge. The dredge is then raised through the desired distance—in our experiments, 3 meters—and the larger or closing messenger is sent down. This releases the closing weight, which pulls the cover shut, and in so doing raises the opening weight. The dredge is then drawn to the surface. It has been found that there is no leakage of crustacea into the dredge during raising. The thin brass of the cover is tightly pressed against the frame as soon as the upward movement begins, and the guides at the edge of the cover present so narrow and tortuous a passage that the water does not readily flow through it. Besides, the guides are so constructed that the water displaced by the dredge flows away from the groove and not into it. An examination of the cut (Pl. VIII, fig. 1) shows that the arrangement is such that the animals are not likely to come in. In our numerous hauls it was found entirely tight, so far as crustacea were concerned. Many times the dredge was hauled from the bottom of the lake through water whose upper levels contained thousands of crustacea, and on opening was found to contain perhaps 6 or even fewer crustacea, with, perhaps a *Chironomus* or *Corethra* larva. Experimental hauls, sending down and raising the dredge when closed yielded uniformly negative results.

When the messengers arrive at the surface they are detached, the dredge hauled up, and the contents washed down into the bucket. This is removed and the catch washed into a collecting tube, modeled on those designed by Prof. J. E. Reighard of the University of Michigan, made and used as follows:

The bottom is cut from an eight drachm short homeopathic vial, a piece of fine cloth is tied tightly over the neck, and a cork fitted to the bottom. A rubber band is placed upon the conical tube of the bucket, so that the collecting tube can be pushed tightly upon it. The rubber cork is lifted from its place in the bucket, the catch runs out into the collecting tube, and the bucket is carefully washed down into the tube. The water drains off through the cloth, the tube is detached, filled from a large jar of alcohol, and placed in the jar, where it floats cork uppermost, and requires no more attention until a convenient time offers. Most of our collecting was done at one depth, yielding six hauls. The collecting tubes were provided with corks marked in sets from 1 to 6, so that no labels were needed while on the water. This is often a convenience, especially when one is working alone and at night. The tubes are shown in Pl. VII, figs. 2, 3.

The dredge was used from a rowboat. In the bow of the boat an upright was stepped like a mast, about seven feet in length, having at the top a cross arm, to whose end was attached the pulley for the dredge. The small size of the boat caused us to lose several sets of observations. When the wind was strong, the lake was too rough to permit the boat to go out, and in several sets of observations the waves ran so high as nearly to swamp the boat.

The observations included in Period I were not made at any one place since they were experimental in character. All of them, however, were made in the same general region as were the observations of the later periods. The water, however, was shallower in most of these observations than at the place finally selected. As a result, only one of the observations of Period I extended below 15 m.

In the last three periods the observations were made at a buoy, which was moored in water something over 18 m. in depth, so that the dredge could be raised through six levels of 3 m. each. This distance was chosen because it gave us an interval small enough to give a fair indication of the vertical distribution of the crustacea, and at the same time large enough to bring our observations within a manageable number. Each interval is known as a level, and is named from the depths between which it lies. The upper level is known as 0–3 m. level, and so on to the bottom. A series of six hauls of the dredge therefore constituted one complete observation called a "series" in this paper.

In beginning an observation the dredge was lowered to the depth of 18 m., opened, raised to 15 m. at the rate of $\frac{1}{2}$ m. per second, closed, and drawn to the surface. In this way the work proceeded, passing regularly from the deeper levels to the higher ones. The reason for this order lay in the fact that the greater number of crustacea were in the upper level of the lake, and it was desirable to pass from a region containing fewer crustacea to one containing a greater number, rather than the reverse. Any accident in washing out the dredge, by which a few crustacea remained adherent to it would introduce a considerable error in passing from the higher to the lower levels, while in passing in the opposite direction the error would practically amount to nothing. Great care was taken in washing the dredge, and it is not probable that any appreciable number remained adherent to it, but this method was followed to avoid any possible error from this source.

METHODS OF COUNTING AND COMPUTING THE CRUSTACEA.

The counting and computing were done almost entirely by Messrs. Harder and Olson.

The apparatus employed for counting consisted of a 25 cc. glass cylinder graduated to $\frac{1}{2}$ cc., a 2 cc. pipette, graduated to $\frac{1}{10}$ cc., microscope, shallow crystallizing dishes, troughs, and registering cards.

The trough was made of a microscope slide, to which were cemented four strips of glass by means of marine glue. Thus there was formed a narrow and shallow trough, 60 mm. $\times$ 6.5 mm. $\times$ 2 mm., holding about .8 cc. The width of the trough was a little less than the diameter of the field of the microscope when a low power objective and eye piece were used. In our counting a Leitz objective No. 1 and ocular I were employed. A card like the accompanying cut was used in recording the kinds and number of crustacea, as well as the level in which they were obtained, together with other important observations. The method used in counting was simple, and with practice became somewhat rapid. The catch to be counted was placed in the graduated cylinder, and sufficient alcohol added to make 24 cc. This quantity was then thoroughly stirred and shaken, so that the animals and plants were evenly distributed through it. From this mixture two quantities of 2 cc. each were taken and transferred to watch glasses. One of these quantities was counted by each of the observers who were at work. From the watch glass there was taken and placed in the trough a sufficient amount of material to give about 60 or 70 animals of the most numerous kind. This quantity was found by experience to be the most advantageous, since a greater number of animals was likely to cause confusion and fatigue in counting, and a smaller number led to loss of time. The trough thus filled was slowly moved through

STATION *Picnic Point* SERIAL No. *217*

DATE *Aug. 1, 1894* HOUR *9 p.m.*

SKY *Clear* WIND *N. 12 m.* TEMP. *18°*

DEPTH *0–3* m. TOTAL DEPTH *18* m.

CATCH DILUTED TO *24* ccm.

Ccm. COUNTED *4* . FACTOR *6*

	Counted	Total
DIAPTOMUS *136 . 126* .	*262*	*1572*
CYCLOPS . *88* *92* .	*180*	*1080*
DAPHNIA PULEX, var. PULICARIA *0 0*	*0*	—
D. HYALINA . *8* *9* .	*17*	*102*
DAPHNELLA BRACHYURA . .	*9*	*54*
LEPTODORA HYALINA . . .		*21*
CHYDORUS SPHAERICUS . .	—	—
CORETHRA LARVAE		*16*
CHIRONOMUS LARVAE . . .		*1*

FIG. 1.—Specimen Registry Card.

the field of the microscope, one species was counted at a time, and the number noted. When the entire quantity had been counted the results were footed up and compared. In general each of the countings showed closely corresponding results. The numbers, while not absolutely the same, were practically equivalent. An illustration taken at random from the cards may be cited:

July 17, 12 *midnight.* 0·3 *m.*

Observer, H. Diaptomus, 206............................Cyclops, 34
Observer, O. Diaptomus, 216...... ....Cyclops, 25

July 27, 12 *midnight.* 0·3 *m.*

Observer, H. Diaptomus, 146................. ....Cyclops, 65
Observer, O. Diaptomus, 123...................... .... Cyclops, 79

This system of checking each other's work was carried on through the entire task, and whenever the numbers obtained differed widely from each other a second counting was made, in order to secure greater accuracy.

The results thus obtained were multiplied by a factor found by dividing the total quantity of alcohol by the quantity removed from the graduate, thus determining the total number for the particular level and series. In the heavier catches $\frac{1}{6}$ of the total number was actually counted and the factor was 6. It would probably have been better had the quantity of alcohol been so chosen that the factor might have been 10. The selection, however, was determined by the instruments at hand. In the catches containing but few specimens. as in the 12-15 m. and 15-18 m. levels, the entire quantity was counted. In the 9-12 level the catch was diluted to either 16 or 12 cc., and from this quantity 4 or 6 ccm. respectively would be counted.

After determining the number of the smaller crustacea, the contents of the cylinder were poured into a shallow crystallizing dish, which was placed upon a black tile to facilitate observation. All large types, such as *Leptodora* and the larvae of *Corethra* and *Chironomus*, were then counted directly.

After the catch made during any of the periods had been counted, the cards were arranged in order, the results were posted, and the totals and percentages for the different levels were computed. A specimen of a part of such a sheet is given herewith.

August 1, 1894.

	6. P. M.		9. P. M.	
Diaptomus.	No.	Per cent.	No.	Per cent.
0-3 m	1788	41.04	1572	59.21
3-6	1068	24.51	462	17.40
6-9	1110	25.48	486	18.31
9-12	384	8.81	105	3.95
12-15	3	.07	19	.72
15-18	4	.09	11	.41
Total	4357	....	2655	....

After computing the percentage for each series of observations, the average distribution of each of the species was determined for each period and for the entire month. In determining these averages the total number of crustacea obtained from each level was found and divided by the number of observations. The sum of all these results form the base on which the average percentages were computed. In this way observations could be used which did not form part of complete series, and in several cases one or two more observations were included in the upper level than in some of those below. The number of crustacea, however, was in general so nearly uniform that the inclusion or omission of these partial observations made no appreciable difference in the percentages.

In determining the averages for the month a similar method was used. Each series of observations was used by itself, and the average for the month is the average for the observations, and not the average of the different periods taken as units. Since these periods are unequal in length they have a different value in determining the total average, but it seemed to us that a fairer average would be reached by taking the observations in this way, rather than by considering each period as a unit.

Our discussion of results is based rather on percentages of distribution than on actual numbers of crustacea per square or cubic meter. This has been done for two reasons: First, the coefficient of the dredge was not determined at the time that the computations were made, and it was therefore impossible for us to figure our numbers in terms of individuals per square meter of area. Secondly, the percentages seemed to us to offer an easier and fairer basis of comparison for our purposes than do the actual numbers. In the case of the more abundant crustacea, the numbers per square meter rise into the millions, and are therefore inconvenient for basis of comparison. Again: In lakes of different character the total number of crustacea will vary greatly, so that comparison between lake Mendota and other bodies of water would not be easy. A comparison of the percentile distribution of the crustacea is, however, easily made, and is or should be measurably independent of the actual number of crustacea per square meter.

In determining the average departure of each observation from the average of the period, the difference between the number of crustacea found in each observation and the average for the period was determined, and the sum of these departures was divided by the total number of observations. In determining the average percentile departure in each level a similar method was followed. In these determinations, however, only those observations could be used in which a complete series was present. The average per cent. used for this purpose is therefore somewhat different from the percentage which is given as the average of the period, since in that were included partial series of observations as well as complete ones.

METEOROLOGICAL CONDITIONS.

In planning our work it was thought best to distribute our observations over several periods of two or three days each, extending through a month, in order that the distribution of the crustacea by day and night might be tested under different conditions of weather, and under different aspects of the moon. The observations have been divided into four sets, known as periods. Of these the first, Period I, includes the week from July 7 to July 14, when observations were being made to test the working of the dredge and our methods for counting. A number of observations made at this time were failures for various reasons, and were rejected. Nine series, which have been retained, were successful. They were taken at various times of the day, but not at regular intervals and none later than 8 to 10 p. m. The comparison of these observations with those made later showed that they present substantially the same features as do the others, and they were therefore included, in order to add to the number of the observations in striking an average.

Regular work began in the period known as Period II, extending from 9:30 a. m. of July 16 to 12 noon of July 19. During this period observations were taken every three hours during the day and night, with the exception of two, 6 and 9 a. m. of July 18, which were omitted by reason of losing the messenger for closing the dredge. During this time the weather was exceedingly uniform. Most of our notes are marked "calm," and in most cases the water was entirely unrippled. The observations of the Washburn Observatory, which is situated on the bank of the lake, show breezes not exceeding 5 miles an hour, until the last day, when a maximum observation is made of 10 miles per hour. These breezes were mainly in the nature of puffs, rather than a steady wind. The nights were moonlight, and the sky was practically without clouds during the entire period. The weather was also intensely warm. The thermometer at the Washburn Observatory reached, on each day, a maximum of 33.6° C. (92.6° F.) to 35.1° C. (95.3° F.) and a minimum of 20.2° C. (68.4° F.) to 22.5° C. (72.5° F.). The surface temperature of the water was 22° C. at 3 p. m. of July 19, and rose to about 27° in the hottest part of each of the succeeding days. At night the temperature of the surface fell to 19° or 20°. These are precisely the conditions which Francé indicates as causing the crustacea to remain in the deeper part of the water. This comparatively long period of intensely hot and bright weather was broken at 3 p. m. of July 19 by a thunder storm, which surprised the boat upon the lake and put an end to work for the day.

The third period extended from 12 o'clock midnight of July 27 to 12 o'clock midnight of July 29, thus including two entire days. In this period the wind blew mainly from the south, southeast, and southwest, the velocities registered at the Washburn Observatory ranging from 10 to 24 miles per hour. Several of the observations were prevented by wind—those of 12 m.

and 3 p. m. of the 27th, and 12 m. and 9 a. m. of the 28th. The maximum temperature of the air was 33.3° C. (92° F.) on July 27 and 30° C. (86.2° F.) on July 28. The minimum temperatures were 23.2° (73.8° F.) and 21° (69.9° F.) respectively. The temperature of the surface ranged from 18° at night to 20°–22° C. in the middle of the day. The wind in this case blew from the nearer shore, the buoy being placed not quite a half mile from the southern shore of the lake. The nights were dark, somewhat hazy and cloudy. This period and the fourth would have been made longer except that it became plain that the distribution of the crustacea was essentially the same as in Period II.

In the fourth period, extending from 6 a. m. of August 1, to 9 a. m. of August 4, the wind was in the north and northwest, and was so heavy as to interfere with observations. No observations were made after 9 a. m. of August 2 until 9 a. m. of August 3. The wind at this time was not too heavy to permit a large boat to go upon the lake, but as our observations were made from a rowboat, it was impossible to make them when even a moderately strong wind was blowing from the north. The temperature reached a maximum of 31° C. (88° F.) on the 1st of August, and of 21° (70.5° F.) on the 3rd, with a minimum of 20° (69° F.) on August 4 and of 8.8° (47.9° F.) on August 3. The effect of the long continued and somewhat heavy north wind was apparently to distribute the crustacea over a greater depth. It will be seen from the tables that the average catch for the 9–12 m. level was considerably increased. Below 12 m. the wind had no appreciable effect. During this period the nights were dark.

It thus appears that the last three sets of observations covered a great range of meteorological conditions. In Period II the weather was calm and bright and the nights were moonlight. In Period III the wind was from the south, the weather the ordinary summer weather, and the nights dark. In Period IV the weather was distinctly cool, the wind was from the north, and the sky in both of the later periods was somewhat clouded. With the exception of the influence of the wind, of which mention has been made, no effect upon the distribution of the crustacea could be traced to these varying conditions of the weather. It is worth noticing that the number of crustacea obtained was not to any notable extent affected by the direction of the wind. Since our buoy was placed about $\frac{1}{8}$ of the distance across the lake, it might reasonably have been expected that the pelagic crustacea would be decreased in number by a breeze blowing from the nearer shore, and possibly somewhat increased by a wind from the farther shore. No such effect, however, was observable and indeed the number of crustacea obtained in the last period, when the wind was from the more distant shore, was smaller in all species than the number obtained in the preceding series, when the wind was from the nearer shore.

GENERAL DISTRIBUTION OF THE CRUSTACEA.

Altogether 59 sets of observations were counted, and are made use of in determining the average of the distribution ot crustacea for the month. The number of observations varies somewhat in the different levels. Forty-nine observations only are recorded for the lowest level, 15–18 m., for reasons indicated above. In each of the upper levels, except the upper, from one to three observations were lost by various accidents. In one or two cases the dredge did not open or close properly, thus vitiating the observation. In one or two cases the contents of the dredge were partially lost, thus making it impossible to count them. However, the general uniformity of observations is such that no noteworthy change would be made in the results if all the sets of observations had been perfect. In the last three periods observations were taken at intervals of three hours during the day and night. The times selected were midnight, 3 a. m., 6 a. m., etc. The observations taken at 9 p. m., midnight, and 3 a. m. are reckoned as belonging to the night. Those at the other hours are reckoned as belonging to the day. In July, of course, the hours of 6 a. m. and 6 p. m. are fully within the daylight hours. Had there been any diurnal movement of the crustacea these observations would have been treated by themselves, but since the day observations do not differ in any marked way from those made at night, the 6 a. m. and 6 p. m. series are included and averaged with those of the day. Of the 59 sets of observations, 33 belong to the day and 26 to the night. The number is about equal in each of the periods, except Period II, where the numbers are 15 for the day and 9 for the night. In any considerable series, this discrepancy in numbers would, of course, be present, since five of the eight daily observations are credited to the day.

Six kinds of crustacea were regularly present in the dredge: *Diaptomus oregonensis* Lillj.; *Cyclops leuckarti* Sars; *Cyclops brevispinosus* Herrick; *Cyclops pulchellus* Koch; *Daphnia hyalina* Leydig; and *Daphnia pulex*, var. *pulicaria*, Forbes. These were present in very unequal numbers. On the average during the month the dredge caught 6556 crustacea in each series of hauls from the six different levels. Of these, 64 per cent. or 4221 were *Diaptomus;* a little over 2000 or 30.5 per cent. were *Cyclops*, including all species; 222 or 3.3 per cent. were *D. hyalina*, and 103 or 1.5 per cent. were *D. pulicaria*. The tables which accompany this paper show the average number and the variation of each of these crustacea in the different periods. It may, in general, be said here that *Diaptomus* was always by far the most numerous, ranging from 53 per cent. to 79 per cent. of the total catch, but declining somewhat both in absolute numbers and in percentage in the later series of observations. *Cyclops* ranged in the different periods from 13 to 40.5 per cent. of the catch, increasing in percentage in each period to the end. This increase in numbers of *Cyclops* continued later in the year, until the latter part of October or the first of November, while *Diaptomus* fell off rapidly in numbers during August. *D. hyalina* constitutes from 2.3 per cent. to 6.4 per cent. of the total catch. Its numbers were about stationary during the month, but showed later a rapid and very great increase. It became the leading crustacean, as the species reached in October a maximum catch of over 8000 individuals in a single series of hauls. *D. pulicaria* in the first three periods yielded between 1.5 and 2 per cent. of the entire catch, with an average of 125 individuals, while in the last period it gave only about .3 per cent., averaging 18 individuals. Later this species practically disappeared entirely from the lake, so that it is probable that we are here dealing with the last of its development.

The crustacea were far more numerous in the upper part of the water than in the deeper levels. Nearly one-half of the entire catch was found in the upper 3 m. The average for the month from this level was 48.6 per cent., ranging from 41.75 per cent. to 57.6 in the different periods. The 3–6 m. level contained on an average about 30 per cent. of the total number of crustacea, and the 6–9 m. level about half as many, 15.3 per cent. On an average, then, the upper 9 m. of the lake contained nearly 94 per cent. of the total number of crustacea. This distribution was maintained with great regularity. Very few observations showed any great number of crustacea below 9 m., and these were almost wholly confined to the 9–12 m. level. The number found in this level varied very greatly, ranging in the case of *Diaptomus* from 2 to 570 in different observations. Most of these crustacea were probably in the upper part of the level, and everything indicates that the densely populated portion of the lake is of somewhat varying thickness, as would be expected. The crustacea apparently stopped rather abruptly either somewhat above or somewhat below the 10 m. level. On the average during the month 5.4 per cent. of all of the crustacea were found between 9–12 m., the averages for the different periods ranging from 3.7 per cent. in Period II, when there was almost no wind, to 7 per cent. in Period IV, when the lake was very greatly disturbed. Below 12 m. practically no crustacea were present. Only .8 of 1 per cent. of the total number was found between 12 m. and 15 m., and only .1 of 1 per cent. between 15 m. and 18 m. Observations in the deeper parts of the lake, down to 22 m., made for purposes of control, showed similar conditions. We may therefore conclude that practically all of the crustacea during July are contained in the upper 12 m. of the water, and that more than 90 per cent. of them will be tound above the 9 m. level. This distribution apparently continues throughout August and the early part of September. Later in the year, as the temperature of the lake falls and becomes uniform, the distribution changes, and the crustacea become pretty uniformly distributed throughout the whole depth. In general, this new distribution continues, though more or less irregularly, throughout the winter and into the spring, but no observations as yet show the time when this very distinct tendency of crustacea toward the upper part of the water begins or the date at which it has become established.

In observations made on lake Plön, and printed in the 3d Report of the Biological Station (p. 137), Zacharias gives a few observations regarding the number of crustacea and their distribution in depth at that lake. He finds that *Cyclops* is in September by far the most numerous genus, having a maximum number of over 400,000 per square meter of surface. In August, however, he notes that only 140,000 per square meter was present. As the opening of our dredge was $\frac{1}{25}$ of a square meter, the average number of this genus caught by us during July would be at the rate of 50,000 per square meter and the maximum would be over 136,000. Since the coefficient of the dredge can hardly be lower than four, the number of *Cyclops* per square meter of surface is not smaller in July in lake Mendota than that noted for August in the far-deeper lake Plön. No figures are given by Zacharias for *Diaptomus*, which was our most numerous species. *Bosmina* he finds abundant, while no pelagic *Bosmina* or *Ceriodaphnia* has been found in lake Mendota. *Hyalodaphnia* is present in very large numbers, ranging from 62,000 to 94,000 per square m. A corresponding species of *Hyalodaphnia* is found in lake Mendota in July and later in very small numbers. Only a few scattering individuals were noticed in our counting, the number being quite too small to use in the study of the crustacea.

In observations on the crustacea from different depths, Zacharias found the crustacea distributed as follows:

August 19.	*Hyalodaphnia.*	*Copepoda.*	*Bosmina.*	Aug. 31—*Cyclops* (2 obs.).	
0 — 10 m.	540	840	150	690	690
0 — 20 m.	510	1,350	100	2,190	1,500
0 — 40 m.	660	1,620	100	3,510	1,320

These figures indicate that almost or quite all of the individuals of *Daphnia* and *Bosmina* were confined to the upper 10 m., and so far his observations agree substantially with our own. They indicate also that the *Copepoda* extend to very considerable depths. About 15 per cent. of the *Copepoda* were found in the first observation below a depth of 20 m. and about 32 per cent. between 10 and 20 m. On Aug. 31 the proportion found in the deeper levels was much increased, the upper 10 m. containing less than 20 per cent. of the crustacea while more than $\frac{1}{3}$ were between 20 and 40 m. In the second observation no specimens seem to have been found at a depth below 20 m. If these few observations represent the average summer conditions in lake Plön, it is obvious that the *Copepoda* extend to far greater depths than in lake Mendota, since deeper hauls here would have added few or no crustacea to the number obtained in the upper 10 m. No reason can at present be assigned for this difference in distribution, but the fact of the difference is sufficient to show that each lake demands careful individual study, if we are to form any correct idea of the actual condition and distribution of life in it. This fact is still more clearly indicated by Francé's observations on the diurnal movement of the plankton of lake Balaton, to which more extended reference is made in another part of this paper.

No diurnal movement is clearly disclosed by our results. This question is discussed in detail for each of the crustacea, and the general conclusions are stated in connection with comments on Francé's paper.

In the following tables, A to D show in the columns headed "No." the average number of crustacea caught in each period from each level. The column headed "per cent." shows the percentage which that number constitutes of the total number of crustacea obtained from that level, or, in the bottom line, the percentage of the total catch which the particular species furnished. The last columns show the total number from each level, and the per cent. of the entire catch which the number from each level constituted. Table E shows the same facts for the entire month. Tables F and G bring together the percentile relations shown in the preceding tables.

TABLE A—July 7-14—PERIOD I—9 Series.

DEPTH.	*Diaptomus.*		*Cyclops.*		*D. hyalina.*		*D. pulicaria.*		TOTAL.	
Meters.	No.	Per ct.	No.	Per ct.	No.	Per ct.	No.	Per ct.	No.	Per ct.
0—3........ ...	1860	84.01	234	10 57	119	5 37	1	.05	2214	45.68
3—6..........	1201	83.87	154	10.75	73	5.09	4	.28	1432	29.54
6—9.........	593	72.32	137	16.71	63	7.68	27	3.29	820	16 92
9—12....	120	44.78	71	26.49	44	16.42	33	12.31	268	5.53
12—15....... ...	18	20.00	28	31.11	10	11.11	34	37.78	90	1.86
15—18....... ...	16	69 56	2	8.70	3	13.03	2	8.70	23	.48
Total......	3808	78.56	626	12.92	312	6 44	101	2.08	4847	....

TABLE B—July 16-19—PERIOD II—24 Series.

DEPTH.	*Diaptomus.*		*Cyclops.*		*D. hyalina.*		*D. pulicaria.*		TOTAL.	
Meters.	No.	Per ct.	No.	Per ct.	No.	Per ct.	No.	Per ct.	No.	Per ct.
0—3....... ...	2675	75.6	798	22.5	61	1.7	3	.08	3537	57.6
3—6......... .	1133	68.5	463	28	47	2.9	9	.5	1652	26.9
6—9....	384	57	201	30.6	31	5	39	6	655	10.6
9—12.........	53	22.9	114	49.4	5	2.1	59	25.5	231	3.7
12—15..	3	2	34	54	1	2	25	39	63	1
15—18..........	5	83	1	17	0	0	0	0	6	.1
Total... ...	4253	69 3	1611	26.2	145	2.3	135	2	6144	.. ..

TABLE C—July 27-29—PERIOD III—14 Series.

DEPTH.	*Diaptomus.*		*Cyclops.*		*D. hyalina.*		*D. pulicaria.*		TOTAL.	
Meters.	No.	Per ct.	No.	Per ct.	No.	Per ct.	No	Per ct.	No.	Per ct.
0-3.	2271	62.68	1229	33.92	123	3.4	0	.0	3623	41.75
3—6...........	1831	61.24	1059	35.42	95	3.17	5	.17	2990	34.45
6—9......	881	59.72	475	32.20	49	3.32	70	4.75	1475	17.00
9—12..........	156	28.89	332	61.48	4	.74	48	8.89	540	6.22
12—15..........	3	6.25	40	83.33	3	6.25	2	4.17	48	.55
15—18....... ..	1	33.33	2	66.67	0	.00	0	.00	3	.03
Total	5143	59.26	3137	36.15	274	3.15	125	1.44	8679	....

TABLE D—Aug. 1-4—PERIOD IV—12 Series.

DEPTH.	*Diaptomus.*		*Cyclops.*		*D. hyalina*		*D. pulicaria.*		TOTAL.	
Meters.	No.	Per ct.	No.	Per ct.	No.	Per ct.	No.	Per ct.	No.	Per ct.
0—3..........	1560	57.5	1038	38.2	113	4.1	0	0	2711	43.4
3—6	919	53.4	730	42 4	69	4	0	0	1718	27.3
6—9...........	715	52.8	570	42.1	62	4.5	5	.4	1352	21.6
9-12...........	224	50.9	187	42.5	16	3 6	13	2.9	440	7
12—15..........	5	63	3	37	0	0	0	0	8	.1
15—18..........	5	55	3	33	1	11	0	0	9	.1
Total.... ...	3428	53.3	2531	40.5	261	4.2	18	.3	6238	....

TABLE E—*Average catch and percentage for month.*

DEPTH.	*Diaptomus.*		*Cyclops.*		*D. hyalina.*		*D. pulicaria.*		TOTAL.	
Meters.	No.	Per ct.	No.	Per ct.	No.	Per ct.	No.	Per ct.	No.	Per ct.
0—3	2229	70	863	27	94	3	2	.06	3188	48.6
3—6......	1257	65	612	31	66	3.4	6	.3	1941	29.9
6—9...........	592	59	329	32	46	4.6	37	3.7	1004	15.3
9—12..........	133	36.5	176	48.3	13	3.5	42	11.5	364	5.4
12—15....... ..	6	11.5	28	53.8	2	4	16	30.7	52	.8
15--18..........	4	57	2	30	1	13	0	0	7	.1
Total......	4221	64	2010	30.5	222	3.3	103	1.5	6656	....

The facts of this table are shown in Pl. VIII, figs. 2–8.

TABLE F—*Percentage of total catch found at each level.*

DEPTH.	PERIOD.				
Meters.	I.	II.	III.	IV.	AV.
0—3....	45.7	57.6	43	41.7	48.6
3—6...........................	29.5	26.9	34.8	34.5	29.9
6—9.	16.9	10.6	15.7	17.0	15.3
9—12..........................	5.5	3.7	5.7	6.2	5.4
12—15...........	1.9	1	.7	.6	.8
15—18	.5	.1	.02	.03	.1

TABLE G—*Table showing the percentage of each form of crustacea by periods and levels.*

DEPTH.	*Diaptomus.* PERIOD.					*Cyclops.* PERIOD.				
Meters.	I.	II.	III.	IV.	Av.	I.	II.	III.	IV.	Av.
0—3...	84.0	75.6	62.68	57.5	69	10.57	22.5	33.92	38.2	26
3—6...	83.87	68.5	61.24	53.4	65	10.75	28	35.42	42.4	31
6—9 ..	72.32	57	59.72	52.8	59	16.7	30.6	32.20	42.1	32
9—12..	44.78	22.9	28.89	50.9	36.5	26.49	49.4	61.48	42.5	48.3
12—15..	20.	2	6.25	63	11.5	31.2	54	83.33	37	55.7
15—18..	69.56	83	33.33	55	57	8.70	17	66.67	33	30
Av...	78.56	69.3	59.26	53.3	64	12.92	26.2	36.15	40.5	30.5

DEPTH.	*Daphnia hyalina.* PERIOD.					*Daphnia pulicaria.* PERIOD.				
Meters.	I.	II.	III.	IV.	Av.	I.	II.	III.	IV.	Av.
0—3...	5 37	1.7	3.4	4.1	3	.05	.08	0	0	.06
3—6...	5.09	2.9	3.17	4	3.4	.28	.5	.17	0	3
6—9...	7.68	5	3.32	4.5	4.6	3.29	6	4.75	.4	3.7
9—12..	16.42	2.1	.74	3.6	3.5	12.31	25.5	8.89	2 9	11.5
12—15..	11.11	2	6.25	0	4	37 78	3.9	4.17	0	30.7
15—18..	13.03	0	0	11	14	8.7	0	0	0	0
Av...	6.44	2.3	3.15	4.2	3.3	2.08	2	1.44	.3	1.5

THE DISTRIBUTION OF THE CRUSTACEA IN DETAIL.

Diaptomus oregonensis Lillj.

Number.—This species was by far the most numerous of the crustacea taken during July in lake Mendota, and at the same time was the species whose vertical distribution was most distinctly marked. The average total catch of *Diaptomus* for the

59 sets of observations was 4221 or about 64 per cent. of the total number of crustacea. Since the opening of the dredge was 400 square centimeters, this catch would be at the rate of over 100,000 per square meter of surface. The co-efficient of the net has not been determined, but partial observations show that it lies probably near four so that the number of *Diaptomi* per square meter of surface of the lake would average over 400,000. The maximum would be nearly 900,000 and the minimum about 200,000.

The minimum number caught in a single series of hauls was 1991, and the maximum, 8703, or a variation between four and five fold. The range of variation was, therefore, not so great as that noted by Apstein and Zacharias, who speak of a ten fold variation in the plankton. It agrees however with the numbers noted by Zacharias in lake Plön in 1894. The close correspondence in number of sucessive hauls was often very striking. As examples may be noted:

July 16.		July 19.	
9 A. M	5584	6 A. M	5478
12 M.	5988	9 A. M	5072
3 P. M.	5786	12 M.	5039

The three observations of July 16 did not agree as closely in the distribution of the numbers as in the numbers themselves. The arrangement in the three upper levels was as follows:

Depth.	9 A.M.	12 Noon.	3 P. M.
	per cent.	per cent.	per cent.
0–3 m	57.3	45.4	72.8
3–6 m	37.5	48.7	20.8
6–9 m	4.4	5.8	6.4

In the observations of July 19 the distribution is almost the same in each observation.

The greatest variations in successive hauls were:

July 27.	July 19.	July 27.
6 P. M 3759	12 Midnight..........3898	3 A. M 4021
9 P. M 7134	3 A. M 4564	6 A. M 8703
	6 A. M 5478	

The last is the only case where one catch is double the preceding one.

Averaging the total catch of the periods, we find:

Period I	3808
Period II	4253
Period III	5144
Period IV	3428

In spite of this absolute increase in numbers the percentage of *Diaptomus* to the whole number of crustacea declined, chiefly on account of the more rapid increase of *Cyclops*. In Period I *Diaptomus* constituted 79 per cent. of the crustacea; in Period II 66.3 per cent; in Period III 57.1 per cent.; in Per.od IV 53.3 per cent.

These numbers would indicate that the period of maximum number of *Diaptomus* falls in July. This conclusion is confirmed by subsequent observations. Catches made on August 24 and 25, 3 in number, gave from 1000 to 1500 *Diaptomi*. After September 18, when regular observations were resumed, very few catches passed 1000, and in October the number declined still more.

A curious fact, for which no full explanation is possible, is that the catches made by night average smaller than those by day. No cause can be assigned for this at present beyond chance. All but one of the exceptionally large catches occurred during the day, and although the smallest catch was made at 6 a. m., most of the exceptionally small ones were made at night. The night catches of *Daphnia hyalina* average somewhat larger than those of the day.

Distribution in depth.—As has already been stated, the water of the lake at the point of observation was slightly over 18 m. in depth, so that it was possible to obtain material from six levels of 3 m. each. In the lowest level, that from 15 m. to

18 m., almost no *Diaptomi* were found. The maximum number from this level was 13, and in about one-fourth of the hauls none were found. The average was 4. The 12–15 m. level contained scarcely more, having an average of 6 and a maximum of 15. Nine hauls out of fifty-five showed no result. On July 21, seven observations were made in the deeper parts of the lake at widely separated points, where dredgings could be made down to a depth of 22 m. or a little more. The same conditions were found to exist here. Below 15 m. almost no *Diaptomi* were found. The average of the 7 m., 15–22, was only about 3, with a maximum of 8. Similar observations were made on other days, with precisely the same result. It is therefore plain that the region of water below 12 m. was practically without *Diaptomi*. On the average more than 99 per cent. of the species was found in the upper 12 m. of the lake.

The 9–12 m. level contained more,— a little over 3 per cent. of the whole catch. The number for the whole time averaged 133, and varied from 2 as a minimum to 570 as a maximum. In the different periods the number in this level also varied. In Period II the average number was 50, with an average variation of 49 per observation. In Period III the average was 157, with an average variation of 97. In Period IV the average was 224, with an average variation of 175. The number of *Diaptomi* in this level seems to vary with the degree of disturbance of the lake, being smallest in protracted calm weather such as characterized Period II, and greatest in the stormy weather of Period IV. Measured in percentage of the total catch the highest number noted was 12.6 per cent., which was found at 3 a. m. of August 4.

On an average by periods from 92 to 97 per cent. of the *Diaptomi* were found permanently in the upper 9 meters of the lake during July. The maximum number found in this region was over 99 per cent., the minimum 86.5 per cent.

The vertical distribution is well differentiated in the three levels into which the upper 9 m. were divided. In the upper (0—3 m.) level was found on the average 52.8 per cent., with a maximum of 80 (J. 17, 9 p. m.) and a minimum of 31 per cent. found on two occasions (J. 27, 9 p. m.; A. 3, 9 a. m.).

The numbers vary from 984 to 4212, with an average for the whole month of 2229. The next level (3 — 6 m.) contained on the average 29.27 per cent. of *Diaptomus.* The maximum was 48.6 per cent. (J. 16, 12 m.), the minimum 16.4 (J. 17, 6 p. m.). The average number was 1257, the minimum 462, the maximum 3244. This level showed on the whole the smallest amount of variation.

The 6—9 m. level varied greatly, as would be expected, since it contains the lower part of the densely populated region. Its average content was 14 per cent. of the catch, the maximum 32.5 per cent. (J. 27, 12 midnight), the minimum 3.4 (J. 17, 6 p. m.). It is noteworthy that in the second and third periods the percentage found in this level at night was far larger than in the day, the day average in the second period being 4.8 per cent., while that at night was 17.6 per cent. In the third period the numbers were 12.2 per cent. and 22.9 per cent. respectively. In the fourth period the difference was very slight—practically nothing, and in the first the day catch was slightly larger in percentage, though almost exactly the same in numbers.

The center of population for *Diaptomus*, that is the level above which 50 per cent. of the animals are found, lay on the average just above the 3 m. level, if we assume a uniform distribution of the animals in each level. It varied from a depth of about 2.4 meters in Period II, to 3.6 m. in Period III, and 3.3 m. in Period IV. The depth seems to depend upon the degree of disturbance of the water. In calm water the crustacea aggregated nearer the surface, and had a wider distribution in stormy weather when the water was disturbed.

Diurnal distribution.—It will be seen from the accompanying tables and plates that no noteworthy difference exists between the vertical distribution of *Diaptomus* by day and by night. The averages of the observations for each period show that there was no tendency of the *Diaptomi* toward the surface by night, or sinking by day. A closer study of the detailed results serves to strengthen the conclusions drawn from the average. No single observation shows any tendency toward a vertical movement in this direction. In the middle level (3–6 m.) the day and night observations are close together—practically identical—

while there is nearly ten per cent. difference in favor of the upper level in the day and the 6–9 m. level at night. In view of the small number of observations this indication of a nocturnal descent should not be pressed, especially as the greater part of it is due to one of the four sets of observations. In Period II, when the lake was exceptionally calm, the day observations, fifteen in number, gave 68.4 per cent. in the 0–3 m. level, but only 4.84 per cent. in the 6–9 m. level. The night observations gave 51.75 per cent. and 17.6 per cent. respectively. Not only is this true, but every one of the night observations in the 6–9 m. level yielded numbers greater than any of those taken by day. One can hardly resist the conclusion that there is a tendency to the surface by day. The nights in this period were moonlight and cloudless. These facts are graphically shown in Pl. IX, fig. 2.

Even when the whole month is taken into account, there are in the 6–9 m. level only 8 of the 32 day observations which are above the average for the month, while only 4 of the 26 night observations are below the average of the month. In the 0–3 m. level the distribution on each side of the average of the month is more nearly equal, since there are in the day observations 14 below the average and 19 above it, and in the night observations 19 below and 7 above the average for the month. All of the exceptionally large catches in the upper level were made by day. There were 12 cases, a little over 20 per cent. of the total number, where more than 65 per cent. of *Diaptomus* occurred in the upper three meters. All of these were found by day. There is thus a clear indication of a rise of *Diaptomus* by day, but it is plain that the tendency is not strong and is easily overcome by wind, etc.

The observations of Period I, 5 day and 4 night, all in the early part of the night, show a slight excess in the upper level at night, — an excess of 2.2 per cent. of the whole number of *Diaptomus*. Period II shows a day excess of 7.85 per cent in the 0–3 m level, and of 10.8 per cent. by night in the 6–9 m. level. In Period IV the night shows an excess over the day of 3.54 per cent in the 0–3 m level. These numbers while not decisive of any marked movement, are conclusive against any considerable sinking of the crustacea by day.

STATISTICS OF DIAPTOMUS.

Tables H and I show the average catch, the percentile distribution, and the average for day and night for the month and for each period. The percentile relations are shown in Plate IX, the distribution by day and night in Pl. X, fig. 1.

TABLE H—*Results for the month.*

DEPTH.	Obs.	AVERAGE.		DAY.			NIGHT.		
Meters.		No.	Per cent.	Obs.	No.	Per cent.	Obs.	No.	Per cent.
0—3..........	59	2229	52.80	33	2589	56.71	26	1773	46.83
3—6..	57	1257	29.27	31	1379	30.20	26	1111	29.34
6—9..........	58	592	14.02	32	475	10.40	26	735	19.41
9—12..........	56	133	3.15	30	112	2.45	26	157	4.14
12—15..	55	6	.14	31	6	.13	24	6	.15
15—18..........	49	4	09	27	4	.08	22	4	.10
Total.. ...	......	4221	....	.....	4565	....	... ..	3786	....

TABLE I—PERIOD I—July 7-14—9 Series (5 Day, 4 Night).

DEPTH.	AVERAGE.		DAY.		NIGHT.	
Meters.	No.	Per cent.	No.	Per cent.	No.	Per cent.
0—3.......	1860	47 9	1726	47 89	2028	50.01
3—6............	1201	31.6	1174	32 57	1228	30.28
6—9....	593	15.6	591	16.39	596	14.69
9—12....	120	3.1	85	2.35	163	4.00
12—15....	18	.4	16	.44	20	.49
15—18.........	16	.4	12	33	20	.4[illegible]
Total...	3803	... .	3604	....	4055	....

PERIOD II—July 16-19—24 Series (15 Day, 9 Night).

DEPTH.	AVERAGE.		DAY.		NIGHT.	
Meters.	No.	Per cent.	No.	Per cent.	No.	Per cent.
0—3.	2675	62.9	3136	68.41	1915	51.75
3—6....	1133	26.6	1198	26.13	1024	27.69
6—9............	384	9.	222	4.84	652	17.60
9—12	53	1 2	18	.39	99	2.68
12—15...........	3	.08	4	.08	3	.08
15—18	5	.13	6	.13	5	.13
Total	4253	... .	4584	....	3698	....

PERIOD III—July 27-29—14 Series (7 Day, 7 Night).

DEPTH.	AVERAGE.		DAY.		NIGHT.	
Meters.	No.	Per cent.	No.	Per cent.	No.	Per cent.
0—3............	2271	44.16	2706	47.49	1836	39.64
3—6.	1831	35 60	2169	38.06	1544	33.36
6—9.	881	17.13	690	12.10	1060	22.90
9—12......	156	3.03	127	2.22	186	4.01
12—15...........	3	.06	5	.08	1	.02
15—18...	1	.02	1	.01	1	.02
	5143	....	5698	. . ..	4628	....

PERIOD IV—Aug. 2-4—12 Series (6 Day, 6 Night).

DEPTH.	AVERAGE.		DAY.		NIGHT.	
Meters.	No.	Per cent.	No.	Per cent.	No.	Per cent.
0—3	1560	45.51	1805	44.07	1316	47.61
3—6....	919	26.81	1178	28.76	661	23.95
6—9........... .	715	20.86	795	19.34	636	23.01
9—12....	224	6.53	307	7.49	142	5.13
12—15...........	5	.15	5	.12	5	.18
15—18...	5	.15	5	.12	5	.18
Total.. ...	3428	....	4095	....	2765	.. ..

In Table J the column headed "variation" shows the average departure of a single observation from the mean. The column headed "per cent." shows the average per cent. which the number obtained from any given level constituted of the total number caught. It is not exactly the same as that given in the preceding tables since only the complete series could be used in computing it. The next column gives the variation in per cent. of the whole number caught. Thus in Period III the catch from the 0–3 m. level was on the average 44 per cent. of the entire number with an average departure of 9 per cent., or from 35 per cent. to 53 per cent. Succeeding columns show that the range was from 74 per cent. to 31 per cent. The day and hour of maxima and minima are given to show the irregularity of distribution. The averages for the month are not given because of the increase or decrease of the number of crus tacea.

TABLE J—Statistics of Variations of *Diaptomus oregonensis* Lillj.

	Depth.	Average.				Maximum No.	Date.	Hour.	Minimum No.	Date.	Hour.	Maximum per cent.	Date.	Hour.	Minimum per cent.	Date.	Hour.
	Meters.	No.	Variation	Per ct.	Var. per cent.												
Period I.	0—3	1860	335	48	9	2676	14	8 p.	1176	9	8 p.	61	14	8 p.	29	9	8 p.
	3—6	1201	207	31.6	3	1540	13	8 p.	950	9	4 p.	38	10	4 p.	22	14	8 p.
	6—9	593	296	15.6	6	1416	9	7 p.	145	10	8 p.	35	9	7 p.	5	10	8 p.
	9—12	120	76	3.1	1.8	315	13	8 p.	22	9	12 p.	7	13	8 p.	1	10	4 p.
	12—15	18	....	.4	....	54	13	8 p.	0	9	7 p.	1	13	8 p.	0	9	7 p.
	15—18	16	....	.4	....	20	13	8 p.	0	0 11 14	9 p.	0	10 11 14	9 p.	0	10 11 14	9 p.
		3808	521			4568	11	9 p.	2800	10	8 p.						
Period II.	0—3	2675	863	62	11	4212	16	3 p.	1008	16	9 p.	80	17	6 p.	36	16	9 p.
	3—6	1133	326	27	6	2916	16	12 p.	588	18	6 p.	48	16	9 p.	16	19	3 a.
	6—9	384	205	10	.6	1164	19	3 a.	93	17	9 a.	26	19	3 a.	2	19	12 p.
	9—12	53*	49*	1.2	....	293	19	3 a.	2	17	12 a	8	19	12 a.	.05	17	12 a.
	12—15	3	....	.08	....	14	19	6 a.	0	17 18 18	12 a. 12 p. 3 p.	26	19	6 a.	0	17 18	12 a. 12&3 p.
	15—18	5	....	.13	....	13	18 19	12 a. 9 a.	0	several		41	18	12 a.	0	several	
		4253	830			5478	19	6 a.	2452	18	3 a.						

* Omitting 2 observations, 25 ± 16.

TABLE J—Continued.

	DEPTH. Meters.	AVERAGE. No.	Variation	Per ct.	Var. per cent.	Maximum No.	Date.	Hour.	Minimum No.	Date.	Hour.	Maximum per cent.	Date.	Hour.	Minimum per cent.	Date.	Hour.
PERIOD III.	0—3	2271	484	44	9	3420	27	9 a.	1278	29	12 a.	74	27	9 a.	31	27	9 p.
	3—6	1831	399	36	8	3486	28	12 p.	918	27	9 a.	60	28	12 p.	20	27	9 a.
	6—9	881	360	17	7	1764	27	6 a.	126	27	6 p.	27	28	7 p.	4	27	6 p.
	9—12	156	97	3	....	379	27	3 a.	12	28	9 p.	10	29	12 a.	.27	28	9 p.
	12—15	3	....	.06	....	13	27	6 a.	0	27 28	9 p. 3 a.	.14	27 28	6 a.	0	27 28	9 p. 3 a.
	15—18	1	....	.02	....	2	......	....	0	......	....	.06	29	12 a.	0	......	....
	....	5143	1199	....	....	8703	27	6 a.	3348	29	12 a.	....	......	....	....	......	....
PERIOD IV.	0—3	1560	458	45.5	6	3480	2	9 a.	666	4	6 a.	59	1	9 p.	31	3	9 a.
	3—6	919	288	26.8	7	1536	3	9 a.	414	4	3 a.	46	4	6 a.	17	4	3 a.
	6—9	715	279	20.8	5	1380	3	9 a.	105	1	9 p.	27	4	12 a.	4	1	9 p.
	9—12	224	175	6.5	4	570	3	9 a.	2	2	3 a.	18	1	9 p.	.10	2	3 a.
	12—15	5	....	.15	....	19	1	9 p.	1	4	9 a.	.72	1	9 p.	.04	4	9 a.
	15—18	5	....	.15	....	11	1	9 p.	2	4	12 a.	.41	1 4	9 p. 9 a.	.06	4	12 a.
	....	3428	1136	....	....	6201	2	9 a.	1991	4	6 a.	....	......	....	....	......	....

Cyclops leuckarti Sars., *Cyclops pulchellus* Koch., and *Cyclops brevispinosus* Herrick.

The three species of *Cyclops* named above stood second in number among the pelagic crustacea of July, averaging 30.5 per cent. for the entire month and increasing from 13 per cent. in Period I to 40.5 per cent. in Period II. They were counted together, as no considerable difference in their vertical distribution appeared, and as it was difficult or impossible to distinguish the species from each other under a low power of the microscope. Observations made later in the year seem to show that *Cyclops leuckarti* was more abundant at greater depths than was *Cyclops brevispinosus*, but no sufficient number of observations have been made to warrant a positive opinion. In all cases *Cyclops brevispinosus* was the most abundant, and ordinarily there were several times as many of that species as of the others.

Number of Cyclops.—The average number of *Cyclops* caught in each series of hauls for the entire month was 2010. The area of the dredge was $\frac{1}{25}$ square meter, and its co-efficient probably about four, indicating a number of *Cyclops* of 200,000 per square meter of surface. The greatest number obtained was 5460 (J. 27; 6 a. m.). The smallest number was 176 (J. 10; 8 p. m.). The variations in successive hauls were somewhat smaller than was the case in *Diaptomus*. The greatest variations observed in successive catches were:

July 27, 3 A. M	2945
July 27, 6 A. M	5460
July 27, 9 A. M	3036

This exceptionally large catch of *Cyclops* coincided with a similar large number of *Diaptomus*, and the number found was unusually large at all of the 4 upper levels (0–12 m.). The least variation in number was obtained in 4 consecutive catches on July 18, from noon to 9 p. m., the numbers being 1384, 1395, 1381, and 1397, respectively. It may, however, be added that in these 4 catches the distribution in the different levels was quite different. The number caught in the 0–3 m level ranged from 498 to 906; in the 3–6 m. level, from 222 to 540; in the 6–9 m. level, from 140 to 336. Thus while the total number of crustacea remained the same the density in different portions of the water was quite different.

The average number of *Cyclops* caught in the different periods greatly increases in the later periods over the earlier ones. The catch was as follows:

	Average.	Minimum.	Maximum
Period I	626	176	1006
Period II	1611	836	3087
Period III	3147	1800	5460
Period IV	2531	1336	4683

It is thus evident that the number of *Cyclops* was increasing during the month of July. The percentage of *Cyclops* in the total number of crustacea caught during the month was 30.5. In Period I, *Cyclops* averaged 13 per cent. of the total crustacea; in Period II, 26.2 per cent.; in Period III, 27.4, and in Period IV, 40.5. This conclusion is confirmed by observations made later in the year. Three catches made in the latter part of August gave an average of more than 3000, and a maximum of more than 6000 *Cyclops* was reached in the latter part of September and the first part of October. Observations made in the upper levels of the water on the 23d of July, for the purpose of testing the horizontal distribution of the crustacea, showed a large increase of *Cyclops* above the observations of the 19th, indicating apparently the development of a new generation of *Cyclops* at that time. The falling off in number of Period IV, as compared with Period III, is probably not significant of any real change in the average number of the species.

Vertical distribution.—In general the distribution of *Cyclops* agreed closely with that of *Diaptomus*, as may be seen on the accompanying plates and tables. The percentage of *Cyclops* in the upper level is not so great as that of *Diaptomus*, and the number found in the lower levels is somewhat greater. Yet the distribution of the two species agrees quite closely, as Pl. IX shows at once. The upper 9 m. of the lake contain on an average from 78 per cent. to 93 per cent. of the total number.

The minimum percentage in the upper 9 m. was 67.6 per cent. (J. 10, 8 p. m.) and the maximum 99.33 per cent. (A. 2, 3 a. m.). The catch from the lowest level, that from 15 m. to 18 m., contained on an average two specimens of *Cyclops*, with a maximum of 10, and a minimum of 0, which last result was found in about a quarter of the observations. The next level, 12–15 m., contained on the average 28 *Cyclops*, with a maximum of 79, and a minimum of 1. *Diaptomus* had in this level a maximum of 13. The average percentage of this level was about 1.4 per cent. of the entire number of *Cyclops*. The 9–12 m. level contained on an average 176 specimens, with a maximum of 723 and a minimum of 1. The average percentage in this level was 8.77 per cent. For the entire month, therefore, just about 90 per cent. of the *Cyclops* were found in the upper 9 meters. This distribution of *Cyclops* was true for the deeper parts of the lake, as was also found in the case of *Diaptomus*. In observations made on the 21st of July, the number of *Cyclops* found between the depths of 15 and 22 m. ranged from 0 to 9, with an average of about 2.

In the upper 9 meters of the lake the distribution was much as for *Diaptomus*. In the 0–3 m. level the average number was 683, with a maximum of 2340 (A. 4, 6 a. m.) and a minimum of 30 (J. 10, 8 p. m.). The average percentage of the total catch found in the upper level was 43, with a maximum of 66 per cent. (J. 18, 6 p. m.) and a minimum of 17 per cent. (J. 10, 8 p. m.). In the 3–6 m. level the average number was 612, with a maximum of 1944 (J. 28, 3 a. m.) and a minimum of 60 (J. 10, 8 p. m.). The average percentage was 30.44, with a maximum of 59 per cent. (J. 28, 12 p. m.) and a minimum of 16 per cent. (J. 14, 8 p. m., 18, 6 p. m.). The average number for the 6–9 m. level was 329 with a maximum of 1146 (A. 2, 6 a. m.) and a minimum of 29 (J. 10, 8 p. m.) The average per centage was 16.35, the maximum was 46 per cent. (J. 9, 7 p. m.) and the minimum was 5 per cent. (J. 28, 12 p. m.).

Diurnal distribution.—In general, *Cyclops* shows the same facts of distribution by day and night as does *Diaptomus*, but the differences in distribution are not quite as plainly marked as in that genus. If we compare the results for the entire month, we find that the upper level contained somewhat more *Cyclops* by day than by night, the percentage found in the 0–3 m. level being 44.75 per cent. by day and 39.64 per cent. by night. The percentage found in the 3–6 m. level was almost the same in the two cases, being 30.81 per cent. by day and 30.05 per cent. by night. The 6–9 m. level showed, of course, a smaller number by day, 15.08 per cent., and a larger number at night, 18.55 per cent. These numbers are, however, not large enough to show decisively any migration of the crustacea. In the different periods much the same differences in diurnal distribution are noticed as for *Diaptomus*. In Period I, the number found by night in the 0–3 m. level is slightly greater than by day, but the difference is so small as to come well within the limits of error. In Period II, the day observations show a very considerable excess, having 52 per cent. of the total catch, while the night observations show only 44.5 per cent. A difference still greater was found in Period III, where the day observations gave 42.75 per cent. in the upper level, and 33.09 per cent. by night. This last difference is greater than the difference of *Diaptomus* for the same period. In Period IV, the night catches show a slight excess over the day catches, the upper level containing 39.44 per cent. by day and 43.7 per cent. by night. It is clear that here are no indications of a descent of the crustacea by day and also that they do not indicate an ascent by day as plainly as does *Diaptomus*. If there is any diurnal migration of the crustacea, *Cyclops* would probably not show it as distinctly as *Diaptomus*, since its power of locomotion are so much smaller. In Period I, while the number in the 0–3 m. level at night was somewhat larger than that by day, the number in the 9–12 m. level was also considerably larger by night than by day. The number of specimens and the number of observations in this period were both so small that chance would play a considerable part in the apparent distribution of the crustacea, and the night observations were all made earlier than 10 p. m.

Center of distribution.—The level above and below which lay 50 per cent. of the *Cyclops* varied somewhat during the month. In Period I it lay at 4.54 m. below the surface. In Period II it was at 3 m. almost exactly. In Periods III and IV it was between 3.9 m. and 4 m.

Horizontal distribution of Diaptomus and Cyclops.— On July 23 and 31 two series of observations were taken in the 0—3 m. level at widely separated parts of the lake, in order to get some idea of the horizontal distribution of the crustacea. The number of *Cyclops* and *Diaptomus* in these catches was determined, with the following result:

July 23.

Diaptomus...........................	3600	4210	3280	3320	3540	2620
Cyclops.............................	1060	2620	2550	1760	3690	2330

July 31.

Diaptomus...............................	2320	1750	1860	1190	3870
Cyclops.................................	1300	1490	1110	900	1010

These numbers vary in much the same way as do the successive observations made at the buoy both as to actual numbers and in the relative numbers of the two genera, and it is therefore probable that the place selected for our observations fairly represents the average conditions of the lake. Two successive observations were taken at the buoy at this time with the following result:

Diaptomus..	2400	2440
Cyclops..	1256	1250

These results show an agreement quite as close as could be expected. The numbers are larger than the average, especially those of *Cyclops*.

STATISTICS OF CYCLOPS.

TABLE K—*The average catch and the percentile distribution of Cyclops by day and night, for the month.*

Depth.	Average.		Day.		Night.	
Meters.	No.	Per cent.	No.	Per cent.	No.	Per cent.
0—3	863	42.96	997	44.75	682	39.64
3—6	612	30.44	686	30.81	517	30.05
6—9	329	16.35	336	15.08	319	18.55
9—12	176	8.77	181	8.11	171	9.92
12—15	28	1.38	26	1.17	30	1.74
15—18	2	.10	2	.08	2	.13
Total	2010	....	2228	....	1721	....

The facts of this table are represented in Pl. X, fig. 2.

TABLE L—*Average, and day and night distribution by Periods.*

PERIOD I.—July 7–14.

Depth.	Average.		Day.		Night.	
Meters.	No.	Per cent.	No.	Per cent.	No.	Per cent.
0—3	234	37.38	233	36.24	236	38.50
3—6	154	24.60	178	27.68	130	21.21
6—9	137	21.88	157	24.42	111	18.11
9—12	71	11.34	60	9.33	85	13.87
12—15	28	4.47	10	1.56	50	8.15
15—18	2	.32	5	.77	1	.16
Total	626	....	643	....	613	....

PERIOD II.—July 16–19.

DEPTH.	AVERAGE.		DAY.		NIGHT.	
Meters.	No.	Per cent.	No.	Per cent.	No.	Per cent.
0–3	798	49.54	889	51.99	647	44.56
3–6............	463	28.74	485	28.36	427	29.41
6–9............	201	12.48	185	10.82	227	15.63
9–12........	114	7.07	123	7.19	102	7.02
12–15.........	34	2.11	26	1.52	48	3.30
15–18...........	1	.06	2	.12	1	.07
Total	1611	....	1710	....	1452	....

PERIOD III.—July 27–29

DEPTH.	AVERAGE.		DAY.		NIGHT	
Meters.	No.	Per cent.	No.	Per cent.	No.	Per cent.
0–3............	1229	39.18	1480	42.75	895	33.09
3–6.	1059	33.76	1201	34.69	893	33.01
6–9...	475	15.14	414	11 96	545	20.15
9–12	332	10.58	311	8.98	359	13.27
12–15.......	40	1.28	55	1.59	9	.33
15–18...........	2	.06	1	.03	4	.15
Total.......	3137	....	3462	....	2705	....

PERIOD IV.—August 2–4.

DEPTH.	AVERAGE.		DAY.		NIGHT.	
Meters.	No.	Per cent.	No.	Per cent.	No.	Per cent.
0–3............	1038	41.01	1259	39.42	817	43.69
3–6.......... .	730	28 84	927	29.02	533	28.50
6–9.	570	22.52	770	24.11	370	19.79
9–12	187	7.39	232	7.26	143	7.65
12–15...........	3	.118	3	.09	4	.21
15–18.......... .	3	.118	3	.09	3	.16
Total........	2531	....	3194	....	1870	....

TABLE M—CYCLOPS, *Statistics of Variation by Periods.*

	DEPTH.	AVERAGE.				Maximum No.	Date.	Hour.	Minimum No.	Date.	Hour.	Maximum Per cent.	Date.	Hour.	Minimum Per cent.	Date.	Hour.
	Meters.	No.	Variation	Per cent.	Var. Per cent.												
PERIOD I.	0—3	234	98	37	9	552	14	8 p.	30	10	8 p.	55	14	8 p.	17	10	8 p.
	3—6	154	42	25	4	276	10	4 p.	60	10	8 p.	34	10	8 p.	16	14	8 p.
	6—9	137	41	22	7	258	9	7 p.	29	10	8 p.	46	9	7 p.	13	14	8 p.
	9—12	71	26	11	7	130	7	4 p.	15	9	12 p.	32	10	8 p.	3	9	4 p.
	12—15	28	16	5	3	118	13	8 p.	0	9	7 p.	15	13	8 p.	0	9	7 p.
	15—18	2	2	0	....	5	10	4 p.	0	10	8 p.	1	10	4 p.	0	10	8 p.
										11	9 p.					11	9 p.
										14	8 p.					14	8 p.
	....	626	171	....	....	1006	14	8 p.	176			....	......	....	....	......	....
PERIOD II.	0—3	798	279	50	7	1860	19	6 a.	354	17	12 a.	66	18	6 p	33	17	12 p.
	3-6	463	92	29	5	810	19	6 a.	222	18	6 a.	3	17	12 a.	16	18	6 p.
	6—9	201	47	12	3	336	18	9 p.	74	17	6 a.	24	18	9 p.	8	19	6 a.
	9—12	114	25	7	2	165	16	6 p.	1	17	12 a.	14	17	6 a.	.10	17	12 a.
	12—15	34	16	2	1	102	19	12 a.	3	17	9 p.	6	16	9 p.	.23	17	9 p.
	15—18	1	1	0	....	7	19	9 a.	0	......	....	0	18	12 a.	0	......	....
	....	1611	358	....	....	3087	19	6 a.	836	17	6 a.	......	......	....	....	......	....

TABLE M—*Statistics of Cyclops*—Continued.

	DEPTH.	AVERAGE.				Maximum No.	Date.	Hour.	Minimum No.	Date.	Hour.	Maximum Per cent	Date.	Hour.	Minimum Per Cent	Date.	Hour.
	Meters	No	Variation	Per cent	Var. Per cent.												
PERIOD III.	0--3	1229	288	39	8	2082	27	6 a.	498	29	12 a.	58	27	6 p.	25	27	9 p.
	3--6	1059	342	34	8	1944	27	9 p.	528	28	3 a.	59	28	12 p.	22	27	6 p.
	6--9	475	176	15	5	1068	27	12 a.	152	28	12 p.	30	29	12 a.	5	28	12 p.
	9--12	332	134	11	3	723	27	3 a.	65	28	12 p.	14	28	9 p.	2	28	12 p.
										28	3 a.						
	12--15	40	48	1	1	257	28	3 p.	3	29	12 a.	3	27	6 p.	14	28	3 a.
	15--18	2	2	0	....	10	27	12 a.	0	......	....	......	......	......	....	......	....
	....	3137	634	....	....	5460	27	6 a.	1800	29	12 a.	......	......	......	....	......	....
PERIOD IV.	0—3	1038	340	41	7	2340	2	9 a.	426	4	6 a.	57	4	9 a.	25	4	6 a.
	3 -6	730	193	29	5	1302	2	6 a.	360	1	9 p.	47	4	6 a.	18	1	9 p.
	6- 9	570	231	23	5	1146	2	6 a.	140	1	9 p	33	4	12 a.	7	1	9 p.
	9--12	187	111	7	4	492	3	9 a.	10	2	3 a.	20	1	9 p.	.45	2	3 a.
										2	6 a.						
	12--15	3	1	0	.. ..	7	4	3 a.	1	3	9 p.	1	4	3 a.	.02	2	6 a.
	15—18	3	1	0	....	7	1	6 p.	0	2	12 a.	0	4	3 a.	0	2	12 a.
	. ...	2531	721	....	... .	4683	2	9 a.	1336		3 a	....	......	......	....	......	....

Daphnia hyalina Leydig.

This species was present in far smaller numbers than either of those which have been already described. The average number taken was 222 for the whole series of observations, or about 3.3 per cent. of all the crustacea. The number varied from 42 as a minimum to 541 as a maximum. In the different periods the average varied quite irregularly. The average number was as follows: Period I, 312; Period II, 144; Period III, 274; Period IV, 260. It is probable that the large number included in Period I depended to some extent upon chance. The observations made later in the year show conclusively that in July we have the beginning of the main development of *D. hyalina.* In August (3 observations) the numbers taken average 1000 or more, and in September and October a maximum of over 8000 was reached. The numbers assigned to *D. hyalina* are probably not as accurate as those for *Cyclops* and *Diaptomus,* since the larger number of the former species was contained in the upper levels of the lake, where there were enormous numbers of *Cyclops* and *Diaptomus.* The number counted, therefore, depended somewhat upon chance. At the same time the numbers of *D. hyalina* do not vary more widely or more irregularly than do the numbers of *D. pulicaria,* of which species by far the larger number was found in the lower levels of the lake, where comparatively few crustacea were present, and where a larger portion were counted than in the upper levels.

Vertical distribution.—Very little need be said of the vertical distribution of *D. hyalina,* since it agrees very closely with that of *Cyclops* and *Diaptomus,* more closely with the former. A glance at the curves of Pl. VIII, where the percentile distribution of all the crustacea is platted, will show *Cyclops* and *D. hyalina* agree in percentile distribution almost exactly. On the average about 42 per cent. was found in the 0–3 level, 30 per cent. in the 3–6 m. level, and 21 per cent. in the 6–9 m. level.

Thus the upper 9 m. of the lake contain about 93 per cent. of the total catch. As a maximum there were found in these levels 100 per cent., and as a minimum 47.16 per cent.

The number of *Daphnia hyalina* fell off greatly below 9 m., the average catch in the 9–12 m. level being 13 (5.9 per cent.);

2 in the 12–15 m. level, and one in the 15–18 m. level. In these deeper levels, however, a larger per cent. of the total number of *Daphnia* was obtained than was the case with the more numerous *Diaptomus* and *Cyclops*.

Diurnal distribution.—Very little need be said on this subject beyond a reference to the tables. In the first three periods the actual number obtained at night was larger than that caught by day. In Period III especially, the numbers differ considerably, being 210 by day as an average and 329 by night. The numbers are, however, so small that chance has probably determined this distribution. In the percentile distribution little difference appears between day and night. In Period I there is a slight excess in the 0–3 level at night. In all other periods the upper level is smaller at night than during the day. There is no positive indication of either ascent or descent of this species.

The center of distribution ranged from 3.5 m. below the surface in Period IV to 4.5 m. in Period I. It averaged about 4.1 m. for the month.

STATISTICS of D. HYALINA.

TABLE N—*Vertical distribution day and night. Average of month.*

DEPTH.		AVERAGE.			DAY.			NIGHT.	
Meters.	Obs.	No.	Per cent.	Obs.	No.	Per cent.	Obs.	No.	Per cent.
0–3	59	94	42 34	33	88	44	26	103	40.7
3–6	57	66	29.72	31	61	30.5	26	73	28.8
6–9	58	46	20.72	32	41	20 5	26	53	20.9
9–12	56	13	5.85	30	9	4.5	23	20	7.9
12–15	54	2	.90	31	1	.5	24	3	1.18
15–18	50	1	.45	27	0	......	23	1	.39
Total	......	222	......	......	200	......	......	253	......

The facts of this table are represented in Pl. X, fig. 3.

Table O—*Vertical distribution by periods.*

Period I.—July 7–14.

Depth	Average.		Day.		Night.	
Meters.	No.	Per cent.	No.	Per cent.	No.	Per cent.
0—3	119	38.14	105	36.4	137	40.0
3—6	73	23.4	73	25.3	73	21.3
6—9	63	20.19	70	24.3	56	16.4
9—12	44	14.10	33	11.5	58	17
12—15	10	3.20	4	1.4	15	4.4
15—18	3	97	3	1.0	3	.9
Total	312	....	288	....	342	....

Period II.—July 16–19.

Depth.	Average.		Day.		Night.	
Meters.	No.	Per cent.	No.	Per cent.	No.	Per cent.
0—3	61	42.0	62	44.6	58	38 3
3—6	47	32.4	50	36	42	28.0
6—9	31	21.4	24	17.3	42	28.0
9—12	5	3.5	3	2.2	7	4.7
12—15	1	.7	0	0	1	.7
15—18	0	0	0	0	0	0
Total	145	....	139	....	150	....

Period III.—July 27–29.

Depths.	Average.		Day.		Night.	
Meters.	No.	Per cent.	No.	Per cent.	No.	Per cent.
0—3	123	44.9	101	48.09	146	44.4
3—6	95	34.7	68	32.4	118	35.9
6—9	49	17.9	36	17.1	61	18.5
9—12	4	1.5	5	2.4	3	.9
12—15	3	1.1	0	0	0	0
15—18	0	0	0	0	1	.3
Total	274	....	210	....	329	....

PERIOD IV.—Aug. 1-4.

DEPTHS.	AVERAGE.		DAY.		NIGHT.	
Meters.	No.	Per cent.	No.	Per cent.	No.	Per cent.
0—3	113	43.5	124	45.7	98	39.7
3—6	69	26.5	73	27	66	26.7
6—9	61	23.5	65	24	58	23.5
9—12	16	6.15	8	3	24	9.7
12—15	0	0	0	0	0	0
5—18	1	.39	1	.3	1	.4
Total	260	......	271	......	247	......

Daphnia pulex, var. *pulicaria* Forbes.

This species of *Daphnia* is very closely related to the European form *D. schoedleri* Sars, and is possibly identical with it. In general appearance it closely agrees with *D. pulex*, as also in the armature of the post-abdomen, and in the teeth of the caudal claw. The chief difference lies in the transparency of the animals. Specimens belonging apparently to this species are found near Madison in temporary pools, and in such situations, while not showing the yellow tint characteristic of *D. pulex* they become opaque, having a grayish white color. In the open lake, however, they are nearly as transparent as *D. hyalina*.

This species was the smallest in number of the forms which regularly appeared in our dredging. The average number for the whole period was 103, with a maximum of 279 (J. 19, 9 a. m.) and a minimum of 1 (A. 2, 3 a. m.) and 0 (3 obs., Aug. 2 and 3). The number varied greatly in the different periods, the agerage in Period I being 101; in Period II, 135; in Period III, 125, and in Period IV, 18. These numbers indicate the disappearance of the species early in August, and this conclusion is confirmed by the fact that in later observations only single individuals have appeared. The latest date at which a single specimen occurred was December 1, but no other individuals had been found in the preceding two months or more. *D. pulicaria* averaged about 1.5 per cent. of the total number of crustacea caught the percentage ranging from 2.00 in Period II to .3 per cent. in Period IV.

The actual numbers obtained by day and night were almost the same. In Period I the day averaged only 75, against 132 at night. In Period II the day and night were almost identical, being 139 and 129 respectively. In Period III the day catch averaged 128, that at night, 120. In Period IV, day 15 and night 21.

Vertical distribution.—In spite of the small number of the catch the vertical distribution of *D. pulicaria* was very distinctly marked. In general the species was almost entirely lacking in the upper 6 m. of the lake, and equally wanting wanting below the depth of 15 m. Taking the average of the month, more than 93 per cent. of the species was found between 6 m. and 15 m. and over 75 per cent. between 6 m. and 12 m. In the 0–3 m. level the average number found for the month was 2, the maximum number 18 and the minimum 0, which occurred in a majority of the observations. No great confidence can be placed in the accuracy of this number. It will be remembered that the total number of crustacea in this level was very great, averaging more than 3000, and it very rarely happened that more than one individual of this species appeared in the quantity counted. This of course was multiplied by the factor 6, and thus would give a minimum of 6 specimens in the upper level if any were present. It must often have happened that catches containing a few members of the species are marked with 0, because no individual happened to get into that portion of the catch which was counted. Making all allowance for this inaccuracy it is, however, plain that the number of specimens in the upper 3 m. is extremely small. The largest average was found in Period II, when, it will be remembered, the weather was very calm, and the nights were lighted by a full moon. In that period an average of 3 was obtained, or a little over .08 per cent. of the total catch from that level

In the 3–6 m. level the number was somewhat greater, averaging 6 for the whole series of observations, or about 5.8 per cent. of the total number of the species, with a maximum of 30 and a minimum of 0. The same observation regarding inaccuracy of the counting is to be made here as was made in regard to the 0–3 m. level.

With the 6–9 m. level came a great increase in number. The average for the whole period was 37 per observation. The maximum was 196, the minimum 0. In Period I the average number was 27; in Period II, 39; in Period III, 70, while in Period IV an average of only 5 was obtained. During the whole month *D. pulicaria* averaged nearly 4 per cent. of the catch in this level, the percentage ranging from .4 per cent. in Period IV to 6 per cent. in Period II. An average of 36 per cent. of all the individuals of this species was obtained from this level, the percentage ranging from 56 per cent. in Period III to 27 per cent in Period I.

An even larger number was obtained from the 9–12 m. level, the average for the month being 42, with a maximum of 138 and a minimum of 0. The average numbers in the successive periods were 33, 59, 48, and 13, respectively. Since the number of *Cyclops* and of *Diaptomus* was very much smaller in this level than in the upper levels of the lake, *D. pulicaria* constitutes a considerable fraction of the catch made at this level. The percentage is about 3 per cent. in Period IV, where the average number of *Diaptomus* and *Cyclops* was largest on account of the disturbed condition of the water, and where an average of only 13 specimens of *D. pulicaria* were caught. In Period II, 25.5 per cent. of the total catch from this level consisted of *D. pulicaria.* The tables show that in this period very few specimens of *Diaptomus* and *Cyclops* were found at this level. and also that the greatest absolute number of *D. pulicaria* was found there. In Periods I and III the percentage was between 9 and 10. *D. pulicaria* constituted 11.5 per cent. of the average catch from this level for the entire month.

In the 12–15 m. level a considerable number of this species was found, although the number declined very greatly from the 9–12 m. level. Probably the greater portion of those credited to the 12–15 m. level were obtained from the upper part, since almost no specimens were found below 15 m. The average number for the month was 16, with a maximum of 152 and a minimum of 0. This maximum is more than twice as large as any other catch from this level. Almost all of the specimens obtained in this level were caught in the first two periods, where they averaged 34 and 25 respectively, while in Period III, an average of only two was obtained, and none at all in Period IV. The decline in numbers of *Diaptomus* and *Cyclops* in this level makes the absolute small number of *D. pulicaria* constitute an important percentage of the catch from this level. In Period I, 17.6 per cent. of the catch belonged to this species, and in Period II, 39 per cent. For the second period *Cyclops* with 34 specimens on the average was the only species which exceeded *D. pulicaria* in absolute number. In the third and fourth periods the number is so small as not to constitute any considerable fraction of the total catch.

In the 15–18 m. level only 18 specimens were obtained throughout the entire month. Since all the catch from this level was counted, unquestionably all the specimens of *D. pulicaria* have been enumerated. It is highly improbable that the species visits the deeper part of the lake in considerable numbers. No specimens in the control observations were obtained below 15 m. to a depth of 22 m.

Diurnal distribution.—The number of *D. pulicaria* is so small that little need be said regarding its diurnal distribution. In general the species agrees with all the others which have been studied, in showing no constant variation between day and night. If we average the catches for the total period there is a slight tendency of the species toward the bottom by night, since in the day catches only 11.5 per cent. of the total catch was found in the 12–15 m. level, while nearly 22 per cent. of the entire catch was found in the same level at night. The absolute numbers, however, are so small and the quantity of the catch so dependent upon chance, that no conclusion should be drawn from these results. In general, we may say that almost the entire number of this species occupied the space between 6 and 15 metres both by day and night.

No reason can be assigned at present for this singular vertical distribution. It will be observed that the distribution of this species is in striking contrast to that of *D hyalina* from which it did not differ greatly in absolute number. While nearly 75 per cent. of *D. hyalina* were found on the average above the 6 m. level, 93 per cent of *D. pulicaria* were found below the same line. The 6–9 m. level was common to the two species, and they appear there in not very dissimilar numbers, the average from this level being 46 for *D. hyalina*, and 37 for *D. pulicaria*. It is possible that *D. pulicaria* develops in the spring, while the water of the lake is still cold, and remains in that cooler water as the temperature of the lake rises. However, the temperature can hardly be the sole factor in determining its distribution, or we should expect the species to be more abundant in the still deeper and cooler parts of the lake.

The center of distribution for *D. pulicaria* varied from 8.46 m. in Period IV to 10.7 m. in Period I. In Periods II and III it was 9.83 m. and 10.15 m. respectively. Thus the center for those periods when any considerable number was present lay at about 10 m. below the surface, assuming the distribution of the animals to be uniform in each of the 3 m. levels.

STATISTICS OF D. PULICARIA.

TABLE P—*Vertical distribution. Day and night. Average for month.*

DEPTH.		AVERAGE.		DAY.			NIGHT.		
Meters.	Obs.	No.	Per cent.	Obs.	No.	Per cent.	Obs.	No.	Per cent.
0—3....	59	2	1.9	34	2	1.9	25	1	1.0
3—6..........	57	6	5.8	32	5	4.8	25	6	5.9
6—9....... ...	58	37	35.9	33	39	37.5	25	34	33.7
9—12	57	42	40.8	32	46	44.2	25	38	37.6
12—15.........	56	16	15.6	33	12	11.5	23	22	21.8
15—18.........	55	0	0	30	0	0	25	0	0
Total	......	103	....	......	104	....	......	101	....

The average percentile distribution of *D. pulicaria* is shown in Pl. IX.

TABLE Q— *Vertical distribution by periods.*

PERIOD I—July 7-14.

DEPTH.	AVERAGE.		DAY.		NIGHT.	
Meters.	No.	Per cent.	No.	Per cent.	No.	Per cent.
0—3............	1	.99	2	2.67	0	0
3—6............	4	3.96	6	8.00	2	1.51
6—9.	27	26.7	28	37.3	26	19.7
9—12...........	33	32.7	26	34.7	41	31.06
12—15...........	34	33.7	12	16.0	61	46.2
15—18..	2	1.99	1	1.3	2	1.51
Total........	101	. . ..	75	....	132	....

PERIOD II—July 16-19.

DEPTHS.	AVERAGE.		DAY.		NIGHT.	
Meters.	No.	Per cent.	No.	Per cent.	No.	Per cent.
0—3...........	3	2.22	4	2.9	3	2.3
3—6..	9	6.7	7	5.0	13	10.08
6—9.............	39	28.9	41	29 5	34	26.4
9—12....	59	43.7	65	46.8	50	38.8
12—15	25	18.5	22	15.8	29	22.5
15—18	0	0	0	0	0	0
Total.........	135	....	139	....	129	....

PERIOD III—July 27-29.

DEPTH.	AVERAGE.		DAY.		NIGHT.	
Meters.	No.	Per cent.	No.	Per cent.	No.	Per cent.
0—3....	0	0.	0	0.	1	.83
3—6......	5	4.0	3	2.34	7	5.84
6—9............	70	56.0	68	53.13	72	60.00
9—12............	48	38.4	55	42.97	40	33.3
12—15...........	2	1.6	2	1.56	0	0.
15—18......	0	0	0	0.	0	0.
Total	125	....	128	....	120	....

PERIOD IV—August 1-4.

DEPTHS.	AVERAGE.		DAY.		NIGHT.	
Meters.	No.	Per cent.	No.	Per cent.	No.	Per cent.
0—3............	0	0.0	0	0.0	0	0.0
3—6............	0	0.0	0	0.0	0	0.0
6—9............	5	27.8	7	46.7	3	14.3
9—12............	13	72.2	8	53.3	18	85.7
12—15............	0	0.0	0	0.0	0	0.0
15—18............	0	0.0	0	0.0	0	0.0
Total......	18	....	....	....	21	....

OTHER PELAGIC ARTHROPODA.

Four animals, other than those already described, were obtained in considerable numbers during our observations, although they were not numerous enough nor present with sufficient regularity to give any clear conclusions as to their vertical distribution. The first of these is *Diaphanosoma brachyurum* Fisch. Scattering individuals of this species were obtained in Period I, the total number being 16, with an average of less than 2 for each series of observations. In Period II, 109 were taken, giving an average of about 4 to an observation. In Period III, 276, or an average of nearly 20; and in Period IV, 1135 were obtained, giving an average of nearly 100 for each set of observations. It is obvious that we have during July the beginning of the story of the development of *Diaphanosoma*, and observations made later in the year confirm this idea. In August three observations showed a catch of 400 to 600, and in September the number of *Diaphanosoma* rose to a maximum of more than 1000 per series of observations, and the species disappeared in October. The vertical distribution of this species follows very closely that of *Cyclops* and *Diaptomus*.

Leptodora hyalina Lillj. was constantly present in our collections, but in very varying numbers. As stated in the account of our methods, all of the individuals belonging to this species were counted, and from all of the observations a total of 347 individuals was obtained. This would be an average of about 6 specimens to each series of observations, but the number was very irregularly distributed. The irregularity, however, was of a somewhat uniform nature, comparatively large numbers being obtained at occasional intervals throughout the month. The largest individual numbers were taken in the upper level. One of these catches yielded as many as 25 individuals, another 21, and a third 15. The lower levels were practically without this form. All of the single catches containing more than 6 specimens in the upper levels were made at night. This would indicate a rise of *Leptodora* by night, were it not for the fact that none of the day catches show any corresponding numbers of the species at greater depths.

The larva of a species of *Chironomus* was found in very small numbers, the total number counted in the 59 sets of observations being only 105. The largest individual catches were obtained in the upper 6 m. The largest number caught was 12 on July 27.

The larva of a species of *Corethra* was the most abundant animal except those which have been regularly tabulated. Nearly 2000 were obtained during all our observations, an average of 33 animals per series. The average number per series in Period I was about 13; in Period II, 18; in Period III, 80, and in Period IV, 22. An enormous number of this species was obtained in a few catches on the 28th of July, where the larvæ were found in comparatively large numbers throughout the entire vertical distance. The largest number was 148, 85 of which came from the 6–9 m. level. The numbers taken are too small and too irregularly distributed to say anything definite regarding the vertical distribution, beyond the general fact that a large number of this species proportionately was found in the lower levels of the lake. It was not at all uncommon for the dredge to contain perhaps a dozen crustacea from the lower levels, and one or two specimens of *Corethra.*

Daphnia Kahlbergiensis, var. *retrocurva*, Forbes, our representative of the section *Hyalodaphnia*, was found very sparingly. Only two or three specimens were seen during the entire month.

Chydorus sphaericus O. F. M., one of the most abundant of plankton crustacea in the autumn, did not appear in July in numbers sufficient to count. A few individuals were present, but were not studied.

One or two specimens of *Pleuroxus trigonellus*, O. F. M., were caught—doubtless stragglers from the bottom. A single *Sida crystallina* was obtained.

PLANTS.

No definite work was done upon the plants of the lake, although the water abounded in vegetation throughout the entire time of observations. The predominant alga was a species of *Lyngbya*. Large numbers of *Anabœna* and allied forms were also present, and at times, especially in Period II, the lake was covered with a scum, which is locally known by the name of "working." The number of algæ was greater in the upper levels of the lake, although in the lower levels the quantity of algæ was proportionately much greater than that of the crustacea. Still, in general, it may be said that the vertical distribution of plants and crustacea agree.

THE DIURNAL MOVEMENT OF THE CRUSTACEA.

Francé, in an article on the vertical distribution of the plankton[1] of Lake Balaton in Bohemia, reached conclusions widely different from ours. This lake is 76 km. long and 7½ km. wide, but only 11 m. deep in the deepest parts. Francé found that the plankton animals come by night to the surface, begin to descend at dawn to the deeper regions, remain there until early in the afternoon, when they begin to re-ascend, suddenly appear at the surface shortly after sunset, and there remain over night. The *Cladocera* rise first, the *Copepoda* about an hour later, and the same order was followed in their descent. This general law was modified by wind, cloud, rain, etc., in various ways not necessary to specify. He found that these movements were active, as evidenced by the fact that *Pediastrum* and other minute algæ remained constantly at the surface. His view is that the animals seek the cooler waters. We had ex-

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1 R. H. Francé: Zur Biologie des Planktons. Biol. Cent. XIV., p. 34. Jan. 15, 1894.

pected to confirm this result, at least partially, by finding a migration within a limit of several meters. At the same time the senior author of this paper had so often found crustacea at the surface by day that he doubted whether the law was as simple for lake Mendota as that found in lake Balaton. Until our observations forced the conclusion upon us, we had no idea that the crustacea would remain at the same level by day and by night. Our work was incited by this paper of Francé's, and had at first two aims: (1) Assuming Francé's law to hold for lake Mendota, we wished to determine how deep the crustacea go by day. While Francé found that the crustacea go to the bottom of lake Balaton, it was quite possible that in lake Mendota, more than twice as deep, they would go only part way. (2) We wished to determine the rate of ascent and descent. These original purposes were, of course, interfered with by the result of our observations, which were negative as regards any diurnal movement of the crustacea.

It does not seem to us at all possible that any vertical movement of numbers of the crustacea can have taken place to an extent of 3 m. It is plain that there is no general movement of any species to the surface at any time. There was never an aggregation of all the crustacea in the 0–3 m. level. There was very rarely such a distribution as to make the number in the 3–6 m. level larger than that in the 0–3 m. level. In *Diaptomus* this occurred six times, four by day and two by night. In the greatest difference the 3–6 m. level contained 59 per cent. of the catch, and the 0–3 m. level 34 per cent. In the same species the average percentage of the sum of the 0–3 and 3–6 m. levels was about 82 per cent. There were 17 cases where this sum passed 90 per cent., of which fifteen were by day and two by night. There were eleven cases where the sum fell below 70 per cent., of which eight were at night and three by day. The 3–6 m. level was by far the most constant in percentage. While naturally varying a good deal, the averages were remarkably constant, as the following table will show, which gives for each of the four periods the average percentage which this level contained, of the whole number of the species of crustacea named.

3—6 m.	Period I.	Period II.	Period III.	Period IV.
	Per cent.	Per cent.	Per cent.	Per cent.
Diaptomus, day	33	26	38	29
night	30	28	33	24
Cyclops, day	28	28	35	29
night	21	29	33	29

Had there been at any time a diurnal movement of even one-third of the individuals of the 0–3 m. level into the 3–6 level, the result would hardly have failed to show this plainly, in the reduction of the percentage in the upper level and a corresponding increase of that of the second. We feel confident, therefore, that a general movement of the crustacea by as much as one meter would have been detected by our method. It is still possible that crustacea rose and fell within the limits of the 0–3 m. level. A few observations were made to test this idea. These were by day, and showed an abundance of crustacea in the upper 1 m. The crustacea were not counted, as time was lacking for a full study, but especially as the method of observation was not well suited for intervals as small as 1 m. Further, a movement within the upper 3 m. did not appear to us to fall within the limits of our investigation. A migration of a part of the crustacea at the top of the water for a meter or two was not a phenomenon at all comparable to that observed by Francé.

The question then arises,—are our results trustworthy? It seems to us that they are. The material is sufficient and the result unmistakable. It should be noted that in this question a day observation is quite as valuable as one at night, and numerous as were the catches recorded in this paper, there were many more made by day which do not appear in our tables, because they covered only the upper levels of the lake. They were made for purposes of control in different parts of the lake, at different periods, and on different days. Several sets of hauls from the upper levels were made to test the horizontal distribution of the crustacea. Altogether about 100 series of observations were made during July. All of them agreed in finding nearly one-half of the crustacea in the upper 3 m. during the summer, and observations continued into the early fall show the same result. It is not necessary to count the crustacea in order to see the difference in number from different levels. The six bottles of a series can be placed in order with certainty, except in those cases where the bottom level and that next above it contain almost nothing. The total amount varied, but that from the upper level was always the largest.

As confirming the accuracy and sufficiency of the method employed, we may briefly refer to results obtained later in the year—in October. As soon as the temperature of the lake became uniform from top to bottom the crustacea became pretty uniformly distributed, showing an arrangement wholly different from that of the summer months. One example is added:

Number of crustacea caught.

Oct. 17, 9 A. M.	*Diaptomus.*	*Cyclops*	*D. hyalina.*	Temp.
Meters. 0—3	192	732	702	0.10 m. 12.85° C
3—6	234	666	678	
6—9	186	1098	576	
9—12	282	978	300	
12—15	228	720	480	
15—18	164	696	564	18 m. 13.10° C
Total	1364	4890	3280	

Other catches were about the same in proportion, though differing in numbers, as would be expected. This disclosure of the change in distribution, which came on rather gradually during some two weeks, together with the concordance in the result of observations taken about the same time, seems to give additional confidence in the results obtained by our methods.

A second peculiar fact of distribution, also of uniform occurrence, is the singular vertical position of *Daphnia pulicaria* during July. If little confidence could be placed in our methods, this curious result could hardly have been reached. *D. pulicaria* did not differ widely in number from *D. hyalina*, yet the distribution of the two species was as distinct as possible. An un-trustworthy method could hardly have led to such different results, and to results so constantly different.

When in August *Diaphanosoma* began to appear in numbers sufficient to count, its distribution agreed with that of *Diaptomus*. This agreement persisted through September, when the number of *Diaphanosoma* caught in each series increased to nearly 1,000, to disappear early in October.

While, therefore, we are not disposed to urge that the results reached by us are to be considered as mathematically accurate, we believe that they are essentially correct. Even taking into account all the various sources of possible error, the general results are so strongly marked that they can hardly be affected by such errors. When the number in the upper level, 0–3 m., is ordinarily 50 per cent. to 100 per cent. more than that from any other level, with an average number of over 3000 crustacea in the upper level, it is impossible to be mistaken in the general fact. When this large excess of crustacea in the upper level is found at all times of day and night, it is impossible to believe in a descent of the crustacea by day, and a reascent at night.

Zacharias, in the Third Report of the Biological station at Plön (p. 126), announces that the plankton of that lake shows no diurnal movement. His observations were made on September 16, 17, and the report came to hand just as this paper was going to press.

GENERAL CONCLUSIONS.

1. The plankton crustacea of lake Mendota during July consist chiefly of *Diaptomus oregonensis* (64 per cent.), three species of *Cyclops* (30.5 per cent.), *Daphnia hyalina* (3.3 per cent.), and *D. pulicaria* (1.5 per cent.).

2. All of the crustacea but the last named agree in vertical distribution, having 50 per cent. or more in the upper 3–4 m. of the lake. *D. pulicaria* is found chiefly between 6 m. and 12 m. and almost wholly between 6 m. and 15 m. is distribution is maintained throughout the month.

3. During July, only the upper 12 m. of lake Mendota are tenanted by crustacea, and over 90 per cent. are in the upper 9

m. Nearly 50 per cent. are in the upper 3 m.; 30 per cent. between 3 and 6 m. and over 15 per cent. between 6 and 9 m. There is, therefore, apparently an "abyssal" region with little crustacean life. This region is only temporarily unoccupied, being peopled by the crustacea later in the year, as the temperature of the lake falls.

4. There is practically no diurnal movement of the crustacea, or, if any, it is downward by night and upward by day. This movement, if present, is so slight as to be obscured by the action of the wind.

5. No change in the distribution of the crustacea can be attributed to moonlight. The period of our observation included no protracted cloudy weather, but such short periods as were present were without effect.

6. Winds affect the distribution in summer only slightly, increasing somewhat the number of crustacea in the 9–12 m. level, and partially equalizing the distribution through the upper 9 m. They do not seem to produce any effect below 12 m.

Madison, Wis., April 23, 1895.

EXPLANATION OF PLATES.

PLATE VII.

Fig. 1. General view of the dredge. See pp. 424–428.
Fig. 2. Upper cylinders of bucket and collecting tube.
Fig. 3. Bucket, stopper, and collecting tube.

PLATE VIII.

Fig. 1. Full sized section through front of frame of dredge and part of cover, which is slipped back from frame.

A, frame; B, support for guide; C, guide; D, cover; E, flange of cover. The flange is slightly turned up at its front edge, so that it will not strike the guide as the cover closes; G, eyelet for cover-cord; H, pulley; I, support for pulley; J, eye on cover for attachment of cord; K, cylinder for attaching dredge net; M, guide for cover.

A section through the side of the frame would be substantially the same except that the cover would be in the groove below C and the flange E would not be turned up on the edge.

Figs. II–VIII. Graphic representation of the general distribution of the crustacea. The size of the circles is proportional to the number from the entire depth or from each level. Each circle is divided into sectors proportional to the number of each kind of crustacea. See p. 445, Table E.

PLATE IX.

Fig. 1. Graphic representation of the percentile distribution of the crustacea during the month of July. Each vertical line in the diagram represents two per cent. of the total catch and each horizontal line one meter of depth. The percentage of the whole number of each species yielded by each 3 m. level is indicated by a circle placed at the center of the level. The circles or dots for each species are connected by lines.

d, *Diaptomus;* c, *Cyclops;* h, *Daphnia hyalina;* p, *Daphnia pulicaria.*

Fig. 2. Graphic representation of the percentile distribution of *Diaptomus* in the single observations of Period II. Each vertical line represents the total catch, 100 per cent., divided into 10 per cent. intervals by horizontal lines. The lighter lines represent day observations, the heavier ones those taken at night. The first small circle with a dot within it marks the percentage found in the 0–3 m. level, the second circle adds that of the 3–6 m. level and the third that of the 6–9 m. level. The remainder of the line shows the percentage from the remaining 9 m. The dotted horizontal line represents the average per cent. found in the 0–3 m. level and the line of dashes that of the 0–3 and 3–6 m. levels combined. The shorter lines indicate the average for day or night as they cross the light or heavy lines. It is plain that the upper levels are not so populous by night as by day, but the smaller absolute number found by night should also be noted. See p. 451.

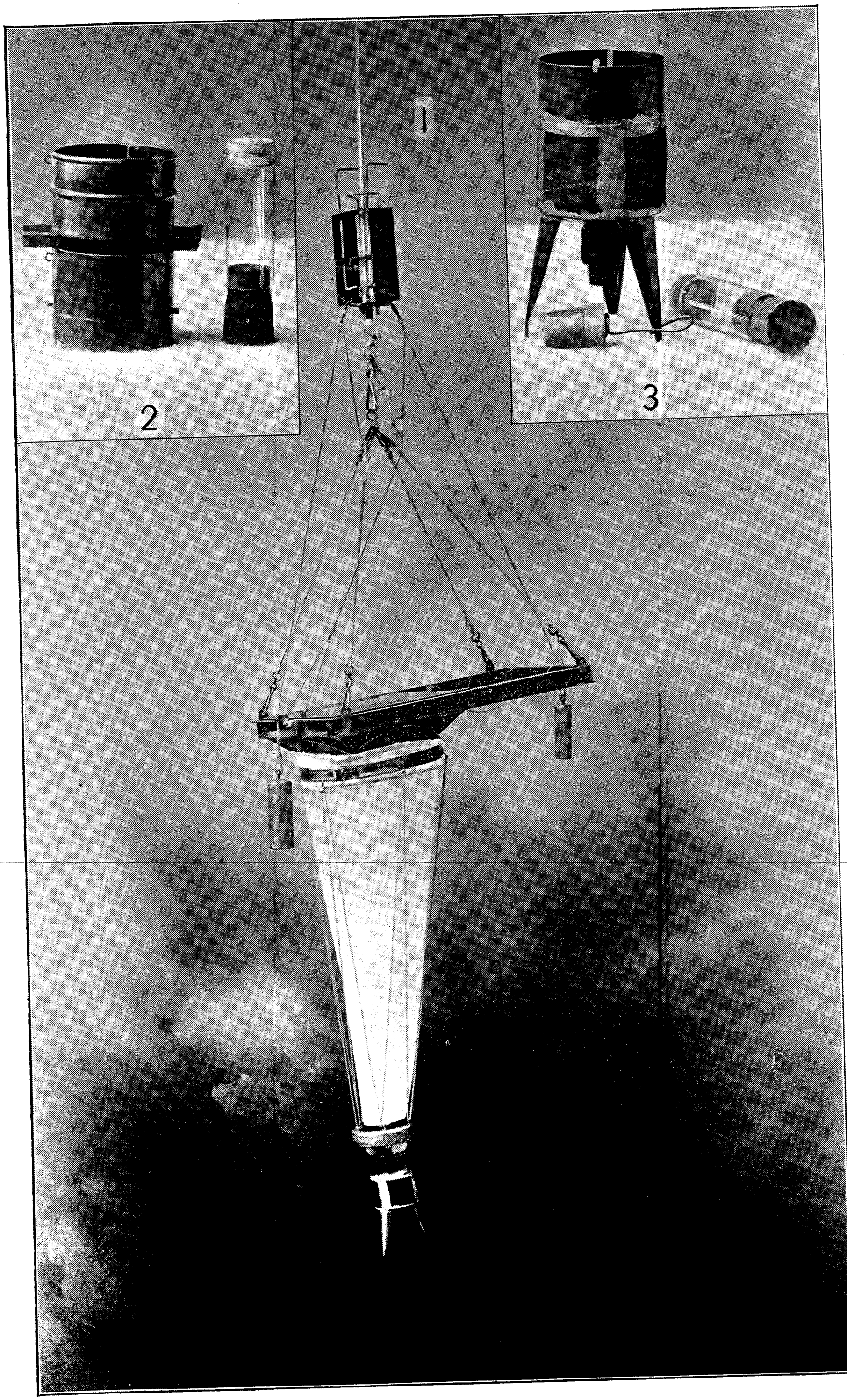
PLATE X.

Fig. 1. Average percentile distribution of *Diaptomus* and day and night distribution by periods. The diagram is constructed in general like Pl. IX, fig. 1. The night and day averages for each period are indicated and marked N or D. Those for each period are connected by a line numbered I, II, III, or IV. See p. 452, Table H.

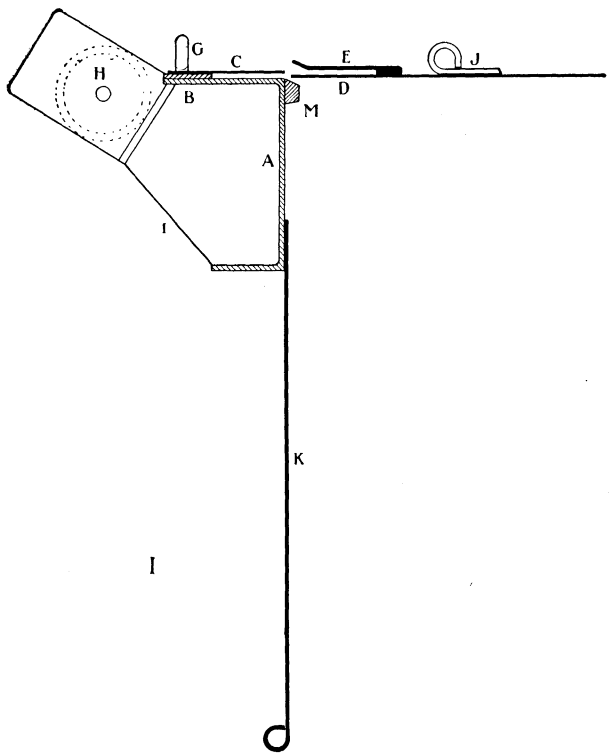
Fig. 2. Similar diagram for *Cyclops;* p. 462, Table K.

Fig. 3. Similar diagram for *D. hyalina;* p. 467, Table N.

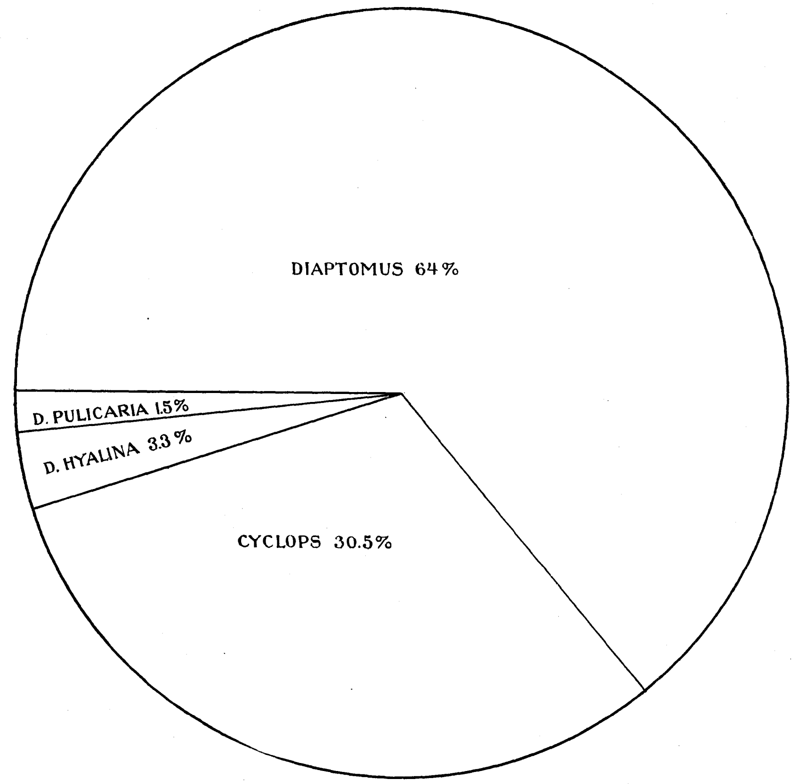
The upper levels only are indicated in these diagrams as the numbers from deeper levels are too small to be platted.



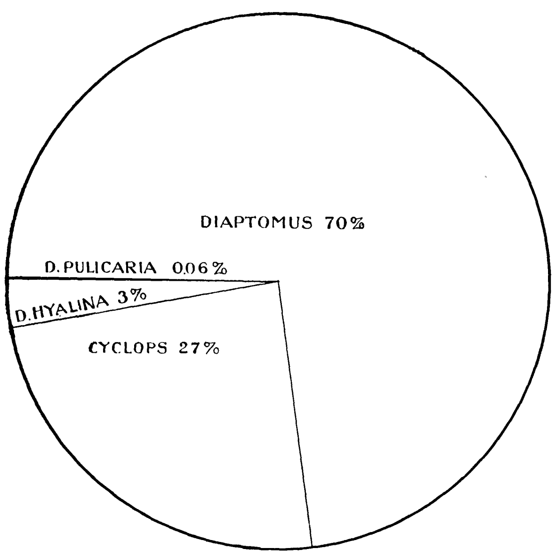
BIRGE ON CRUSTACEA OF LAKE MENDOTA.



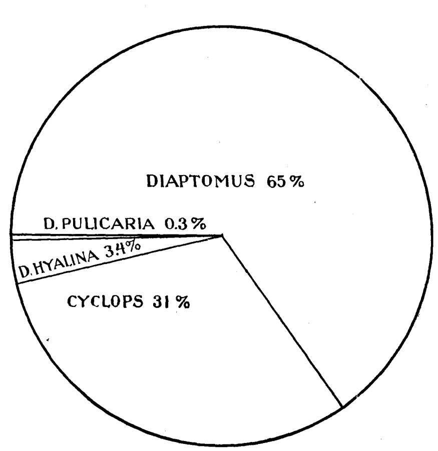
I



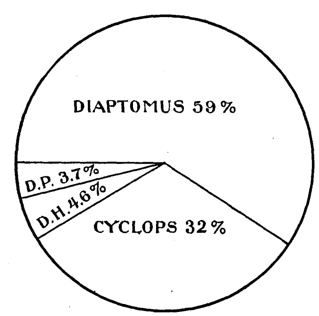
II. TOTAL



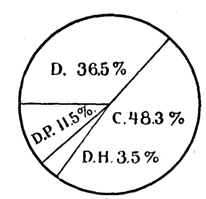
III. 0-3 M.



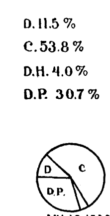
IV. 3-6 M.



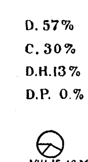
V. 6-9 M.



VI. 9-12 M.



VII. 12-15 M.



VIII. 15-18 M.

BIRGE ON CRUSTACEA OF LAKE MENDOTA.

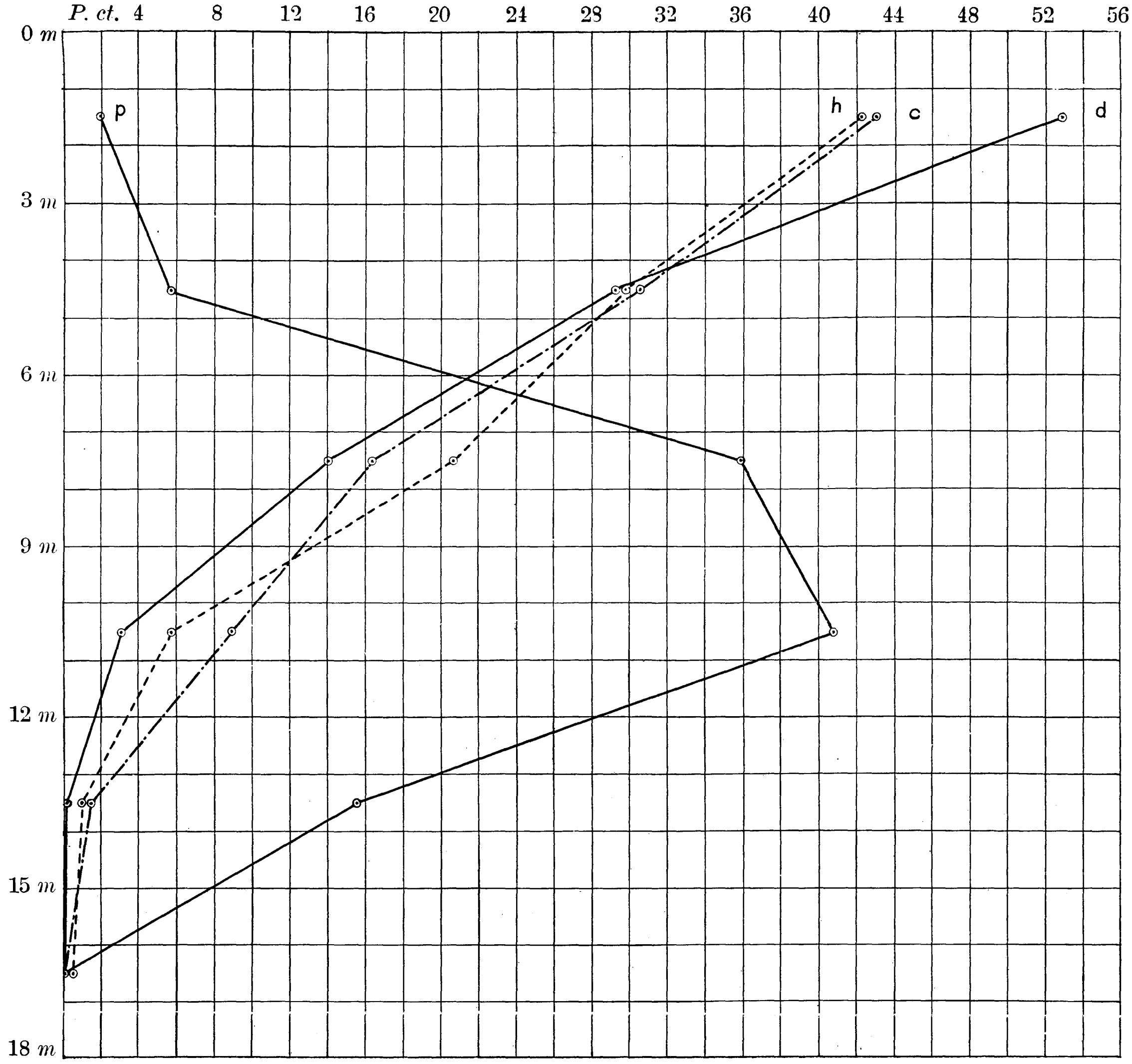


FIG. 1.

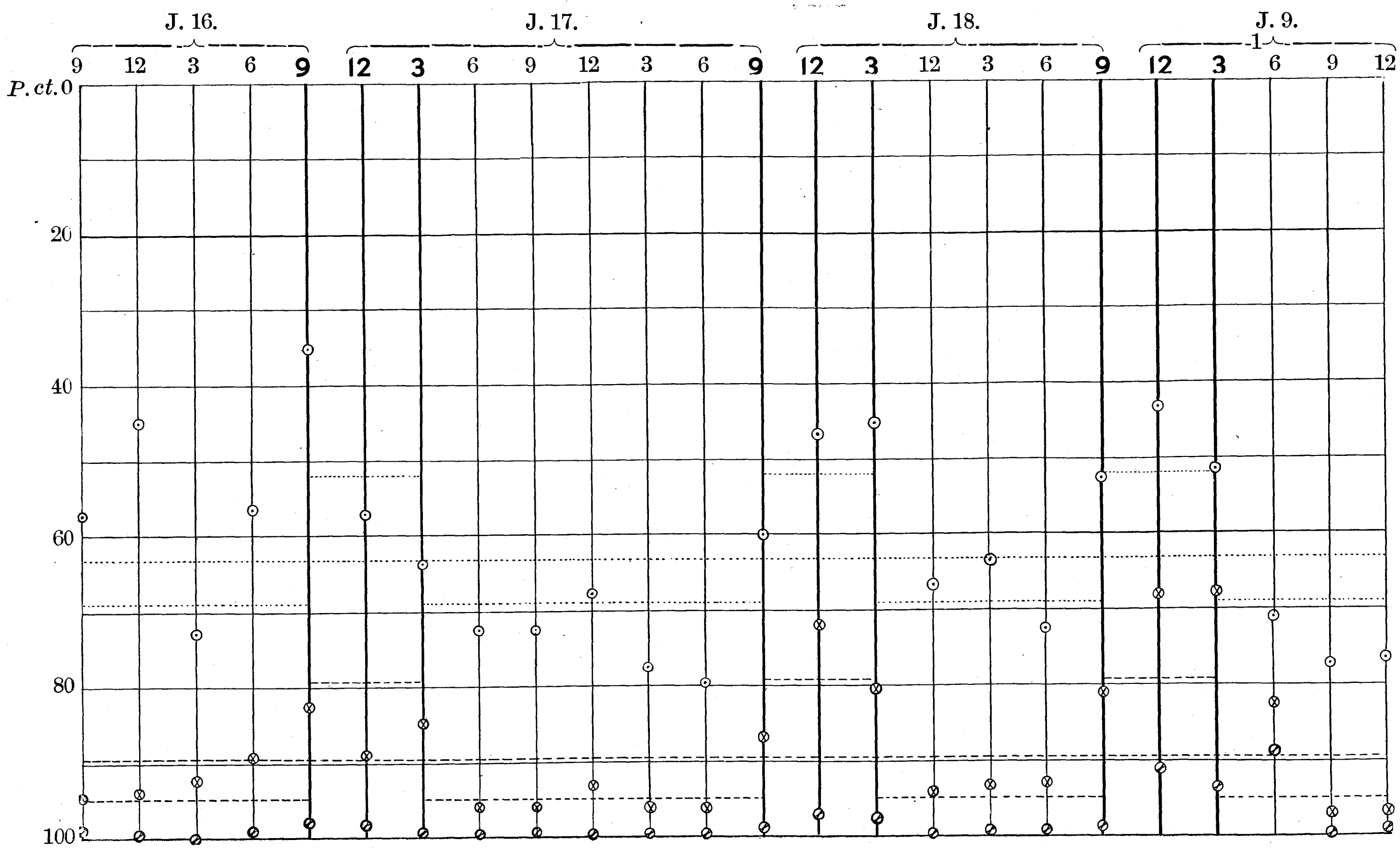


FIG. 2.

BIRGE ON CRUSTACEA OF LAKE MENDOTA.

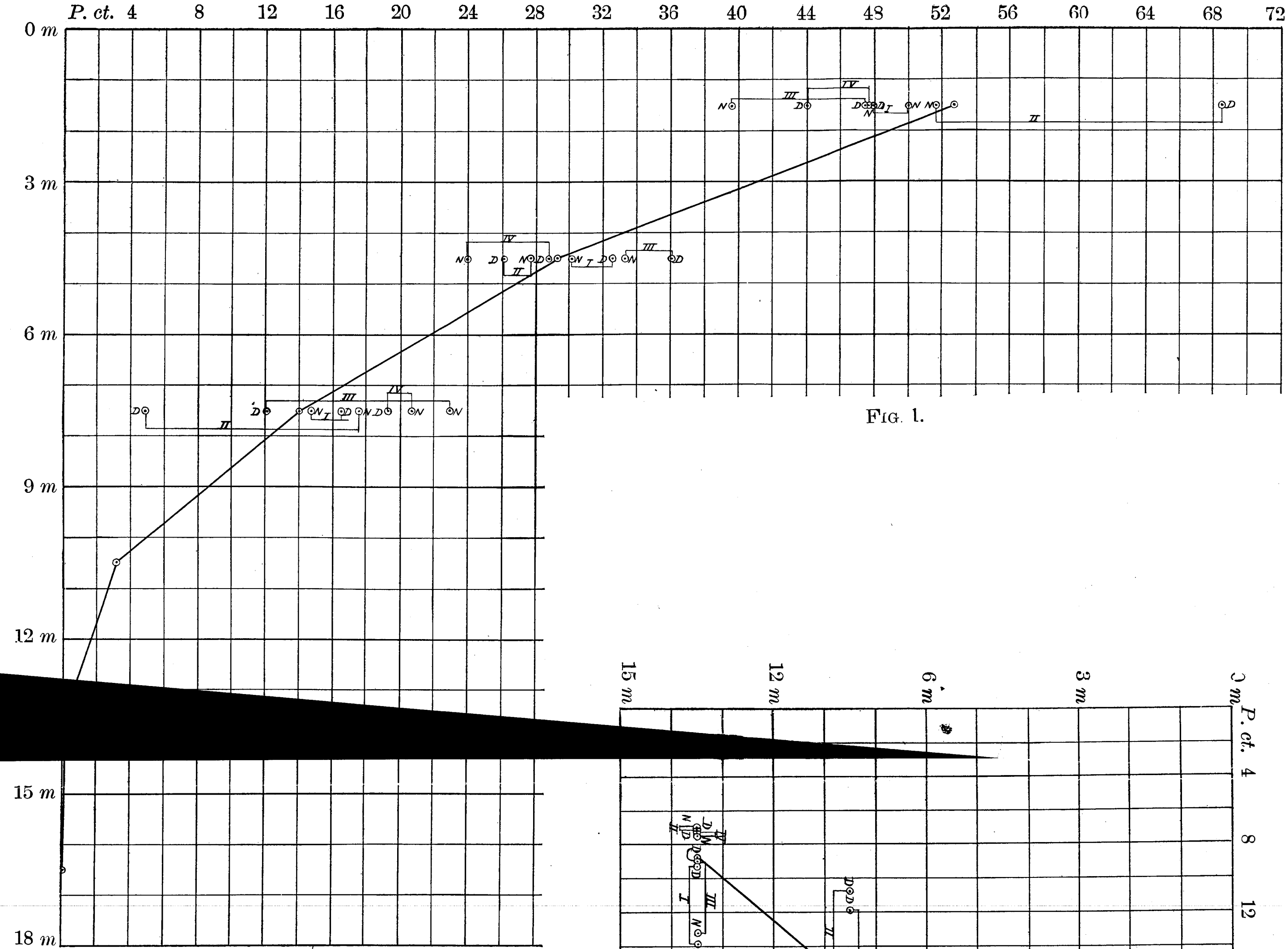


FIG. 1.

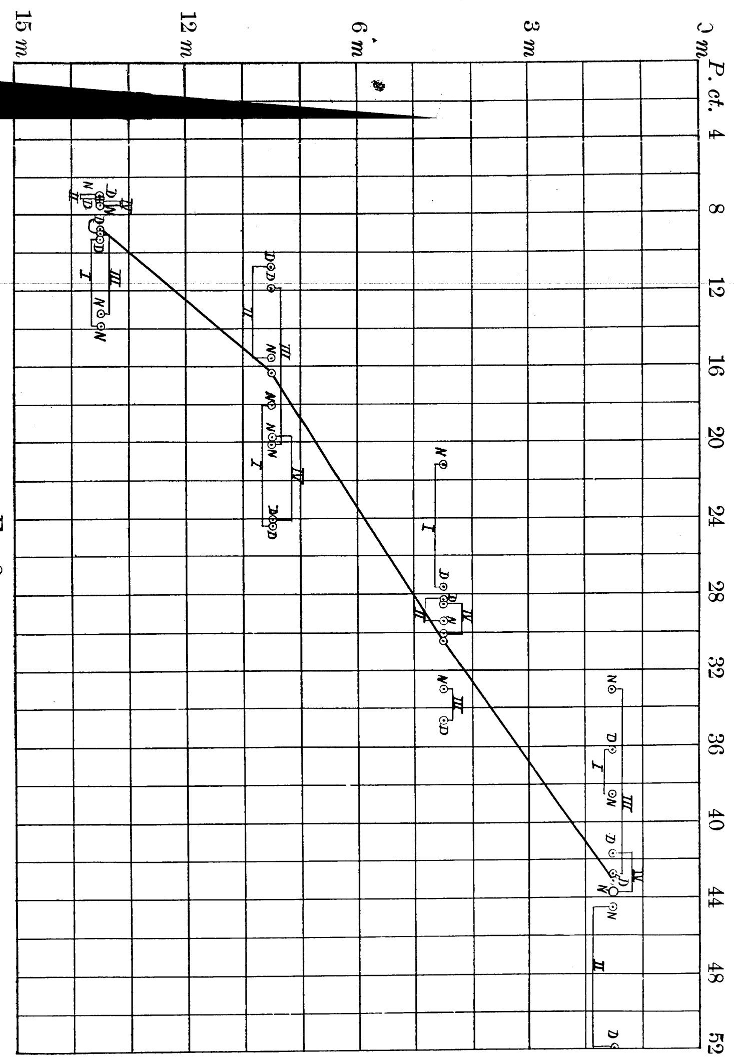


FIG. 2.

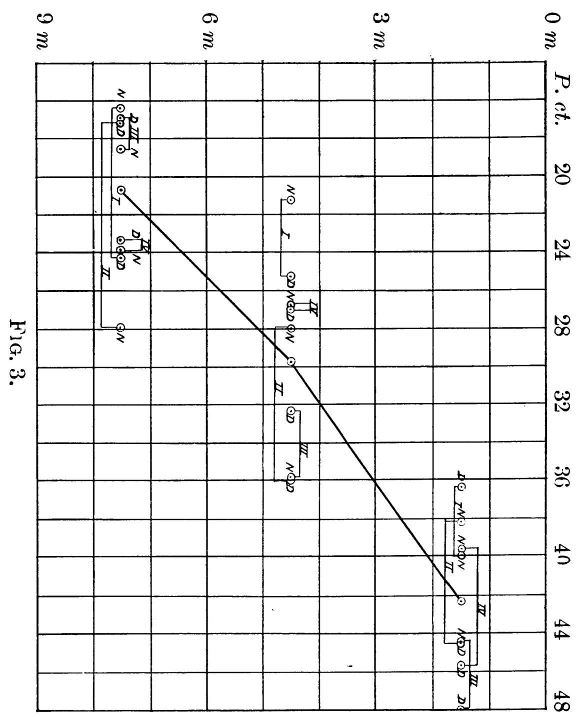


FIG. 3.

BIRGE ON CRUSTACEA OF LAKE MENDOTA.

BOWLDER TRAINS FROM THE OUTCROPS OF THE WATERLOO QUARTZITE AREA.

IRA M. BUELL.

INTRODUCTION.

The study of the crystalline knobs and attendant bowlder trains of southeastern Wisconsin was undertaken by the author in the summer of 1884, under the direction of Dr. Chamberlin, geologist in charge of the glacial division of the U. S. Geol. Survey. It was finally completed in 1894, and the preliminary report, of which this article is but a résumé of one of its most important features, passed from the hands of the author in the summer of that year. The work itself and the elaboration of its material for publication has been done under the immediate supervision of Prof. Chamberlin, to whom the credit is due for its plan and general scope. The details of the latter, however, and the general conclusions derived therefrom are the author's, no one else sharing responsibility for their utterance. Dr. Chamberlin has, however, kindly given his permission for their publication in this form.

GENERAL FEATURES.

The geology of this interesting region has frequently been described. The earliest mention of its ledge areas was made by Dr. Owen in his report to congress upon the geology of Wisconsin, Minnesota and Iowa in 1848.[1] Percival afterwards describes them;[2] also Irving,[3] Chamberlin,[4] and the author.[5]

[1] Senate Documents, 1st Sess., 30th Cong., 1847, Vol. VII, No. 57, p. 39

[2] Ann. Report Geol. of Wis. for 1856, p. 101.

[3] Am. Jour. Science, 3d Ser., Vol. V, p. 282, and Wis. Geol. Survey, Vol II, p. 501.

[4] Wis. Geol. Survey, Vol. II, p. 252.

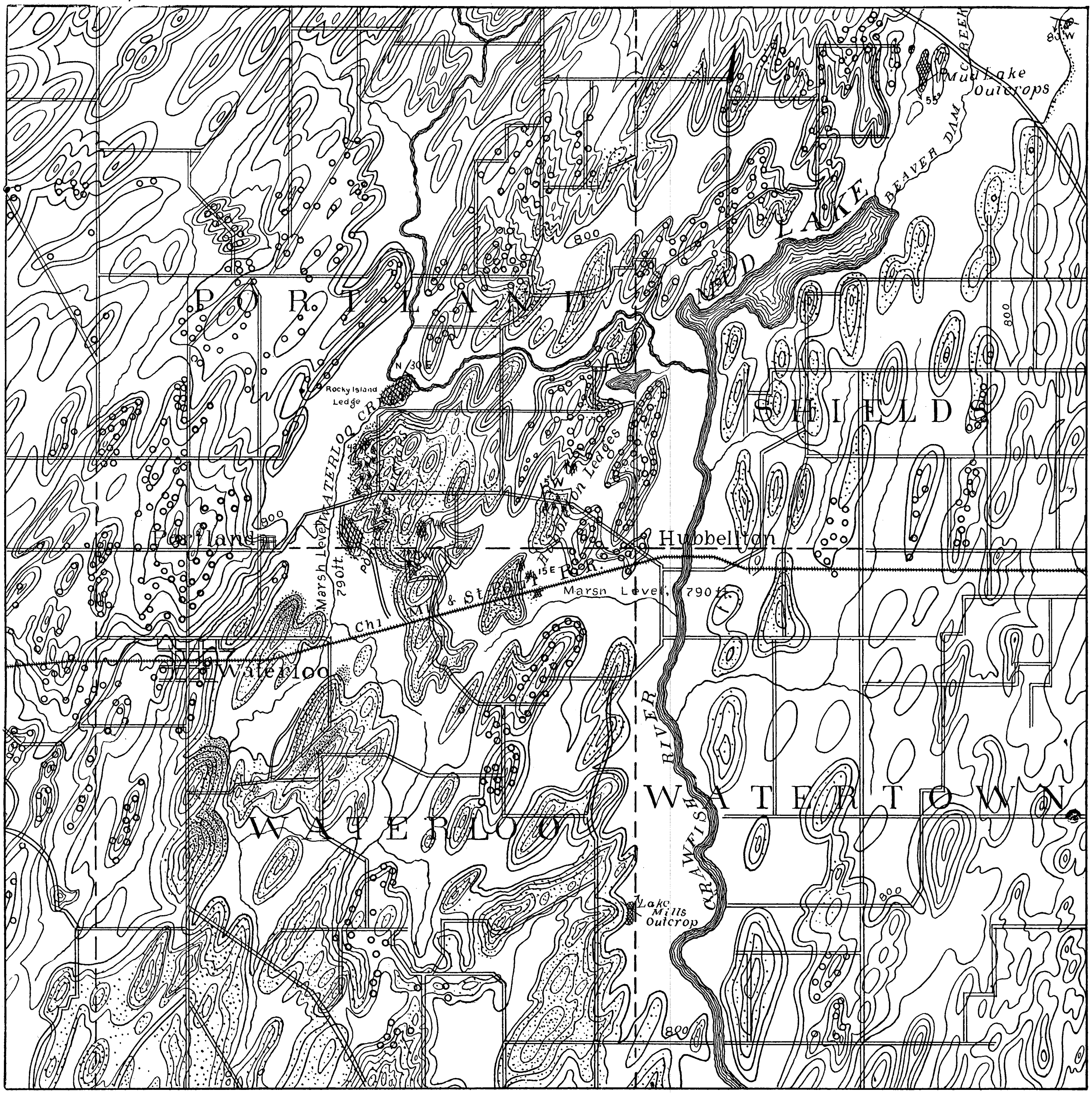
[5] Trans. Wis. Acad. Sci., Vol. IX, p. 255, *et seq.*

From the summary of the last article the following facts are gleaned which will serve to bring the general geological relations into brief review.

The ledges all lie in the basin of Crawfish river, a small tributary of the Rock in southeastern Wisconsin which is crossed about midway by the railway line joining Madison and Watertown. The area is marked by profound preglacial erosion, the region being formerly, no doubt, within the horizon of the upper Silurian, but now these strata are entirely removed, the quartzite ledges appearing in the horizon of the St. Peter's sandstone and the adjacent marsh basins being cut quite through the lower Silurian, exposing the Cambrian strata. In the ridge crests adjacent to the valley on the west the lower beds of Trenton limestone appear.

The accompanying map, plate XII, gives the topographic features of that part of the basin which contains the outcrops, indicates the relations of the outcrops to one another and to the forms of surface relief, and shows the surface distribution of the quartzite drift upon the proximate areas of their boulder trains.

The outcrops, numbering forty or more, counting brief exposures, are grouped into four clusters which are separated by considerable intervals of drift-covered surface, which is underlaid by the lower Silurian rock of the region. The areas have been designated from their geographic relations the Portland outcrops, the Hubbellton group, the Mud Lake ledges and the Lake Mills ledge. From the correlation of observations upon the dip and strike of the strata exposed in these ledges, it is evident that they represent the remnants of one or more profound synclinal folds, which appear to have a direction between N. E.-S. W. and E.-W. The Portland and Mud Lake outcrops belong to the northwest margin of a fold, and the sharp turn in the strike shown in the southern exposures of the Portland area indicates an easterly pitch of the same fold which comes to the surface in that vicinity. The more gentle dip of the strata in the Hubbellton area marks a position near the bottom of the trough, and the sharp northwest dip in the Lake Mills outcrop may represent the reverse side of another fold.



BOULDER TRAINS WITH ABUNDANT MATERIAL — SINGLE FRAGMENTS — OUTCROPS

Contour interval, 20 feet

BUELL ON BOWLDER TRAINS.

Dips as high as 60° appear in the Portland and Lake Mills areas and the rapid variations in dip and strike even within a single exposure, as at the quarry ledge, are evidences of strong orographic movements in this area.

The rock is throughout a quartzite. In portions of the Portland and Mud Lake areas it becomes conglomeratic and in the Lake Mills area are strata of magnetite schist. Sericite is the most abundant constituent, after quartz, while magnetite and zircon are present, the former commonly, and the latter sparingly, as primary inclusions. Microscopic examinations of the sections show much deformation of the quartz. Evidence of the detrital character of the rock has been almost obliterated by the crushing and re-cementation of the quartz grains. The development of the abundant secondary mineral, sericite, is another result of this metamorphism.

Differences in composition and degrees of metamorphism have produced four tolerably distinct types of quartzite, the recognition of which in the fragments composing the bowlder trains is of great assistance in defining their distribution. These types correspond in the main with the isolated areas described above and are designated as the Portland type, the Hubbellton type, the Red quartzite, and the Mud Lake type. Microscopically the distinctions lie in the relative coarseness of texture, the amount of granulation of quartz, the relative development of the secondary sericite and the way in which the larger quartz granules are united, whether by interlocking without interstitial material, or by cementation with finely granulated quartz and sericite. While these differences are not always great they nevertheless suffice in most cases to identify drift specimens with the rock exposed in some one of the parent ledges. Corresponding with the microscopic differences are variations in the aspect of the rock which, though slight and difficult to describe, have been found sufficient in most cases for the unaided eye to distinguish the erratics from the different areas.

Comparison of structural features found in these rocks with Huronian quartzites from the areas of their occurrence to the north and northeast of this region clearly shows that the former present specific differences, so well marked as to lead to their ready recognition in the area of their glacial distribution.

EVIDENCES OF GLACIAL DISTRIBUTION.

These may be briefly summarized as follows:

1. *Abrasion of the ledge surfaces.*—These, wherever exposed, bear evidence of intense abrasive agencies. The highest outcrops present rounded, moutonnée forms and briefer exposures often show smooth tabular surfaces. The low reliefs of the larger ledges are also significant. The Mud Lake ledges have an elevation of but five and twelve feet, respectively, above the marsh level in areas of twenty and fifty rods breadth, and the largest ledges of the Portland group rise only from thirty to forty-five feet above the surrounding marsh.

Glacial striations are everywhere present and agree in direction with the lines of drift movement indicated by the accumulations of the latest glaciation. These vary from S.5°W. in the most remote ledge of the Mud Lake area to S.34°W. on the slopes of the western ledges of the Portland area. Comparison of ledge profiles with those obtained from exposures of similar rock in the driftless areas indicates that many feet of rock have been removed from these surfaces by glacial action.

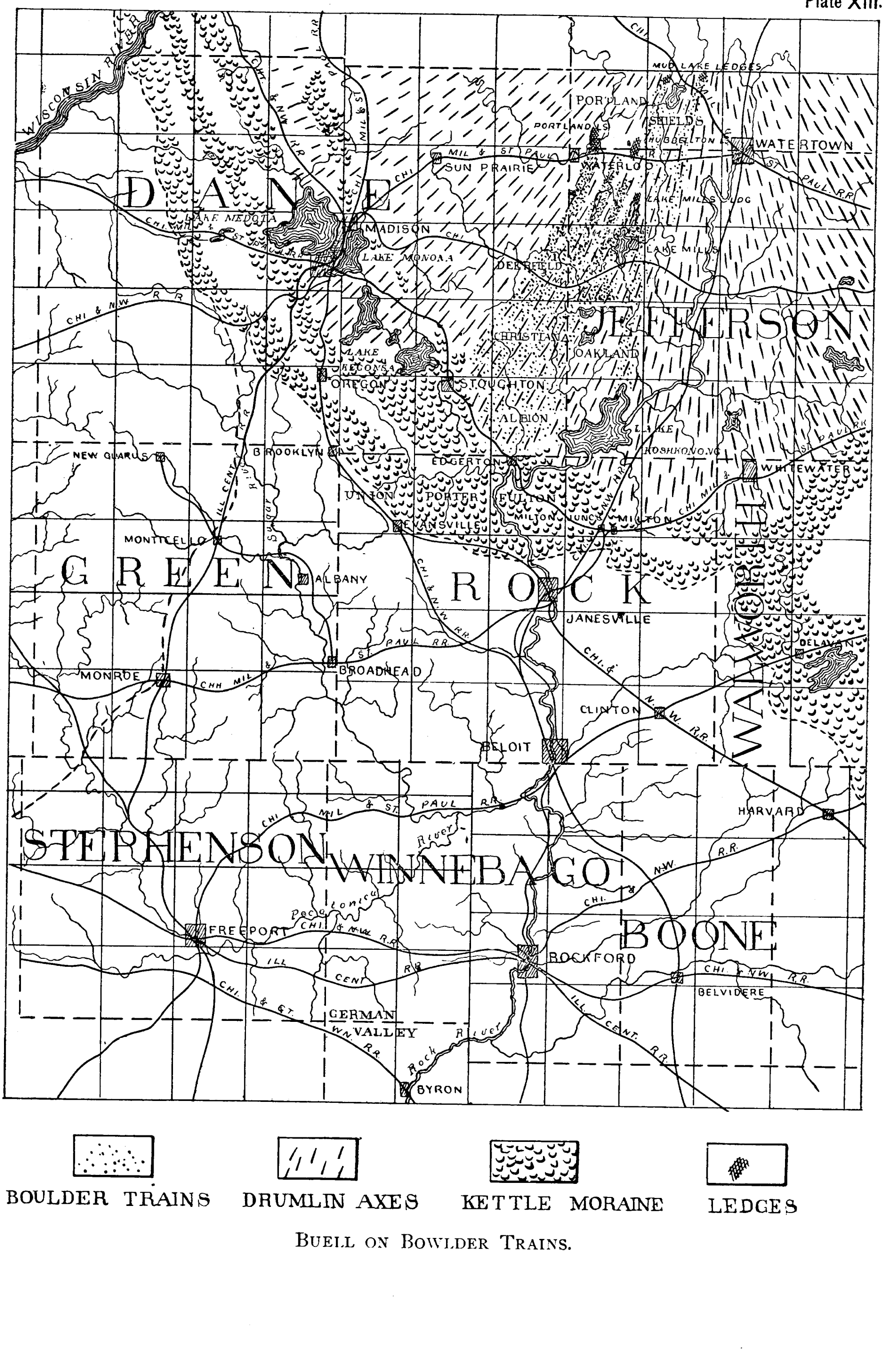
2. *Distribution of drift material.*—The evidence upon this point is exhaustive and is comprised under the following heads:

a. A greatly increased amount of bowlder material at all points favorable for observation in the line of glacial movements. The general facts of this distribution are indicated upon the map of the area, and the amount of this material is given in the descriptions of the bowlder trains.

b. The recognition in this increased bowlder content of the quartzite rock exposed in the ledge surfaces of the adjacent areas.

c. Evidence of the local origin of this drift material in the absence of the imprint of extended glacial abrasion.

d. The recognition of the specific types of quartzite rock found in the different ledges in the local crystalline drift over the whole area of the so-called bowlder fan.



BUELL ON BOWLDER TRAINS.

e. The demonstration of identity in composition and microscopic structure, in both ledge and bowlder train specimens.

f. The recognition in the distribution of the drift material of all the characteristic features of glacial distribution, namely, association with all the different members of the glacial formation, evidences of the effects of glacial transportation and its distribution in well defined trains whose locations were determined by the positions of the ledge exposures and the directions of ice movement across their surfaces.

The convergence of these lines of evidence has afforded the author the strongest grounds for the conclusion that no appreciable part of the material hereafter described as belonging to the various bowlder trains had its origin in any hitherto concealed or undiscovered ledges in the Waterloo area or in any other ledge area near or distant from the locality here described. The study of the drift distribution from these ledges has developed the fact that we have represented within the area of the bowlder fan not alone the distinctive trains of bowlders from each ledge area, but successive trains from the several areas which represent distinct episodes of glacial movement, widely differentiated in time, direction of movement and conditions of drift dispersion. These are here taken up in the order of their prominence as drift phenomena, which is naturally the reverse order of their deposition.

THE BOWLDER TRAINS OF THE LATEST GLACIAL MOVEMENT.

PLATE XIII.

Outlines of bowlder fan.—This is embraced entirely within the Green Bay loop of the Kettle moraine and its attendant overwash deposits and gravel trains. The ledge area lying well toward the end of the lobe of which the moraine is the margin, and almost in the center of its peripheral arc, was in a position to receive the most characteristic effects of attrition and dispersion. Hence the striking features of glacial abrasion alluded to in the preceding section. Where the line of strike coincides with the direction of drift movement, the surface of the larger ledges is left in long gentle swells like the fluted hills of adjacent drift formation. Where the strike is transverse to this movement, as in the Mud Lake area, the whole surface has been reduced to a comparative level, broken only by the sharp irregularities left by the plucking out of the quartzite blocks from the fissured and tilted strata.

The general direction of the latest ice movement over this area is that of the axis of the Green Bay lobe, but its extreme breadth and near approach to the drift margin has given considerable lateral divergence to the opposite sides of the train. The eastern ledges show striations from 6° to 10° W. of S., and on the western exposures the striae vary from 25° to 34° W. of S. These directions correspond with the axes of the drumlin forms in the vicinity, and also coincide with the margins of the bowlder trains on either side.

The bowlder trains from the four ledge groups within the area are here described together as they mingle their material on their margins over the remote half of their territory. The radial margins of this broad train are sharply defined on the drift surface south and south-southwest from the borders of the ledge area. On its east margin the scattered drumlins in the Crawfish and Mud Lake basin show from one to one and a half per cent. of quartzite drift as far south as section 4, Watertown. It is easily made out by its content of local crystalline rock across the intervening townships to the east end of Lake Koshkonong, and is indicated by less abundant material southward on the east shore of Lake Koshkonong, across Milton township in Rock county to the outer margin of the moraine in the northwest corner of Harmony township. The western margin of this train is very sharply defined within the proximal limits of the area. Along the west side of Waterloo township the crests and east slopes of the drift ridges are thickly strewn with quartzite blocks while the west slopes of the same ridges are almost free from local drift. This border is traced across the intervening townships of Dane county to the outer margin of the moraine on section 26, Union township, Rock county. The peripheral border of the train has an extent of about seventeen miles, the train thus doubling its breadth in its course of thirty-five miles.

The quartzites on the outer margin of the moraine between these limiting points have an abundant distribution. Beginning with the southwest margin in Union township, the outer ridge on section 26 shows for a quarter mile about eighty blocks, or one for each rod in extent. They are still more abundant over the central portions of the train. On section 33, Porter township, on a surface of forty square rods over 100 quartzites were noted, and at other points in this vicinity the local drift exposed aggregates about four cords per acre.

Near the east margin of the train there is also a decrease of the local material. On the outer crests of the moraine in Janesville township, west of the river, the quartzites again average one to each rod of drift margin, while east of the river they are much less abundant though they are found in roadside and railway sections, in the townships of Milton and Harmony, as far west as the line of the Chicago & Northwestern railway.

Relative amount of local drift.—The relative amount of local drift at proximal points is of course much greater than this. At several points adjacent to the Portland ledges are heaps or mounds of bowlders, evidently from preglacial talus accumulations. These mounds rise from ten to twenty feet above the marsh level, cover one-quarter to two acres of surface and appear to be composed of from 25 to 75 per cent. of quartzite fragments. The marsh borders adjacent to the ledges bear a fringe of bowlders from two to ten rods wide, the blocks averaging from twenty-five to 150 per square rod.

Drift sections on the roads and railway south of the principal ledge area show a quartzite content of from 5 to 20 per cent. at points within two miles of the ledge areas. These proportions diminish to one and one-half per cent. at points six miles away and to about one per cent. at points ten miles distant. Over the medial portion of the train this percentage has decreased to one-half per cent. and on the periphery of the lobe the relative amount of local drift is one three-hundredth.

The total amount of quartzite drift exposed on the surface is closely approximated from observations made upon almost every square mile within the area, and is placed at about 35,000 cords The estimated amount contained within the drift formations belonging to this episode as determined from observations made upon drift sections found in all parts of the field is sufficient to indicate a degradation from the glacially exposed surfaces of from fifty to seventy-five feet.

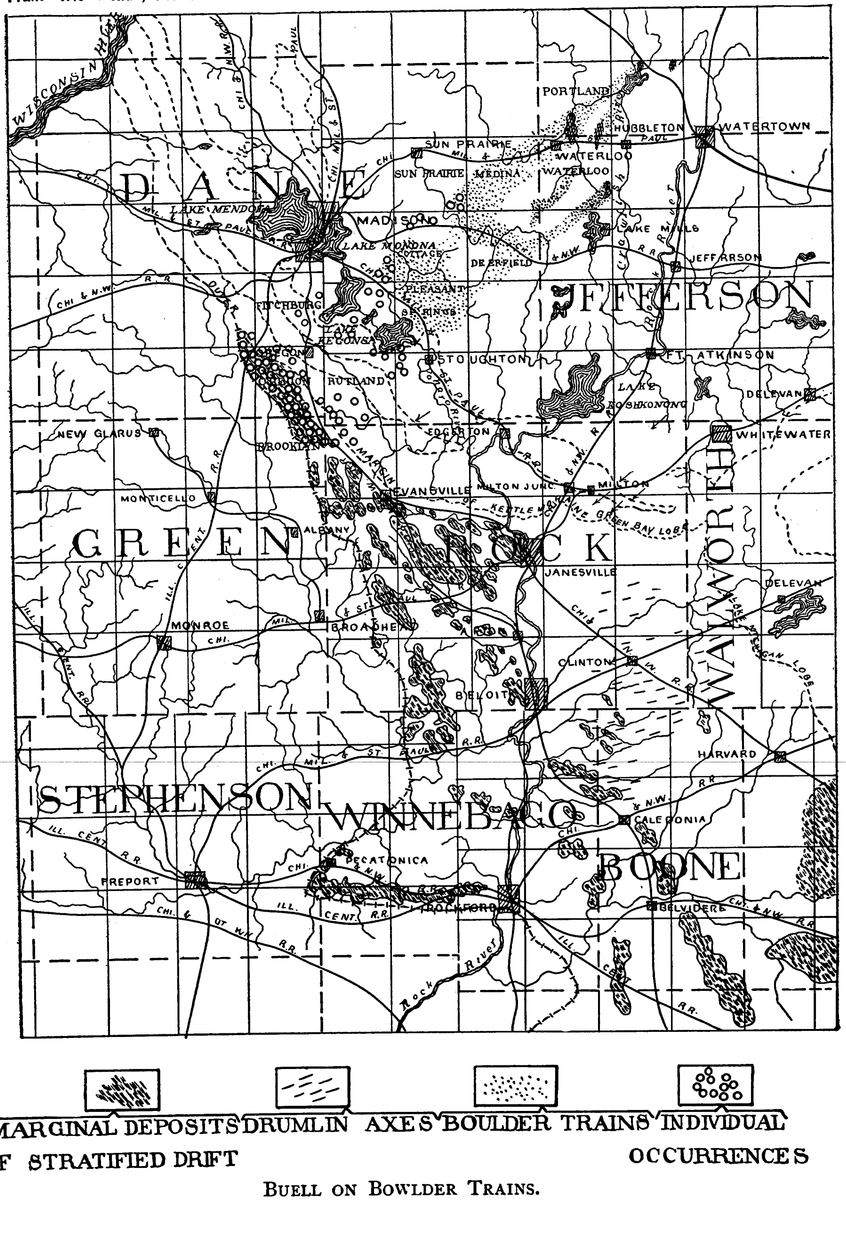
THE SOUTHWESTWARD BOWLDER TRAINS. PLATE XIV.

Outlines of bowlder fan.—The quartzite distribution indicated on the accompanying map is believed by the author to have been brought about by a glacial episode next preceding that which is bounded by the Kettle moraine.

The presence of this older train is indicated within the area of the Green Bay lobe by a considerable amount of quartzite material in the drift over areas to the southwest of the ledges and west of the main trains. It is also sharply determined by their presence in abundance in the old moraine belt beyond the area occupied by the Green Bay lobe.

Its most abundant distribution is upon the area between the Mud Lake and Portland ledge groups, on the west side of the Mud Lake basin. The drumlin clusters on both sides of the Crawfish in the southeast quarter of Portland township show among the bowlder material on their surfaces a large proportion of the Mud Lake quartzite. These are especially abundant on the roadsides crossing sections 24 and 25, and sections 23, 26 and 27. On ridge crests north of the Crawfish and west of the marsh tributary to Mud Lake from 2 to 5 cords per acre were noticed at several points. An estimate from a large number of observations made upon this area indicated about a thousand cords of the local crystalline drift upon the surface between the two areas. Southwest from the Portland ledges, the quartzite drift is much less abundant upon the surface but is still found on all ridge areas, across Medina township, the southeast corner of Sun Prairie, and in Deerfield, Blooming Grove, Pleasant Springs, Dunn, Fitchburg and Rutland, to the margin of the Green Bay lobe in Oregon and Verona.

Its distribution beyond the Kettle moraine in Montrose and Oregon townships, Dane county, and Albany township, Green county, is its most characteristic development. The sharp outer



MARGINAL DEPOSITS OF STRATIFIED DRIFT — DRUMLIN AXES — BOULDER TRAINS — INDIVIDUAL OCCURRENCES

BUELL ON BOWLDER TRAINS.

ridge of the Kettle moraine with its bordering overwash plain is strongly marked throughout this region and extends diagonally across the townships of Union in Rock county and Oregon in Dane. Beyond these is a moraine less strongly developed, which first emerges from the margin of the Kettle moraine near the center of Union township. This ridge is from fifty to one hundred feet high in the west half of Union. Crossing the high imestone ridges of Albany township its outer margin has a thickness of from twenty to forty feet on the crest of the divide but well sections on its inner slopes show a depth of one hundred feet of drift. As it crosses the marshy basins tributary to Sugar river, in Oregon township, it takes on kame-like features, forming broad, low ridges of stratified drift which bear a few kettle depressions and enclose several shallow lakes.

This formation contains the peripheral distribution of the southwest train. Erosion sections exposing the stony drift usually show one or more quartzite fragments for each square rod of surface. Bowlders are not so common, however, as on the margin of the main train, though about twenty, representing each of the ledge groups, were noted on the roadsides and on the ridge crests in Albany and Oregon townships. The area of erosion and roadside sections examined in this belt aggregates about an acre of surface, and from them over 200 quartzite fragments were noted. Beyond this belt of stony till and gravel deposits the thin, much-weathered drift showed an almost complete absence of quartzite content, though several miles intervened between this margin and the border of the driftless area.

The radial margins of this train are very ill defined, as its area was evidently crossed by the more southward movement of the Green Bay glacier. The quartzite distribution, however, both in the peripheral portion of the train and over the area adjacent to the outcrop indicate a direction about 50° west of south of the ledge groups.

Correlative evidences of the accompanying drift movement.—The evidence of an earlier, more westerly glacial movemont across the Rock river valley afforded by this bowlder train is corroborated by other data observed in the region. Among these are coincident glacial striations observed at several points. A well defined area appears on the rim of limestone that borders the marsh basin of the Crawfish in the township of Milford, east of Lake Mills. This edge of the rock strata was well exposed to the action of the westward moving ice mantle but was measurably protected from degradation from a glacial movement down the valley, hence the preservation on portions of its surface of striations produced by the earlier drift movement. Two brief surfaces exposed in roadway sections, near the river, showed striae S. 60° W. Another in a railroad cut east of Lake Mills station showed deep grooves extending S. 40° W.

Near the margin of the lobe, where the thinned edge of the ice exerted less abrading power, the action of the earlier glaciation is more commonly preserved. On a rock surface uncovered in a roadway section across the end of a well marked drumlin, whose axis lies almost upon the meridian line, the striae show a direction S. 50° W. Several rock surfaces uncovered in wells and cellar bottoms in the neighborhood of Milton show essentially the same direction and one in the southwest corner of Dunkirk township, near Cooksville, bears also striae S. 50° W.

Outside of the Green Bay lobe, striae observed at several points beneath the thinner portions of the old drift, indicate a still more westerly movement of the ice mantle. One of these was noted in the bottom of a roadside gully near the west line of Clinton township, northeast of Beloit. The striae here are S. 75° W. Two surfaces, on the west side of the river near Rockford, show the same direction, and one set near the crest of the limestone ridge just west of the city of Beloit bears directly west.

Upon the high limestone underlaid and heavily drift-covered area, that lies between the overwash plain of the Kettle Moraine in Walworth county and the level, gravel-filled valley of the Rock, the surface shows many drumlin forms which have the same axial direction as the striae just described. These are most abundant in the townships of Bradford and Clinton, Rock county, and in Sharon, Walworth county, but several very prominent forms are found in the townships of Manchester and Caledonia in Boone county. Four or five less distinct forms appear also on the broad limestone divide between the Rock and

Pecatonica basins in Rockton and Owen townships, west of Rock river.

That the glacial movement which produced these striations, molded the elliptical drift ridges, and dispersed the quartzites along these westerly lines did not reach the border of the driftless area is uniformly attested by the fact that all these phenomena cease far within the limits of the drift area. Its outer margin at successive stages in its occupancy of the area appears to be marked by belts of kame-like deposits that cross the area between the Rock and Sugar river valleys in Wisconsin, and are continued to the southeast on both sides of the Rock in northern Illinois. The position of these belts is indicated on the map of the southwest train. The outer of these belts appears on the crest of the high limestone ridge south of the ridge forming the peripheral border of the bowlder train in the northeast corner of Green county, Wisconsin. It forms a series of broad gravel ridges in the basins of the eastern tributaries of the Sugar river on the line between Green and Rock counties, and is strongly developed across the low col between two adjacent basins draining respectively into the Rock and Sugar rivers in the south half of Rock county. Farther south it appears as a series of broad ridges, semi-morainic in part, but mainly of gravel or fine sand, which cover the west side of the Coon Creek valley in Newark township. Low gravelly ridges continue the belt over into the Pecatonica basin and a light line of gravel ridges crosses the divide in the same general direction into the valley of the Rock north of Rockford.

Apparently correlated with this is a belt of thickened drift, kame-like on lower levels and morainic in places on the ridge crests, that appears on the south side of the Pecatonica from Rockford west to the Stephenson county line. It here disappears on the south bank of the river and has very slight development on the north side of the valley. It apparently marks the south margin of a southwestward protrusion of the ice lobe which moved up the broad low valley of the Pecatonica.

A second belt starts near the same point as the last and crosses Rock county diagonally to the river valley at Beloit. Its main development, like the last, is in the low lands, but is almost continuous across the Janesville-Magnolia divide. Within this belt is a regular succession of kame-like ridges that rise from the low basins on either side of the limestone ridge just mentioned and gradually thin out as they approach the crest of the divide. Those nearest the river, however, maintain their massiveness even across the highest levels and show a thickness in well sections of from 100 to 150 feet.

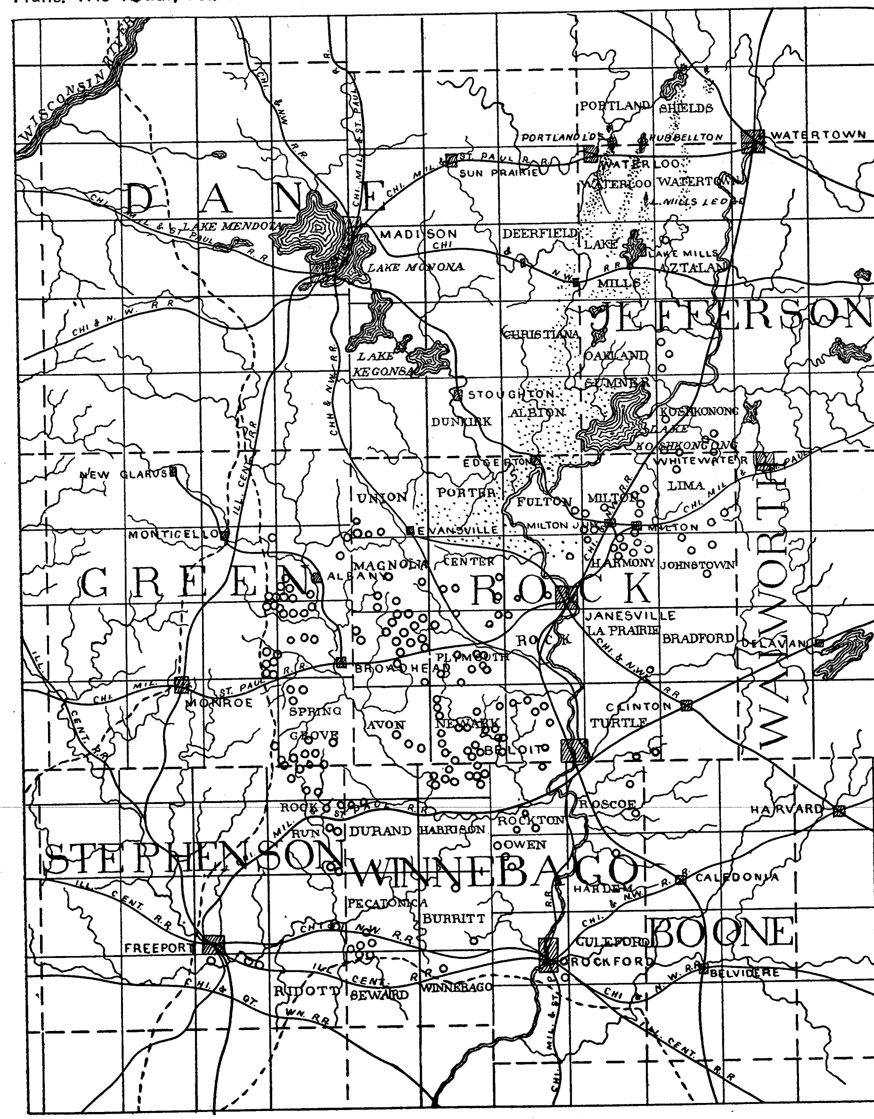
They are all abruptly cut by the deeply eroded and gravel filled valley of the Rock, but remnants reappear on the ridge area east of the river in Winnebago and Boone counties in Illinois, where the isolated ridges indicated upon the map were located by Mr. Leverett.[6] The series has not been traced farther southward, but probably disappears beneath the massive moraines of later formation that lie in concentric bands around the head of Lake Michigan.

THE OLD SOUTHWARD TRAIN. PLATE XV.

Area of distribution.—This area is recognized almost entirely by a bowlder distribution beyond the bounds of the Kettle moraine. A very sparse quartzite distribution has been found upon the area directly south from the Mud Lake ledges and east of the main train as traced in the description of the trains belonging to the Green Bay lobe. This is considered to belong to this earlier train mainly because its quartzites appear farther south along the same lines in the old drift area bordering the Rock river valley on the east. This eastern margin includes, therefore, the few occurrences of quartzites indicated on the map, in the townships of Koshkonong, Lima and Johnstown within the Green Bay lobe, and those found in the old drift in La Prairie and Turtle townships in Rock county and in Roscoe, Harlem and Guilford townships in Winnebago county.

The local quartzites just noted comprise a large bowlder of Lake Mills quartzite, found in the erosion valley of Turtle creek on section 34, La Prairie, a smaller bowlder on the crest

[6] F. Leverett, Special Asst. U. S. Geol. Survey, conference and manuscript notes.



BOULDER TRAINS LEDGES INDIVIDUAL OCCURRENCES

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of a drift ridge in section 15, Roscoe, and several cobbles and pebbles found in the remaining townships. This whole area is heavily covered with the more recent drift brought hither by the southwestward glacial movement which explains the rare occurrence of these erratics from the ledge area to the north.

The centre of this train crosses the west half of Rock and Winnebago counties. It has its most abundant distribution in the townships of Plymouth and Newark, midway between Rock river and Sugar river valleys. In the latter township about twenty-five quartzite bowlders have been noted along the roadsides. These represent the amount upon a small fraction of the surface. They were found both on the surface and within the body of the drift and occur in like proportions in the stratified and unstratified deposits. The largest noted within this area is about two feet in diameter. The quartzite drift in this region was first observed by Dr. Chamberlin in his earlier studies of glacial phenomena of southeast Wisconsin. It was described and mapped by him in the publications upon the geology of Wisconsin,[7] but in subsequent references to the region in his studies of the general problem these remote occurrences of the local crystalline drift were disregarded because of uncertainty of identification.

South of the state line a scattered and meager distribution has been traced across Winnebago county to the outer margin of the morainic border south of the Pecatonica valley, described in the preceding section. Its distribution is not defined by this belt as several fragments have been noted in a line of eskers, extending westward from this formation to the vicinity of Freeport. A small fragment apparently of the same rock was obtained for the writer by Mr. Hershey of Freeport in the Leaf river valley eskers, several miles south of Freeport. This indicates a discharge of gravel-bearing waters across the divide at the southwest angle of the valley toward the Mississippi.

The west margin of this bowlder train appears on the west side of the Sugar river basin, in Green county, Wis., and Stephenson, Ill. Its distribution coincides with a belt of thick-

[7] Geol. of Wis., Vol. II, p. 202.

ened, stony till and kame-like gravel deposits, the former appearing on the ridge surfaces and the latter spreading over the lower levels. This line of marginal deposits is traceable from the north line of Green county, near Belleville, southward across the western tributary valleys of the Sugar river to the divide between the Sugar and Pecatonica basins in northeast Stephenson county, Ill. The heaviest morainic development in this belt is on the east side of the river at Albany, Wis., where the stream cuts across the ridge, its present channel being formed while the main valley of the river was filled by the glacier itself.

South of this are massive gravel ridges which pass over low cols into the broad valley drained by tributary streams crossing Decatur township. Crossing the center of this township are belts of gravel aggregating two or three miles wide and showing in well sections thirty feet of stratified drift. On the deeply cut ridge surface south of this valley a thinned margin of stony till appears continuing the formation across to the Pecatonica valley. Within this latter area, however, the surface is so deeply loess covered that this border is no longer traceable.

North of the west branch of Sugar river the quartzites appear upon this margin only at rare intervals. Their first occurrence in relative abundance is in the gravel ridges in the southwest corner of Albany. On section 30, Albany, and sections 1 and 2, Sylvester, from five to a dozen quartzite cobbles were found in each of the several roadway sections upon surfaces of a few square rods area. The largest quartzite bowlder observed outside of the Kettle moraine was found in this vicinity on section 7, Decatur. It is a gray block of Portland quartzite and measures on its exposed surface 6 × 3 feet. It is only partly uncovered, its thin drift envelop having been removed in the grading of the roadway. Fragments are scattered through the stratified drift in Decatur township and on the ridge surface in sections 25 and 36, Sylvester, several bowlderets were noted in morainic ridges lying upon the steep slopes of the limestone underlaid areas. Numerous small fragments were found in drift sections in the next township south of Decatur and in the adjacent townships of Winnebago and Stephenson counties, Illinois. A few bowlderets were observed in these towns also, but the only bowlder of considerable size found in this remote portion of the train was a block of Mud Lake quartzite two feet in diameter, lying on the roadside in section 16, Rock Run.

A wedge shaped area is outlined upon the map lying between the margin of this bowlder fan and the border of the driftless area. The drift upon this area is very thin except at certain points upon its margin and its surface bears the impress of erosion topography. Its surface has been diligently examined for the local quartzite drift, but thus far without result. No rock resembling the Waterloo types has been found within this area through any of the road and railway exposures that have been examined, though in the various crossings and re-crossings of the tract over a hundred miles of travel have been made. The drift-line exposed contains Niagara and Devonian fossils, and thus bears evidence of its derivation from the lake Michigan basin and is unquestionably of more ancient origin than that which contains the quartzite fragments.

The breadth of this belt of bowlder distribution is considerably greater than in either of the other trains, extending as it does across five townships in the adjacent counties of Wisconsin and Illinois. Its greater linear extent, however, together with the rapid fanning out of the ice lobe which is here assumed to have affected its distribution may be considered as satisfactory explanations of its extent.

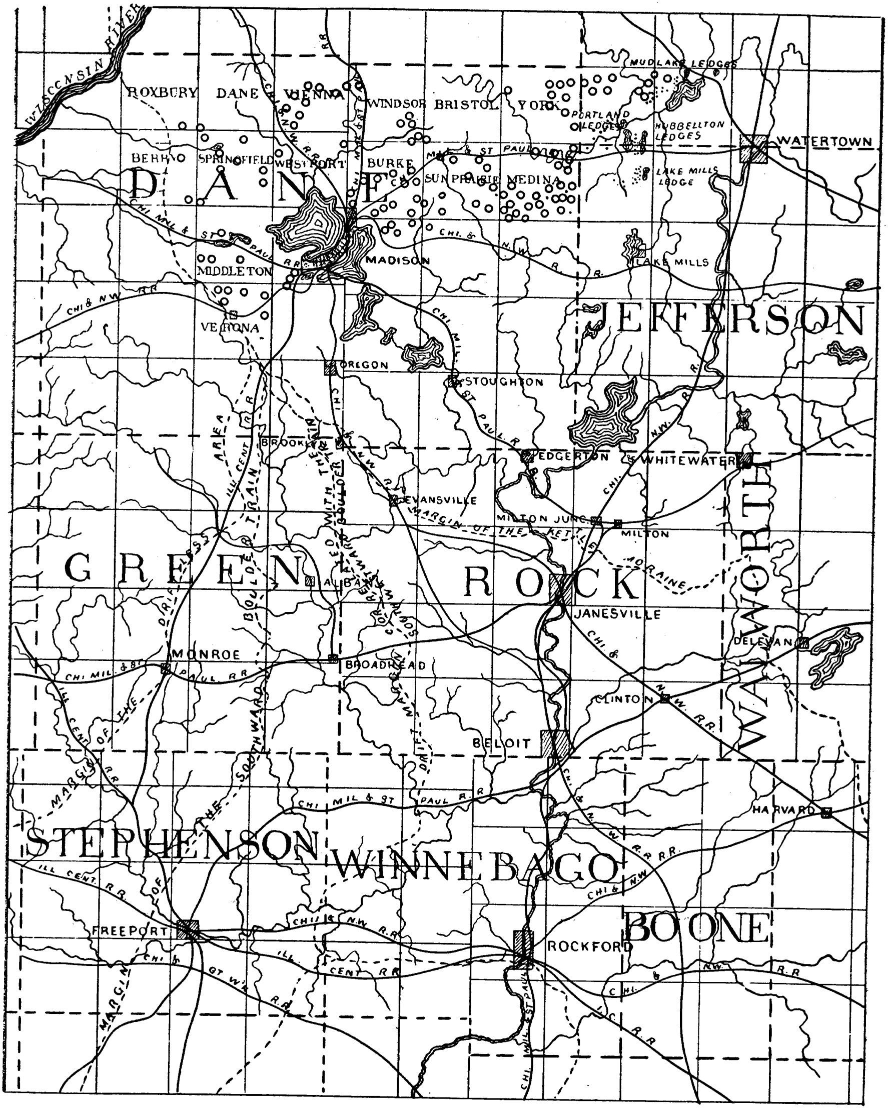
Hypothesis for its phenomena.—The presence of this drift material within the area of the Rock river basin and along the extended axis of the Green Bay lobe, is most satisfactorily explained to the author by the hypothesis of an extended ice tongue down this trough during one of the earlier episodes in the glacial history of this region. Upon the accompanying map the outlines of such a lobe are indicated by the dotted lines, which also include the area of overflow to the southwest, denoted by the esker belts with their quartzite contents in the valleys south and southwest of Freeport.

The amount of quartzite drift observed within the distinctive area of this train, though small as compared with that noted in either of the bowlder fans previously described, is ample for the purpose of identification and definition, and through the median portion of the belt forms a considerable percentage of the crystalline drift found on the surface. About a hundred bowlders and bowlderets have thus far been noted in the region and several hundred smaller fragments. Evidences of glacial wear and reduction are not markedly manifest, as may be shown by the number and comparative size of the bowlders found in the train. There is, however, abundant evidence in the weather-worn and somewhat pitted surface of most of the material that it represents an epoch of glaciation very much older than that of either of the preceding trains. This is seen most strikingly in the larger fragments. Many of the smaller fragments indicate by their surfaces of fresh fracture that they have been much broken up in the process of post-glacial weathering.

THE WESTWARD TRAINS. PLATE XVI.

Area of distribution.—This exceedingly interesting evidence of the complexity of glacial operations that have taken place within the area was the last to be identified in the study of the drift phenomena of the region. Some of the material found in the vicinity of the ledges was, however, noted in my earliest examinations of the region, soon after the discovery of the most remote source of the quartzite drift in the ledges of the Mud Lake area. It was then thought, however, to have originated in some local ledge surface at present concealed beneath the general drift, and the few scattering fragments found at remote localities, in the absence of definite proof, were referred to distant Archæan sources. But the proofs of identity afforded by microscopic examination together with the more careful working out of the limits of this area of quartzite distribution determined the relations of the material as completely as in any of the other areas.

The area of its distribution lies entirely within the Green Bay lobe, but is more completely separate from its fellows than any of the others. The train from the Lake Mills ledge alone inter-



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mingles its drift to any extent with that belonging to the later trains, yet this finally emerges from their area and is deployed on the west margin of the drift covered area.

Its distribution is most distinctly traced from the Mud Lake ledges, where, owing to the marginal position of the outcrops the area of bowlder distribution is entirely separate from each of the succeeding trains.

Bowlders from the east ledge are first found on the surface of the low drumlin ridge which lies in the marsh directly east of the main ledge of the area. Here about one hundred blocks of much weathered quartzite were noted on the surface of a cultivated field or gathered into fence walls on its border, from an area of a few acres northeast of the adjacent ledge. As many more appear on the low ridge just west of the main ledge near the edge of the marsh. On the east slope of the ridge area west of the marsh basin they appear in considerable numbers. The northern limit of their distribution appears in a railway excavation at the point where the track ascends from the marsh on the north line of the township and nearly two miles west from the smaller ledge. Here about twenty large bowlders are left exposed on the sides and over the bottom of a pit formed by the removal of material for the railway grade. These are all from the ledge area to the east and appear to be but a small fraction of the material of this origin which was exposed in the excavation, simply the material too large for convenient removal.

Quartzites are numerous on the ridge slope adjacent to the marsh for the next half mile south. On the east side of the ridge on section four, directly west of the main ledge, something over thirty blocks of quartzite were seen, aggregating one and one-fourth cords. On the ridge surfaces, however, for a mile to the west the quartzites are conspicuons by their absence though the drift is unusually stony, and hundreds of cords of weather worn and glaciated Archæan bowlders are gathered into stone fences. A careful search through these accumulations revealed only a half dozen blocks of local origin in nearly two miles of such material. This feature is noticeable over the whole area westward to the Crawfish river in Portland township. But in the ravines and on the steeper lower slopes of the same ridges in sections 5 and 6, Shields township, the case is different. Whenever in crossing these sections these lower levels are passed the deeply eroded quartzite material characteristic of this bowlder distribution appears. On the west line of section six about 200 of these were counted in a roadside fence whose material was gathered from a surface of perhaps two acres. In each of the half dozen ravines that lie to the east and west of this, similar amounts were seen.

Beyond the township line on this north border the surface is less undulating and the quartzites are of rare occurrence, though in each road side gully from the south line of sec. 6, Shields, to the corresponding line of sec. 7, in Portland township, one or more local fragments appear, and an occasional bowlder is found on the surface. It is impossible to trace the south margin of this train across the area because the succeeding southward drift movements which crossed it and concealed its material over so large a portion of its surface commingled much of the underlying material with their detritus and redistributed it over their own broad fans. It is apparent though from the gradual declination of the north margin as traced across the area that the direction of ice movement in this part of its area was a little south of west, and that the center of the train crossed the north half of Portland township to the center of its west line. Quartzites appear in considerable numbers on the borders of ravines and on the steeper ridge slopes from sections 12 and 13 to 18 and 19. South of this line the more abundant and completely disseminated distribution appears to belong to later southwestward trains from the same sources.

The westward train from the Portland ledges is marked by less abundant surface distribution over the areas bordering the south line of Portland and York townships. Many blocks, however, were found on the surface on the east line of sections 30 and 31, Portland. Along the roadside on the south line of section 31, Portland, and 36, York, the same peculiarity of distribution was observed as upon the area west of the Mud Lake outcrops, namely, the absence of local drift on the crest of the ridges and the not infrequent occurrence of quartzite blocks, in the ravines and on the lower slopes. The massive drumlin forms thickly set over this area indicate a deep deposition over its surface of the products of the latest drift which appears, in the frequent road and railway sections that have been examined in the region, to be almost free from the local quartzite material.

Over the east half of York township from its second tier of sections southward, quartzites are of frequent occurrence on the surface. They are rarely seen, however, on its west half and and none at all in the next township west except in its southwest corner. Here and in the adjacent corner of Windsor, several fragments were found after careful search through a number of roadway sections. Others were found on the west line of this township, the one farthest north on a ridge slope on section 7, west of De Forest station. In the south half of Vienna township three or four bowlders and several smaller fragments were found on the surface and in roadway sections. Two or three were noted in each of the townships to the west, Dane and Roxbury, which mark the northern limits of this bowlder train as here defined.

The center of the train is traced by a more abundant distribution which crosses the next tier of townships to the south, and includes the north half of Medina, all of Sun Prairie except its southeast corner which lies within the bounds of the southwestern train, and the townships of Burke, Westport, Springfield, Berry, Madison, Middleton, and the east margin of Cross Plains. In the townships nearest the ledges, bowlders and smaller fragments are found on nearly all ridge surfaces. In Sun Prairie township they are much less abundant, a half dozen only having been noted within the limits here defined. In Burke township a few were seen upon the high limestone underlaid plateau east of the lakes, and several in the kame deposits found in the valley followed by the Madison and Watertown railway. In Madison township a half dozen quartzite cobbles were found in a gravel pit on the roadside directly east of Lake Mendota and three fragments from as many different areas of the Waterloo group in a railway excavation on the line of the Illinois Central in section 29, two miles southwest of the city.

Others found further south in the north half of the townships of Cottage Grove, Blooming Grove, Fitchburg and Verona were doubtless brought westward by the same drift movement as the last, but were probably redistributed by the later drift movements.

Amount of material.—The amount of material noted within this area is comparatively small as would be inferred from the general concealment of its drift beneath the detritus of later deposits. In the localities described within the proximal portion of the trains about ten cords of quartzites were observed. Over the medial and marginal portions of the train a summary of the whole material noted on a surface exceeding twelve townships in area aggregates less than one-half of a cord. Yet it includes the actual enumeration of some hundreds of fragments of undoubted Waterloo origin, so distributed as to define a symmetrical bowlder fan whose outlines are in exact correspondence with a distribution along lines radially divergent, which may reasonably be referred to the marginal action of an ice lobe whose axis lay somewhere in the line of the Lake Michigan basin.

Correlation.—A correlation of this bowlder distribution with the thin, marginal drift deposit which has already been referred to in the description of the southwestward train is natural and supported by facts apparently conclusive. Among the limestone fragments which abound in certain portions of this marginal drift, fossils from the Niagara and water-lime formations of the area adjacent to Lake Michigan are of frequent occurrence which demonstrate that this drift was laid down along the margin of an ice sheet which crossed the area from the lake basin. This distribution of Niagara and Devonian fossils was along lines parallel with the bowlder belt just outlined and both belong apparently to the earliest incursion of the glacial ice across this region.

CORRELATION OF DATA WITH PHENOMENA IN ADJACENT AREAS.

Naturally the discovery of the complexity of features of drift phenomena shown in this limited district has led to much labor in the attempt to correlate these successive phases of drift movement with determinations made elsewhere.

The results of Mr. Leverett's work in adjacent areas of Illinois are of greatest interest in this connection inasmuch as they cover in part the area under consideration. He has differentiated in this state a broad outer belt of much oxidized till with a surface of old soil which is itself covered over large areas by a loess-like silt. This bears on its surface numerous belts of stratified drift arranged over portions of the area in lines concentric with the drift margin, at others in lines parallel with the glacial movement and indicative of the drainage lines along the retreating ice margin. This drift area in southern and western Illinois is from 60 to 100 miles wide and has hitherto been considered by him to be a simple deposit, the equivalent of what in Iowa Mr. Gee calls the lower till. According to our combined observations on the drift phenomena in the valley of Pecatonica the bowlder trains both of the westward and of the old southward distributions belong to this oldest till. The old silt deposits which are very strongly developed within the valley of the Pecatonica overlie both marginal drift and the adjacent area of the southward fan, and disappear only on the kame-marked borders of the drift deposits here correlated with the southwestward bowlder trains.

The area of comparatively recent drift deposit with its modified drumlin forms and its semi-morainic marginal deposits here described and mapped in connection with the southwestward bowlder train, Mr. Leverett traces down the Rock River valley to the Mississippi and considers it an equivalent of Mr. Gee's upper till of Iowa. The extensive silt deposits overlying the surface of the outer belt gradually thicken as they approach the area occupied by this belt, but disappear upon its margin, very little silt being found on the surface of this later drift. Its deposition is, therefore, considered to be coincident with the melting of the ice sheet over the adjacent area.

Overlying this drift sheet on the southeast margins of the Rock River valley Mr. Leverett traces the margin of a later drift bordered by a massive belt of morainic material which he has designated as the Shelbyville moraine. This covers an area of from fifty to one hundred miles wide from the center of the state eastward to the Kettle moraine. Its northern margin disappears in the northwest corner of Kane county, near the McHenry county line, being overlapped by the formations of the latest drift which here push out beyond its margin.

It has been already noted that the old morainic border, which bears the marginal distribution of the southwestward train in southern Dane, northwestern Rock, and the northeast corner of Green, overlies the kame ridges which appear in Rock and Winnebago counties, as the marginal deposits of the southwestward glacial movement. As this belt itself disappears beneath the Kettle moraine in the center of Union township, Rock county, it is impossible to correlate it with any of the succeeding morainic belts that cross the area west of Janesville, and we have the choice of two hypotheses, either that the quartzite bearing ridge is a northwestward continuation of one of the inner belts that cross the center of Rock county, or that it is a correlative of the later and more distant Shelbyville moraine. In the former case the belts are separated by an overlap of ten or twelve miles. In the latter case, their interval of separation is about 75 miles.

These investigations furnish no data for the determination of this question, and it is immaterial to our present purpose to do so, as the drift movement which effected this marginal distribution, even if synchronous with that producing the Shelbyville moraine, must have followed the same lines as that effecting the earlier morainic deposits of Rock and Winnebago counties. In the latter case we would have not four but five bowlder trains, the third and fourth so closely overlapping as to be indistinguishable.

TIME RATIOS.

The time ratios indicated by the condition of the bowlder material in the successive trains show a very wide lapse between the earliest and latest depositions. The weathered condition of the material in the westward train as compared with that observed in the drift section south of the Portland ledges denotes a ratio greater even than ten to one. This interval appears to be divided rather unequally by the succeeding episodes, the material found on the area of the southward trains showing apparently less than half the erosion that marks the oldest drift. The southwestward train also stands apparently in closer relation to the latest drift than to the earlier, and still the interval between these as measured by erosion on bowlder and drift surfaces is evidently more than 2 to 1.

SUMMARY.

The ledge areas under consideration lie in the basin of the Crawfish, a small western tributary of Rock river, in southeastern Wisconsin. They occur within the horizon of the lower Silurian, adjacent areas showing beds of Cambrian rock.

The crystalline strata are sharply flexed and folded, resulting in extreme alteration in the structure of the rock through dynamic metamorphism. Four different types of quartzite are distinguished, the variations resulting from differences in the original composition of the beds and varying degrees of metamorphism. These differences, though not great, are sufficient to distinguish material belonging to the different ledge areas in all parts of the bowlder fan. The ledge areas are themselves divided into four groups corresponding in the main to these four types of rock.

The quartzite drift distributed from these ledge areas appears in separate bowlder trains, covering in part distinct areas, and indicating successive drift movements separated by considerable time intervals and crossing the area in widely divergent directions. The earliest of these is a bowlder train which extends from the ledge areas westward across the north half of Dane county to the drift margin near the Wisconsin. The observed amount of quartzite material in this train though small is sufficient to determine the proximate limits of its bowlder fan and the area of its distribution covers about 16 townships or 600 square miles.

The bowlder train of the next succeeding glacial dispersal extends southward from the ledge areas down the Rock river valley, and overlapping in part the tributary basins of the Pecatonica and Sugar rivers on the west. This is the most extended train of the series, its peripheral limits being eighty miles distant from the most remote source of its quartzite constituent. The overlapping of the proximal half of its area by the later trains prevents any approximation of the amount of material which should be included in this bowlder fan, but over the central belt of the train in the west half of Rock county, over a hundred quartzite bowlders and several hundred smaller fragments were noted, an amount largely in excess of that noted upon corresponding areas of the earlier fan. Its margins are clearly defined for only a short distance on the west side of the Sugar river valley. In the adjacent valley of the Pecatonica they are buried beneath the deep loess accumulations which surround the southwest margin of the succeeding drift sheet, and on the east side of Rock river the thick overlying deposit of later drift largely conceals the material of earlier deposits, only an occasional quartzite fragment appearing in the deeper rosion sections to attest the southward movement from the edge areas on this side of the valley.

The breadth of the fan as indicated by the limital distribution of its quartzite fragments is considerable, even when compared with the extreme elongation of its train. It covers almost the whole breadth of Rock county on its north line and nearer the south line of the state covers the east range of townships in Green county and the succeeding four ranges of townships in Rock county. In Illinois it covers the whole breadth of Winnebago county and the adjacent range of townships in Stephenson. Its area outside of the Kettle moraine is over 1,000 square miles. Its sharply defined west margin, in the east half of Green county, Wis., is its most characteristic feature, marking as it does a division in the hitherto considered simple genesis of the older drift of the region.

The third bowlder fan extends southwestward from the ledge areas in a direction about midway between the last two. I has a well marked proximal area, in the region adjacent to the two most important ledge groups; quartzites aggregating several hundred cords being noted on the ridge areas crossed by the lines of its glacial movement. Its peripheral distribution is also sharply defined, being confined to a narrow belt of marginal deposits which lie just beyond the southwest border of the Green Bay lobe of the latest drift formation. This terminal moraine is clearly older than the Kettle moraine, being overlapped at both ends by the more massive ridges of fresher drift that belong to this formation, and it in turn overlaps with its fresher material the thin and much eroded drift of the earlier trains. It is here correlated with a well marked drift sheet of northern Illinois traced by Mr. Leverett, from the Wisconsin line southwestward down the Rock river valley to the Mississippi and identified by him with the upper till of the old drift sheet described in Iowa by Mr. McGee. Some features, however, of this morainic belt, which marks the periphery of this bowlder train suggest that it may be correlated with the still later drift sheet bounded in northeastern Illinois by the Shelbyville moraine. In this case we have within these limits a train formed by two successive episodes of glacial advance extending in this area along the same lines and therefore indistinguishable in their effect upon the drift material.

The latest bowlder fan belongs to Green Bay lobe of the last ice sheet and coincides both in extent and in direction with the lines of drift movement indicated by the glacial markings and the till accumulations of that formation. Its bounds are well defined, being marked by the great abundance of quartzite material in its trains. Its breadth increases from eight miles on the south margin of the ledge area to seventeen miles on the outer border of the Kettle moraine. Its area is about 360 square miles. Its surface material aggregates about 35,000 cords, and the relative proportions of local material exposed in drift sections varies from 15 per cent. in railway cuts half a mile south of the Hubbellton ledges to one three-hundredth in sections on the outer slope of the Kettle moraine. The amount of material which is included within the body of the latest drift is estimated from observations made in sections over all parts of the area to show a removal of from fifty to seventy-five feet of rock from the surface of the exposed ledges.

Beloit, Wis.

THE VEGETATION OF THE TOWN PRAIRIE DU SAC.

HERMAN FREDERICK LUEDERS.

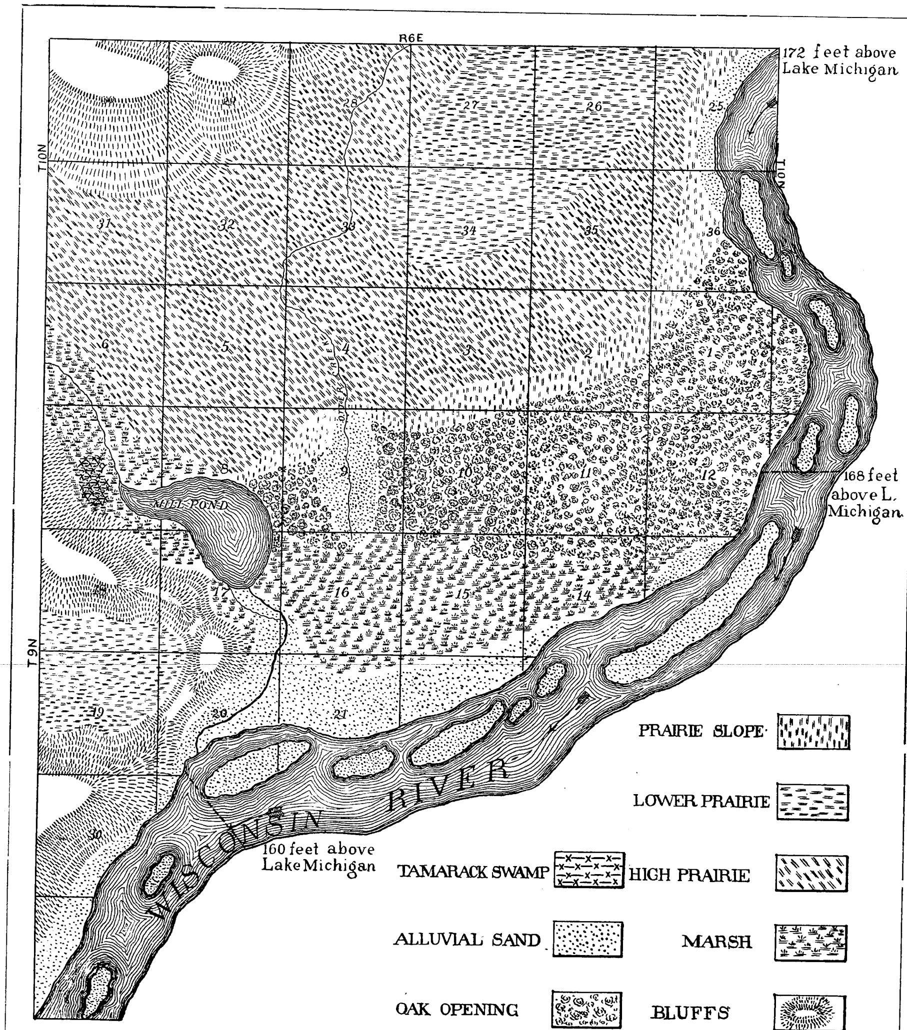
Having during the past twenty years been a witness of the rapidity with which the original boundaries of the distribution of our native vegetation were obliterated, and many formerly abundant species almost destroyed, I concluded to employ a period of enforced partial idleness in obtaining the material for a detailed record of the distribution of the native vegetation of my native county of Sauk.

It is a fragment of this only partly completed work which I here present.

Long continued and intimate acquaintance with the vegetation of the town of Prairie du Sac, had convinced me that the dependence of vegetation on the geological and topographical features of the country received there an unusually forcible expression on account of the number of distinct vegetative groups that presented themselves.

The accompanying map, Plate XVII, is a hasty attempt to retrace the boundaries of these groups as they appeared before invaded by axe and plow.

A few words on the geological surface features of Sauk county may aid in correlating the geology of the town of Prairie du Sac with that of southwest Wisconsin in general. Bounded on the east and south by the Wisconsin river, Sauk county includes in the northern part the most extensive outcrop of Archæan rock possessed by this state, the quartzite of the Baraboo bluffs forming the axis or core of its rocky foundation. Arising near the eastern boundary and extending in a west-northwest direction through several townships, these bluffs are flanked on both sides by unconformably superposed Potsdam sandstone, which in many localities gives evidence of its ancestry and littoral origin by including pebbles and angular fragments of quartzite, or by passing locally into a quartzite con-



LUEDERS ON VEGETATION OF PRAIRIE DU SAC.

glomerate. Farther away from the Archæan the sandstone is capped by Lower Magnesian limestone, which in the depression occupied by parts of the townships of Prairie du Sac and Troy reaches a thickness of about one hundred feet.

The town Prairie du Sac, situated in the southeastern part of the county and bordering on the Wisconsin river, exhibits the same general southeast slope as that part of the county. At the northeast corner of the town we find the surface of the river one hundred and seventy-two feet above Lake Michigan. At the Sauk City bridge a height of one hundred and sixty-eight feet, and at the southwest corner of the town about one hundred and sixty feet.

Notwithstanding that the term "Sauk Prairie" is frequently applied to the surface of the town, a detailed analysis shows, that, instead of being an undulating prairie, it is composed of a series of terraces rising from the river to the northwest. By ascending these terraces we are enabled to note the vegetation of each. The river itself and its two tributaries, Otter and Honey creeks, do not, on account of the rapid flow necessitated by the decided slope of the country, furnish us with an extensive aquatic vegetation. Only some pools show an abundance of Elodea Canadensis, Potamogeton amplifolius, P. spirillus, P. Robbinsii (?) and Spirodela polyrrhiza, with occasional colonies of Nuphar advena and Nymphaea tuberosa.

Commencing our survey at the river bank in section 14, town 9, range 6, we find the river bank built up to a height of about six feet by pinkish and yellowish sand, disposed in thin layers, and with the frequency of false bedding peculiar to stream-built strata. Above the sand we find a variable thickness of vegetable mold reaching in some places three feet in thickness and in some places grading into peat of varying degrees of decomposition.

Having ascended this almost barren bank we stand upon a nearly level tract of land extending northward about one mile and following the river for a distance of about three miles. The subsoil is a heavy bluish clay, upon which follows a bed of fine white sand, which is again succeeded by vegetable mold. This on account of the level surface and imperviousness of subsoil is soaked with water during the greater part of the year, and from its consequent wealth of humic acid becomes fitted for a very characteristic vegetation which includes about three-fifths of all the species found within the limits of the town, and contains an unusually large number of forms peculiar to itself. Prominent among these we note: Ranunculus multifidus, Sarracenia purpurea, Viola blanda, Stellaria longifolia, Hypericum mutilum, Elodes campanulata, Potentilla palustris, Saxifraga Pennsylvanica, Parnassia Caroliniana, Lythrum alatum, Epilobium lineare, Cicuta bulbifera, Galium trifidum, Eupatorium perfoliatum, Boltonia asteroides, Aster Novæ-Angliæ, A. Tradescanti, A. longifolius, Coreopsis trichosperma, Campanula aparinoides, Gentiana Andrewsii, Menyanthes trifoliata, Chelone glabra, Veronica anagallis, Gerardia purpurea, Pedicularis lanceolata, Scutellaria galericulata, Polygonum amphibium, P. sagittatum, Salix discolor, S. petiolaris, Spiranthes cernua, Habenaria psycodes, Lilium Philadelphicum, Juncus tenuis, Acorus Calamus, Typha latifolia, Sagittaria latifolia, Dulichium spathaceum, Eriophorum cyperinum, E. polystachyon, Carex stricta, C. vulgaris, C. grisea, C. rosea, Leersia oryzoides, Zizania aquatica, Cinna arundinacea, Calamagrostis Canadensis, Glyceria fluitans, G. Canadensis, and Aspidium thelypteris. A similar but smaller and distinct area extends several miles along Honey creek.

Proceeding in a northerly direction we come to a steep ascent. A clay bank rises about twenty feet above the level of the marsh, and ascending this we come to an undulating area of irregular boundary. Its soil consists in most places of a thin layer of vegetable mold resting upon a stratum of porous sand varying from one to four feet in thickness, and followed by a thin sheet of gravel, which at the southern edge of this area is about four feet below the surface but gradually rises till it comes to an outcrop along the northern edge. The vegetation of this step of the terrace varies with the varying undulation of the surface, but the following are some of its most constant components: Anemone nemorosa, Lupinus perennis, Baptisia leucophæ, Œnothera pumila, Monarda fistulosa, Corylus Americana, Juglans alba, Quercus alba, Q. rubra and Q. macrocarpa.

Pursuing our course for another mile, we come to another ascent, but much more gradual than the previous, so that, while gradually reaching a height of about sixty feet above the level of the oak-opening, this rise is distributed over about half a mile. This slope has a few vegetation elements peculiar to itself, namely: Anemone patens, var. Nuttalliana, Linaria Canadensis, Œnothera rhombipetela, Aster multiflorus, A. oblongifolius, Arctostaphylos Uva-ursi, and Castilleia sessiliflora.

On the whole, however, the character of the vegetation here is transitional; being intermediate between that of the oak-opening below and the undulating prairie above. The flora of the latter as it stretches now for several miles to the north and east is peculiarly uniform. The Gramineae predominate here at all times, and among them we may mention as characteristic the following: Andropogon furcatus, A. scoparius, Chrysopogon nutans, Sporobulus asper, Bouteloua hirsuta, and Festuca tenella.

In the northeastern part of the town we find a depression in this plain, sinking to about twenty feet below the general level of the surrounding prairie, and, as the soil, which is light and sandy on the latter, here has a larger proportion of clay and loam, the vegetation has, aside from greater luxuriance, some forms that nowhere else form such prominent features, as: Agrostis scabra, A. perennans, Asclepias Cornuti, Viola pedatifida, and Ranunculus rhomboideus. In the southwestern part of the town we have a smaller area of similar vegetation.

Turning now to the west we are met by another sudden rise; this is more considerable than any preceding.

We stand at the foot of the bluff region which is here composed of a series of well-worn sand-stone bluffs rising about two hundred feet above the adjoining high prairie and partly capped by magnesian limestone.

Two separate branches of the general bluff system of Sauk county enter the town; the one cutting off the northwest corner and barely reaching into the limestone horizon, the other entering about the middle of the west line and covering the greater part of that tier of sections down to the southwest corner where some bluffs reach a height of three hundred and fifty feet above the surrounding country.

The foot of these bluffs is well protected by detritus and supports a mixed growth of trees and a few characteristic shrubs and herbaceous plants as: Staphylea trifolia, Arabis Canadensis, Astragalus Canadensis, Polypodium vulgare and Camptosorus rhizophyllus. The sides of the bluffs are frequently too steep for larger vegetation; but we notice Pellaea gracilis, P. atropurpurea, Cheilanthes lanuginosa, Woodsia Ilvensis, Sullivantia Ohionis, Aconitum uncinatum; and on the brow of the bluffs, Symphoricarpus racemosus, Juniperus Virginianus, J. communis, Opuntia Rafinesquii, and Zygadenus elegans.

We have now mounted four successive terrace-steps and found on each some vegetative forms that reached there a fuller development than at other levels and we have in this way covered the greater part of the surface of the town. Two groups have however escaped our notice. The greater part of the course of the Wisconsin river and parts of Honey and Otter creek are fringed by a narrow belt of alluvial sand with hardly any organic or other material to hold the sand together. Its vegetation is therefore wholly dependent upon the streams for moisture and nourishment. Out of similar material the Wisconsin builds its islands that wax and wane at every freshet. The flora of this alluvial sand is not a large one, and is very homegeneous. Vilfa cryptandra, Spartina cynosuroides, Salix longifolia, Betula nigra, Fraxinus Americana, Acer dasycarpum, Thalictrum purpurascens, and Ranunculus abortivus, are its most prominent species.

Another quite distinct group of vegetation is represented by an area of about 40 acres in the centre of section 7. The tamarack swamp, with its characteristic Larix Americana, Cypripedium spectabile, Betula pumila, Rhamnus alnifolius, Trientalis Americana, Cornus Canadensis, and Rhus venenata, has here its typical representation.

With this I close my hasty survey of the vegetation of that region. We see that the surface of the town is mostly disposed in a series of steps differing from one another in character of soil and as a consequence also in the vegetative forms prevailing over the area of these steps.

The species mentioned as typical for each group have been chosen with reference to this locality only, but comparison with notes taken in other parts of the state make me feel confident that elsewhere similar environments will allow us to establish corresponding vegetative groups coinciding with the above in their leading forms.

In order to allow a more detailed comparison of the flora of this region with others, I append a list of all the indigenous and introduced plants that I have found here existing without or contrary to the wishes of man. I call attention to the rare and local Sullivantia Ohionis, and also to the fact that Salsola kali tragus appeared here in 1890, but in a single specimen only, which was transferred to my herbarium. None have been noticed since that time.

PRELIMINARY LIST OF PHENOGAMIA AND PTERIDOPHYTA OF THE TOWN OF PRAIRIE DU SAC, WIS.

Clematis Virginiana L.

Anemone patens L.,
var. Nuttalliana GR.
" cylindrica GR.
" Virginiana L.
" Pennsylvanica L.
" nemorosa L.

Hepatica triloba CHAIX.
" acutiloba DC.

Anemonella thalictroides SPACH.

Thalictrum dioicum L.
" purpurascens L.
" polygamum MUHL(?).

Ranunculus aquatilis L., var.
trichophyllus GR.
" multifidus PURSH.
" rhomboideus GOLD.
" abortivus L.
" recurvatus POIR.
" fascicularis MUHL.
" septentrionalis POIR.
" repens L. (?)
" PennsylvanicusL. f.

Caltha palustris L.

Aquilegia Canadensis L.

Delphinum Consolida L.

Aconitum uncinatum L.

Actaea alba BIGELOW.
" spicata L., var. rubra AIT.

Nigella damascena L.

Menispermum Canadense L.

Berberis vulgare L.

Caulophyllum thalictroides MX.

Jeffersonia diphylla PERS.

Podophyllum peltatum L.

Nymphaea tuberosa AIT.

Nuphar advena AIT. F.

Sarracenia purpurea L.

Sanguinaria Canadensis L.

Adlumia cirrhosa RAF.

Dicentra Cucullaria DC.

Dentaria laciniata MUHL.

Cardamine rhomboidea DC.
" hirsuta L.

Arabis Canadensis L.
" lyrata L.
" dentata TORR. & GRAY.

Draba Caroliniana WALT.

Alyssum maritimum L.

Camelina sativa CRANTZ.

Nasturtium obtusum NUTT.
" armoracia FRIES.

Barbarea vulgaris R. BR.

Hesperis matronalis R. BR.

Sisymbrium officinalis SCOP.

Brassica sinapistrum BOISS.
" nigra KOCH.

Capsella bursa-pastoris MŒNCH.

Lepidium Virginicum L.

Thlaspi arvense L.

HelianthenumCanadensis MX.

Lechea thymifolia MICHX.

Viola pedata L.
" pedatifida G. DON.
" palmata L.
" cucullata GRAY.
" sagittata AIT.
" blanda WILLD.
" lanceolata L.
" pubescens AIT.
" tricolor L.

Gypsophila muralis L.

Saponaria officinalis L.
" Vaccaria L.

Silene Armeria L.
" antirrhina L.

Saline noctiflora L.
Lychnis Githago LAM.
Arenaria lateriflora L.
" Michauxii HOOK. F.
Stellaria media SMITH.
" longifolia MUHL.
" longipes GOLD.
Cerastium nutans RAF.
Portulaca oleracea L.
" grandiflora.
Hypericum Ascyron L.
" perforatum L.
" mutilum L.
" Canadense L.
" maculatum WALT.
Elodes campanulata PURSH.
Malva rotundifolia L.
" sylvestris L.
Abutilon Avicennae GAERT.
Hibiscus trionum L.
Tilia Americana L.
Linum sulcatum RIDDELL.
" usitatissimum L.
Geranium maculatum L.
" Carolinianum L.
Erodium cicutarium L'HER.
Oxalis violacea L.
" corniculata L., var. stricta SAV.
Impatiens fulva NUTT.
Xanthoxylum Americanum MILL.
Ilex verticillata GRAY.
Celastrus scandens L.
Euonymus atropurpureus JACQ.
Rhamnus alnifolius L'HER.
Ceanothus Americanus L.
Vitis labrusca L.
" cordifolia MICH.
" riparia MICHX.
Ampelopsis quinquefolia MX.
Acer dasycarpum EHRH.

Acer rubrum L.
Staphylea trifolia L.
Rhus typhina L.
" glabra L.
" venenata L.
" toxicodendron L.
Polygala polygama WALT.
" sanguinea L.
" Senega L.
" verticillata L.
Baptisia leucantha T. & GR.
" leucophaea NUTT.
Amorpha canescens NUTT.
" fruticosa PURSH.
Petalostemon violaceus MICHX.
" candidus MICHX.
Tephrosia Virginiana Pers.
Robinia Pseudacacia L.
Lupinus perennis L.
Trifolium pratense L.
" repens L.
" hybridum L.
Melilotus officinalis WILLD.
" alba LAM.
Astragalus Canadensis L.
Desmodium acuminatum DC.
" Dillenii DARLINGT
" Canadense DC.
Lespedeza capitata MICHX.
Vicia Caroliniana WALT.
" Americana MUHL.
" Cracca L.
Lathyrus palustris L.
Apios tuberosa MOENCH.
Amphicarpaea monoica NUTT
Prunus Americana MARSHALL
" Pennsylvanica L. F.
" Virginiana L.
" serotina EHRT.
Spiræa salicifolia L.
" tomentosa L.
Physocarpus opulifolius MAXIM.
Rubus triflorus RICHARDS.

Rubus strigosus MICHX.
" occidentalis L.
" villosus AIT.
" Canadensis L.
" hispidus L.

Geum Virginianum L.
" strictum AIT.
" triflorum PURSH.

Fragaria Virginiana MUHL.

Potentilla arguta PURSH.
" Norvegica L.
" Pennsylvanica L.
" palustris SCOP.
" Canadensis L.

Agrimonia Eupatoria L.

Rosa blanda AIT.
" Carolina L.
" Sayi SCHWEIN.
" lucida EHRH.
" humilis MARSH.

Cratægus coccinea L.

Amelanchier Canadensis, var. oblongifolia TORR. & GR.

Amelanchier alnifolius NUTT.

Saxifraga Pennsylvanica L.

Sullivantia Ohionis TORR. & GR.

Mitella diphylla L.

Heuchera Americana L.

Parnassia Caroliniana MICHX.

Ribes Cynosbati L.
" gracile MICHX.
" oxyacanthoides L.
" floridum L'HER.

Penthorum sedoides L.

Sedum acre L.
" telephioides MICHX.

Myriophyllum spicatum L.

Hippuris vulgaris L.

Callitriche verna L.

Lythrum alatum PURSH.

Ludwigia polycarpa SH. & PET.
" palustris ELL.

Epilobium augustifolium L.

Epilobium lineare MUHL.
" coloratum MUHL.

Œnothera biennis L.
" rhombipetala NUTT.
" pumila L.

Circaea Lutetiana L.

Sycios angulatus L.

Echinocystis lobata T. & GR.

Opuntia Rafinesquii ENGELM.

Mollugo verticillata L.

Pastinaca sativa L.

Thaspium aureum NUTT.

Cryptotaenia Canadensis DC.

Sium cicutaefolium GMELIN.

Carum Carui L.

Cicuta maculata L.
" bulbifera L.

Osmorrhiza longistylis DC.
" brevistylis DC.

Eryngium yuccaefolium MICHX.

Sanicula Marilandica L.

Aralia nudicaulis L.

Cornus sericea L.
" Canadense L.
" stolonifera MICHX.
" paniculata L'HER.

Sambucus Canadensis L.

Viburnum opulus L.
" acerifolium L.
" dentatum L.
" Lentago L.

Triosteum perfoliatum L.

Symphoricarpus racemosus MX.

Lonicera glauca HILL.

Diervilla trifida MOENCH.

Cephalanthus occidentalis L.

Mitchella repens L.

Galium Mollugo L.
" Aparine L.
" boreale L.
" trifidum L.
" triflorum MICHX.

Vernonia fasciculata Michx.

Eupatorium purpureum L.
" sessilifolium L.
" perfoliatum L.
" ageratoides L.

Kuhnia eupatorioides L.

Liatris cylindracea Michx.
" scariosa Willd.
" pycnostachya Michx.

Solidago speciosa Nutt.
" ulmifolia Nutt.
" arguta Ait.
" Missouriense Nutt.
" nemoralis Ait.
" rigida L.
" lanceolata L.

Boltonia asteroides L'Her.

Aster grandiflorus L.
" oblongifolius Nutt.
" Novae-Angliae L.
" sericeus Vent.
" azureus Lindl.
" sagittifolius Willd.
" laevis L.
" multiflorus Ait.
" dumosus L.
" diffusus Ait.
" Tradescanti L.
" longifolius Lam.
" puniceus L.
" umbellatus Miller.
" linariifolius L.
" ptarmicoides T. & Gr.

Erigeron Canadense L.
" annuus Pers.
" strigosus Muhl.
" bellidifolium Muhl.

Antennaria plantaginifolia Hk.

Gnaphalium polycephalum Mx.
" uliginosum L.

Silphium integrifolium Michx.

Xanthium strumarium L.

Heliopsis laevis Pers.

Rudbeckia laciniata L.
" subtomentosa Pursh.
" hirta L.

Lepachys pinnata Torr. & Gray.

Helianthus annuus L.
" rigidus Desf.
" occidentalis Ridd.
" grosse-serratus Martens.
" strumosus L.
" decapetalus L.

Coreopsis palmata Nutt.
" trichosperma Michx.

Bidens frondosa L.
" connata Muhl.
" cernua L.
" chrysanthemoides Muhl.

Helenium autumnale L.

Anthemis Cotula D.C.
" arvensis L.

Achillea millefolium L.

Chrysanthemum leucanthemum L.

Tanacetum vulgare L.

Artemisia Canadensis Michx.
" Ludoviciana Nutt.
" vulgaris L.
" biennis Willd.

Senecio aureus L.

Cacalia suaveolens L.

Erechtites hieracifolia Raf.

Arctium Lappa L.

Cnicus lanceolata Hoff.
" altissimus Willd.
" muticus Pursh.
" pumilus Torr.
" arvensis Hoffm.

Onopordon acanthium L.

Centaurea cyanus L.

Krigia amplexicaulis Nutt.

Cichorium Intybus L.

Hieracium Canadensis Michx.
" scabrum Michx.
" Gronovii L.
" longipilum Torr.

Prenanthes serpentaria Pursh.

Lactuca Scariola L.

Lactuca Canadensis L.
" integrifolia BIG.
" leucophaea GRAY.

Sonchus asper WILLD.

Lobelia cardinalis L.
" syphilitica L.
" spicata LAM.
" inflata L.

Specularia perfoliata DC.

Campanula rotundifolia L.
" aparinoides PURSH.
" Americana L.

Gaylussaccia resinosa TORR. & GRAY.

Vaccinium Pennsylvanicum LAM.

Arctostaphylos Uva-ursi SPRENG.

Chimaphila umbellata NUTT.

Pyrola secunda L.
" elliptica NUTT.
" rotundifolia L.

Monotropa uniflora L.

Dodecatheon Meadia L.

Steironema ciliatum RAF.
" lanceolatum GRAY.
" longifolium GRAY.

Lysimachia quadrifolia L.
" stricta AIT.

Fraxinus Americana L.
" sambucifolia L.

Apocynum androsaemifolium L.
" cannabinum L.

Asclepias tuberosa L.
" incarnata L.
" Cornuti DECAISNE.
" obtusifolia MICHX.
" phytolaccoides PH.
ovalifolia DECAISNE.
verticillata L.

Acerates longifolia ELL.
" viridiflora ELL.

Gentiana crinita FROEL.
" quinqueflora LAM.
puberula MICHX.

Gentiana Andrewsii GRIES.
" alba MUHL.

Menyanthes trifoliata L.

Phlox pilosa L.
" divaricata L.

Polemonium reptans L.
" caeruleum L.

Hydrophyllum Virginicum L.

Echinospermum Virginicum LEHM.
" Lappula LEHM.

Cynoglossum officinale L.

Myosotis verna NUTT.

Lithospermum hirtum LEHM.
" canescens LEHM.
" angustifolium MICHX.

Echium vulgare L.

Convolvulus Sepium L.
" arvensis L.

Cuscuta Gronovii WILLD.
" compacta JUSS.

Solanum nigrum L.
" rostratum DUNAL.

Physalis viscosa L.
" lanceolata MICHX.

Datura Stramonium L.

Verbascum Thapsus L.
" blattaria L.

Linaria Canadensis DUMONT.
" vulgaris MILLER.

Scrophularia nodosa L., var. Marilandica GRAY.

Chelone glabra L.

Pentstemon pubescens SOLAND.

Mimulus ringens L.

Gratiola Virginiana L.

Ilysanthes gratioloides BENTH.

Veronica Virginica L.
" Anagallis L.
" peregrina L.

Gerardia grandiflora BENTH.

Gerardia purpurea L.
" tenuifolia VAHL.
Castilleia coccinea SPRENG.
" sessiliflora PURSH.
Pedicularis Canadensis L.
" lanceolata MICHX.
Aphyllon uniflorum GRAY.
Utricularia vulgaris L.
Verbena urticifolia L.
" hastata L.
" bracteosa MICHX.
" stricta VENT.
Phryma leptostachya L.
Teucrium Canadense L.
Mentha Canadense L.
Lycopus Virginicus L.
Pycnanthemum lanceolatum PH.
Hedeoma hispida PURSH.
Monarda fistulosa L.
" punctata L.
Lophanthus scrophulariaefolius BENTH.
Scutellaria lateriflora L.
" versicolor NUTT.
" parvula MICHX.
" galericulata MICHX.
Brunella vulgaris L.
Physostegia Virginiana L.
Leonurus Cardiaca L.
Galeopsis Tetrahit L.
Stachys palustris L.
Plantago major L.
" lancolata L.
Oxybaphus nyctagyneus SWEET.
Anychia dichotoma MICHX.
Amarantus retroflexus L.
" albus L.
Acnida tuberculata MOQ.
Chenopodium album L.
" hybridum L.
" Botrys L.
Salsola Kali L., var. tragus.
Rumex Britannicus L.
" verticillatus L.
" Acetosella L.
Polygonum aviculare L.
" ramosissimum MX.
" amphibium L.
" Hydropiper L.
" orientale L.
" Pennsylvanicum L.
" sagittatum L.
" Convolvulus L.
Fagopyrum esculentum MOENCH.
Asarum Canadense L.
Comandra umbellata NUTT.
Euphorbia serpyllifolia PERS.
" maculata L.
" corollata L.
" Cyparissias L.
Acalypha Virginica L.
Ulmus Americana L.
" fulva MICHX.
Celtis occidentalis L.
Cannabis sativa L.
Humulus lupulus L.
Morus alba L.
Urtica gracilis AIT.
Laportea Canadensis GAUD.
Pilea pumila GRAY.
Boehmeria cylindrica WILLD.
Parietaria Pennsylvanica MUHL.
Platanus occidentalis L.
Juglans cinerea L.
Carya alba NUTT.
" amara NUTT.
Betula pumila L.
" populifolia AIT.
" nigra L.
Alnus incana WILLD.
Corylus Americana WILLD.
Ostrya Virginica WILLD.
Carpinus Caroliniana WALT.

Quercus alba L.
" stellata WANG.
" macrocarpa MICHX.
" bicolor WILLD.
" rubra L.
" coccinea WANG.

Salix lucida MUHL.
" fragilis L.
" longifolia MUHL.
" discolor MUHL.
" humilis MARSH.
" petiolaris SMITH.
" purpurea L.

Populus alba L.
" tremuloides MICHX.
" grandidentata MICHX.
" balsamifera L.
" monilifera AIT.

Ceratophyllum demersum L.

Elodea Canadensis WILLD.

Vallisneria spiralis L.

Microstylis ophioglossoides NUTT.

Liparis liliifolia RICH.
" Loeselii RICH.

Spiranthes cernua RICH.
" gracilis BIG.

Goodyeara pubescens R. BR.

Calopogon pulchellus R. BR.

Orchis spectabilis L.

Habenaria virescens SPRENG.
" bracteata R. BR.
" lacera R. BR.
" psycodes GR.

Cypripedium spectabile SWTZ.
" pubescens WILLD.

Iris versicolor L.

Belmacanda Chinensis ADAM.

Sisyrinchium angustifolium NUTT.

Hypoxis erecta L.

Dioscorea villosa L.

Smilax herbacea L.
" glauca WALT.

Smilax hispida MUHL.

Allium Canadense KALM

Ornithogalum umbellatum L.

Hemerocallis fulva L.

Polygonatum giganteum DIET.

Asparagus officinalis L.

Smilacina racemosa DESF.
" stellata DESF.

Maianthemum Canadense DESF.

Clintonia borealis RAF.

Uvularia perfoliata L.
" grandiflora SMITH.

Erythronium Americanum KER.

Lilium Philadelphicum L.
" Canadense L.

Trillium grandiflorum SALISB.
" cernuum L.

Zygadenus elegans PURSH.

Heteranthera graminea VAHL.

Tradescantia Virginica L.

Juncus effusus L.
" tenuis WILLD.
" bufonius L.
" nodosus L.

Luzula campestris DC.

Typha latifolia L.

Sparganium eurycarpum ENGELM.

Arisaema triphyllum T. & GR.
" Dracontium SCHOTT.

Acorus Calamus L.

Spirodela polyrrhiza SCHLEID.

Lemna trisulca L.

Alisma plantago L.

Sagittaria latifolia WILLD.

Potamogeton amplifolius TUCK.
" Vaseyi ROBB.
" Spirillus TUCK.
" Robbinsii OAKES.

Naias flexilis ROSTK. & SCHMIDT.

Cyperus diandrus TORR.

Cyperus aristatus ROTTB.
" Schweinitzii TORR.
" filiculmis VAHL.
" speciosus VAHL.

Dulichium spathaceum PERS.

Eleocharis palustris R. BR.
" intermedia SCHULT.
" tenuis SCHULT.
" acicularis R. BR.

Fimbristylis capillaris GRAY.

Scirpus pungens VAHL.
" lacustris L.
" atrovirens MUHL.

Eriophorum cyperinum L.
" polystachyon L.

Hemicarpha subsquarrosa NEES.

Carex intumescens RUDGE.
" monile TUCKERM.
" retrorsa WILLD.
" hystricina MUHL.
" squarrosa L.
" Houghtonii TORR.
" filiformis L.
" riparia W. CURTIS.
" vulgaris FRIES.
" stricta LAM.
" crinita LAM.
" gracillima SCHWEIN.
" grisea WAHL.
" conoidea SCHKUHR.
" laxiflora LAM.
" plantaginea LAM.
" Richardsonii R. BR.
" Pennsylvanica LAM.
" decomposita MUHL.
" alopecoidea TUCKERM.
" vulpinoidea MICHX.
" rosea SCHKUHR.
" foenea WILLD.
" straminea WILLD.
" scoparia SCHKUHR.

Spartina cynosuroides WILLD.

Panicum glabrum GAUDIN.
" sanguinale L.
" proliferum LAM.
" capillare L.
" autumnale BOSC.

Panicum virgatum L.
" latifoliun L.
" depauperatum MUHL.
" dichotomum L.
" Crus-galli LAM.

Setaria verticillata BEAUV.
" glauca BEAUV.
" viridis BEAUV.

Cenchrus tribuloides L.

Leersia Virginica WILLD.
" oryzoides SWARTZ.

Zizania aquatica L.

Andropogon scoparius MICHX.
" furcatus MUHL.

Chrysopogon nutans BENTHAM.

Phalaris arundinacea L.

Hierochloa borealis R & S.

Aristida gracilis ALL.

Stipa spartea TRIN.

Muhlenbergia glomerata TRIN.
" Mexicana TRIN.

Phleum pratense L.

Alopecurus geniculatus L. var. aristulatus TORR.

Sporobolus asper KUNTH.
" cryptandrus GRAY.
" vaginæflorus VASEY.

Agrostis alba L.
" " var. vulgaris THURB.
" perennans TUCKERM.
" scabra WILLD.

Cinna arundinacea L.

Calamagrostis Canadensis BEAUV.

Avena fatua L.

Danthonia spicata BEAUV.

Bouteloua hirsuta LAG.
" racemosa LAG.

Koeleria cristata PERS.

Eatonia obtusata GRAY (?).
" Pennsylvanica GRAY.

Eragrostis reptans NEES.

Eragrostis major HART.
" pilosa BEAUV.
" capillaris Nees.
" pectinacea GRAY.

Dactylis glomerata L.

Poa annua L.
" compressa L.
" nemoralis L.
" serotina EHR.
" pratensis L.

Glyceria Canadensis TRIN.
" obtusa TRIN.
" fluitans R. BR.

Festuca tenella WILLD.
" Myurus L.

Bromus Kalmii GRAY.
" secalinus L.
" racemosus L.
" ciliatus L.

Lolium temulentum L.

Agropyrum repens BEAUV.
" violaceum LANGE.

Elymus Virginicus L.
" Canadensis L.
" striatus WILLD.

Asprella Hystrix WILLD.

Juniperus communis L.
" Virginiana L.

Larix Americana.

Pinus Strobus L.

Adiantum pedatum L.

Polypodium vulgaris L.

Pteris aquilina L.

Cheilanthes lanuginosa NUTT.

Pellaea gracilis HOOK.
" atropurpurea LINK.

Asplenium Filix-foemina BERNH.

Camptosorus rhizophyllus LINK.

Aspidium thelypteris SWARTZ.
" spinulosum SWARTZ, var. dilatatum HOOK.
" cristatum SWARTZ.

Cystopteris bulbifera BERNH.
" fragilis BERNH.

Onoclea sensibilis L.
" struthiopteris HOFF.

Woodsia Ilvensis R. BR.

Osmunda regalis L.
" Claytoniana L.
" cinnamomea L.

Botrychium ternatum SWARTZ.
" Virginianum SWTZ.

Equisetum arvense L.
" limosum L.
" hyemale L.

Sauk City, Wis.

THE RELATION OF THE CORTEX OF THE CAT'S KIDNEY TO THE VOLUME OF THE KIDNEY, AND AN ESTIMATION OF THE NUMBER OF GLOMERULI.

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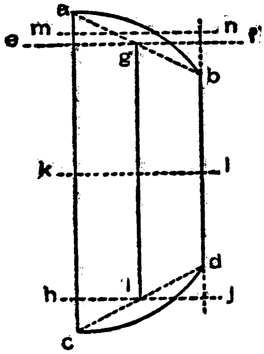
In the following study the kidneys of twelve cats were used; four pair were used fresh, four pair were hardened in Müller's fluid and four pair, after being injected with blue gelatin, were hardened in alcohol. All the animals were chloroformed and bled. The kidneys that were hardened in Müller's fluid and in alcohol were used to determine the per cent. of cortex as shown by area, while the per cent. as shown by volume was estimated on the fresh kidneys. The per cent. of cortex as shown by area was also estimated in the fresh kidneys.

FRESH KIDNEYS.

The kidneys were removed from the body, all fat carefully cut away, the vessels cut close to the hilum and the volume o each kidney found by displacement. The length of each kidney and the distance from hilum to convexity of opposite surface was found by placing each kidney on a piece of sheet cork and erecting perpendicular needles at the several points and measuring the distance between the needles. One of each pair of kidneys was taken and cut into five or six pieces transversely and the exact thickness of each section found by the use of needles; the sum of the thickness of the several sections equaled the total length of the kidney as previously determined.

The separate sections were then taken one by one and covered with a large glass slide; they adhered to this without difficulty and without distortion. The slide was then fastened in a special table in such a manner that the surface of the glass opposite the section of kidney was on a level with the surface of the table. The outline of the section and the boundary line between the medulla and cortex could in this way be plainly seen. With a planimeter the area of the entire section and the entire area less cortex was found in square decimeters, the needle of the planimeter passing over the surface of the glass. Readings were taken on both sides of each section, although theoretically the areas of two sections on the same line ought to be the same. These double readings served as checks on any error. While theoretically the readings on each side of the section line should be the same, in practice it was found there was a slight variation due to the fact that it is next to impossible to follow the lines exactly with the planimeter twice in succession. The sections of the arteries and veins, as well as the difference in color, served as a guide for the dividing line between cortex and medulla; the former had been previously determined as an accurate guide by the careful study, under the microscope, of numerous stained sections.

The entire area of one side was then multiplied by the thickness of the section. This ought to give the exact volume of the section if the area of both sides was the same; but a section was seldom found where both sides did not show considerable variation in area. The exact figure is not the mean of the two areas multiplied by the thickness for this leaves out all curve, which in some sections is great. The truth, as near as we can get at it, is the mean of one-half of the two areas multiplied by the thickness and the greater area multiplied by the thickness. This is shown by the following figure:



The area of side *ac* multiplied by *kl* plus the area of side *bd* multiplied by *kl* divided by 2 is represented by the lines *ef* and *hj*. This leaves the curve entirely out of account. If we add to this mean the greater area multiplied by *kl* and then divide this by 2 we have an area which is represented by the line *mn* and which is as near as we can get at the truth not knowing the exact curve. In this manner the volume of each kidney was calculated, and by subtracting the volume of the medulla the volume of the cortex was obtained.

The kidneys were then taken and with a sharp scalpel the cortex and medulla were separated as accurately as possible. The volume of each was then found by displacement and used as a control for the figures obtained.

The results are given in four tables. The thickness of the medullary portion in the two end sections is not the thickness of the section because the thickness of the cortex must be subtracted. The volume is first found by multiplying one-half of the sum of the two areas of any section by the thickness of section. This is given in column A. The volume found by multiplying the greater area by the thickness is given in column B. The volume of the medulla is found in the same way, with the exception of the two end sections where the thickness of the medullary portion is less than that of the section. The mean is given at the foot of the column. This should be compared with the results found by displacement. The aggregate volume of the four kidneys, the volume of which was computed, was by displacement in water 53.5 cc., while by the method of computation it was 53.23 cc. This shows that while in the computation of a single kidney there is a slight error, it is so small it may practically be disregarded. The aggregate volume of the medulla in the four kidneys was 14.5 cc. by displacement and 14.00 cc. by computation. The area in the the tables is expressed in square decimeters. The average per cent. of cortex by displacement in the four pair of kidneys used fresh was

Cat 1.	Cat 2.	Cat 3.	Cat 4.
.645	.667	.719	.729

The average for four pairs is .690. The per cent. of cortex, by volume, shown by computing volume of medulla and entire volume is

Cat 1.	Cat 2.	Cat 3.	Cat 4.
.575	.679	.766	.784

The average for the four kidneys is .701 per cent. The average volume of twelve pair of kidneys by displacement was 12.9 cc. for both right and left kidneys. The truth is probably nearer .700 than .690 because by the displacement method fractions of a cc. were not noted.

TABLE I. CAT 1.

Left kidney. Volume by displacement in water, 7.5 cc. Length of long axis, 30 mm. The volume of the right kidney was 6.5 cc. The volume of the cortex of the left kidney by displacement was 4.5 cc. and the volume of medulla 3.0 cc.

Section.	Line.	Thickness.	Entire area.	Area medulla.	Area cortex.	Thickness of medulla.	A. Entire volume of kidney.	B. Entire volume of kidney.	A. Volume of medulla.	B. Volume of medulla.
1	1	5 mm.	.015	.004	.011	1 mm.	.375	.750	.020	040
2	1	5 mm.	.017	.004	.013	5 mm.	1.050	1.250	.500	.800
3	2	6 mm.	.025	.016	.090-.010	6 mm.	1.650	1.800	.9225	.960
4	3	7 mm.	.030	.01475	.0615	7 mm.	1.610	2.100	.69125	1.0325
5	4	7 mm.	.016	.005	.011	3.25mm	.560	1.120	.08125	.1625
						Total ..	5.245	7.020	2.2150	2.9950
						Mean ..	6.1325 cc.		2.605 cc.	

TABLE II. CAT 2.

Left Kidney. Volume by displacement in water, 8.5 cc. Length of long axis, 34 mm. The volume of the right kidney was 8 cc. and the length 34.5 mm., but the volume was only found by displacement. The volume of the cortex of the left kidney by displacement was 5.5 cc. and the medulla was 2.5 cc.

Section.	Line.	Thickness.	Entire area.	Area medulla.	Area cortex.	Thickness of medulla.	A. Entire volume of kidney.	B. Entire volume of kidney.	A. Volume of medulla.	B. Volume of medulla.
1	1	4.5 mm.	.016	006	.010	.5 mm.	.3600	.7200	.0150	.0300
2	1	6.5 mm.	.018	.004	.014	6.5 mm.	1.6575	2.1450	.5200	.7800
2	2	......	.033	.012	.021	....	......	....	....	....
3	2	7.5 mm.	.033	.015	.018	7.5 mm.	2.4000	2.4750	.9375	1.1250
3	3	....	.031	.010	.021	....	....	... ...	....	....
4	3	7.0 mm.	.030	.008	.022	7.0 mm.	2.0300	2.1000	.5950	.6300
4	4	....	.028	.009	.019	....	......	....	....	....
5	4	4.5 mm.	.028	.009	.019	4.5 mm.	1.0575	1.2600	.3150	.4050
5	5	....	.019	.005	.014	....	.. ..	......	... .	....
6	5	4.0 mm.	.012	.005	.007	1 mm.	.2400	.4800	.0250	.0500
						Total..	7.7450	9.1300	2.4075	3.020
						Mean..	8.4625 cc.		2.71375 cc.	

TABLE III. CAT 3.

Left Kidney. Volume by displacement in water, 19 cc. Length of long axis, 45 mm. The volume of the right kidney was 18.5 cc., and the length 44.5 mm., but the volume was only found by displacement. The cortex of the left kidney by displacement was 13.5 cc. The volume of the medulla was 4.5 cc.

Section.	Line.	Thickness.	Entire area.	Area medulla.	Area cortex.	Thickness of medulla.	A. Entire volume of kidney.	B. Entire volume of kidney.	A. Volume of medulla.	B. Volume of medulla.
1	1	7.5 mm	.037	.0005	.0365	.5 mm	1.3875	2.7750	.00125	.0025
2	1	8.25mm	.037	007	.030	8.25mm	3.7950	4.5375	1.03125	1.4850
2	2	....	.055	.018	.037	.... .	....	......	...	....
3	2	8.25mm	.053	.017	.036	8.25mm	4.3312	4.3725	1.15500	1.4025
3	3	....	.052	.011	.041	...	..... .	....	......	....
4	3	7.0 mm	.057	.007	.050	7.0 mm	3.5350	3.9000	.7700	1.0500
4	4	....	.044	.015	.029	. ...	....	... ..	... ...	... .
5	4	7.0 mm	.048	.014	.034	7.0 mm	2.9050	3.3600	.87500	.9800
5	5	.. ...	.035	.011	.024	. ....	....	......	..... .	....
6	5	7.0 mm	.030	.011	.019	1.0 mm	1.0500	2.1000	.05500	.1100
						Total ..	17.0127	21.1350	3.8875	5.0300
						Mean ..	19.0738 cc.		4.45875 cc.	

TABLE IV. CAT 4.

Right Kidney. Volume by displacement in water, 18.5 cc. Length of long axis, 48 mm. The volume of the left kidney was 18.5 cc., and the length 46 mm., but the volume was only found by displacement. The cortex of the right kidney by displacement was 13.5 cc. The medulla was 4.5 cc.

Section.	Line.	Thickness.	Entire area.	Area medulla.	Area cortex	Thickness of medulla.	A. Entire volume of kidney.	B. Entire volume of kidney.	A. Volume of medulla.	B. Volume of medulla.
1	1	5.5 mm.	.030	.0005	.0295	1.75mm	.8250	1.650	.0043	.0087
2	1	7.0 mm.	.031	.0005	.0305	7.0 mm.	2 5900	3.010	.5425	1.0500
2	2	....	.043	.015	.0[illegible]8	....	....	.....	... ...	....
3	2	7.5 mm	.046	.0145	.0315	7 5 mm.	3.6375	3.825	.9937	1.0875
3	3	....	.051	.012	.039	....	....	....	....	....
4	3	11.0mm	.050	.011	.039	11.0mm	5.5000	5.500	1.2100	1.2100
4	4	....	.050	.011	.039	....	....	.... ..	....	....
5	4	10.0mm	.050	.012	.038	10.0mm	4.1000	5.000	.9500	1.2000
5	5	....	.032	.007	.025	. ... .	....	....	....	....
6	5	7.0 mm.	.033	.005	.028	2.5 mm.	1.1550	2.310	.0625	.1250
						Total..	17.8075	21.295	3.7640	4.6812
						Mean..	19 551 cc.		4.2226 cc.	

THE RELATION OF THE CORTEX OF THE KIDNEY TO THE ENTIRE AREA OF SECTIONS TAKEN FROM FRESH KIDNEYS.

These measurements are from the same set of kidneys which were used to compute the volume of the cortex. Only one of the pair of kidneys was used in each case and this was cut in five or six sections across the long axis. Theoretically two areas on the same line should be the same but separate readings were made and as the variation was enough to affect the percentage both readings were used. The results are shown in Table V in square decimeters. The average per cent. of cortex as seen in area in four fresh kidneys proved to be .700.

TABLE V.

In this and the following tables T indicates transverse and L longitudinal direction of section. Where any particular section is designated by a * it indicates that the plane of the section passed through the center of the pelvis of the kidney.

	Direction of section.	Entire area.	Medulla.	Cortex.	Per cent. of cortex.	Average per cent. of cortex.
	T	.015	.004	.011	.733	
	T	.017	.004	.013	.764	
Cat 1..	T	.025	.016	009	.360	
	T	.030	.01475	.01525	.508	
	T	.016	.005	.011	.666	.605
	T	.016	.006	.010	.625	
	T	.018	004	.014	.777	
	T	.033	.012	.021	.636	
	T	.032	.015	.017	.531	
Cat 2.	T	.031	.010	.021	.677	
	T	.030	.008	.022	.733	
	T	.028	.009	.019	.678	
	T	.019	.005	.014	.736	
	T	.012	.005	.007	.583	.665
	T	.037	.0005	.0365	.986	
	T	.037	.007	.030	.810	
	T	.055	.018	.037	.672	
	T	.053	.017	.035	.679	
	T	.052	.011	.041	.788	
Cat 3.	T	.057	.007	.047	.877	
	T	.044	.015	.029	.659	
	T	.048	.014	.034	.708	
	T	.035	.011	.024	.685	
	T	.030	.011	.019	.633	.7497
	T	.030	.0005	.0295	.983	
	T	.031	.0005	.0305	.983	
	T	.043	.015	.038	.651	
	T	.046	.0145	.0315	.684	
Cat 4.	T	.051	.012	.039	.764	
	T	.050	.011	.039	.780	
	T	.050	.012	.038	.760	
	T	.032	.007	.025	.781	
	T	.033	.005	.028	.848	.781
Average per cent. of cortex						.700

THE RELATION OF THE CORTEX OF THE KIDNEY TO THE ENTIRE AREA OF SECTIONS TAKEN FROM KIDNEYS INJECTED AND HARDENED IN ALCOHOL.

Four pairs of kidneys were partially injected and hardened in alcohol. Before hardening they were cut up in three or four pieces in the direction indicated in the last column of the table. The partial injection served to show the boundary line between cortex and medulla very plainly. The kidneys were imbedded by the celloidin process and sections cut 35 μ thick. The area of the entire section and of the medulla and boundary zone was found with a planimeter. No estimate of volume of cortex could be made because the thickness of the separate pieces was not estimated before placing them in alcohol. The areas in square decimeters are shown in Table VI. In estimating the number of glomeruli .700 was used as the per cent. of cortex and not .633, although this is the figure for injected kidneys. But in this case the kidneys were only partially injected and the shrinkage was considerable. The kidney which was used to estimate the number of glomeruli was injected with a constant pressure apparatus and when the vessels were filled, the pressure was raised and the gelatin *packed* in.

TABLE VI.

	Direction of section.	Entire area.	Medulla.	Cortex.	Per cent. of cortex.	Average per cent. of cortex.	Volume of kidneys.	
Cat 1	T	.026	.009	.017	.653		R	L
	T	.014	.002	.012	.857		10.5	8.5
	T*	.024	.012	.012	.500		T	L
	L	.051	.019	.032	.627	.659		
Cat 2	T	.033	.007	.026	.787		R	L
	T	.046	.015	.031	.673			20.5
	T	.047	.011	.036	.765			T
	T*	.055	.016	.039	.709	.733		
Cat 3	L	.044	.018	.026	.590		R	L
	L	.047	.031	.016	.340		8.5	8.5
	L	.046	.036	.010	.217		T	L
	T	.016	.006	.010	.625			
	T*	.025	.010	.015	.600			
	T	.011	.004	.007	.636	.501		
Cat 4	L*	.065	.036	.029	.446		R	L
	L	.066	.032	.034	.515		15.	14.5
	T	.040	.013	.027	.675		T	L
	T	.019	.005	.014	.736			
	T	.017	.003	.014	.823	.639		
	Average per cent. of cortex					.633	11.3	13.0

THE RELATION OF THE CORTEX OF THE KIDNEY TO THE ENTIRE AREA OF SECTIONS TAKEN FROM KIDNEYS HARDENED IN MUELLER'S FLUID.

Four pairs of kidneys were hardened in Müllers fluid followed by alcohol. The cats were chloroformed and killed by bleeding. All fat was removed and vessels cut at hilum. The volume of each kidney was found by displacement in water. The neys were hardened in Müllers fluid; washed in running water and eventually placed in 95 per cent. alcohol. They were then imbedded in celloidin and sections cut 35μ thick. Before placing the kidneys in Müllers fluid, the kid neys were cut in three four pieces each—the right longitudinal and the left transverse to the long axis, or vice versa. No record was kept of the thickness of these pieces and the volume of the cortex could not be computed for this reason. A section from each one of these pieces was put between two slides and fastened in the table so that the glass was on a level with the surface of the table. The area of the entire section and of the medulla and boundary zone was then found with a planimeter. The results are given in Table VII. The sections are either longitudinal or transverse and when the line of section passes through the pelvis it is indicated by a *. The areas are in square decimeters. In the last column the volume of each kidney is given, and the direction in which it was cut before hardening in Müllers fluid indicated by L or T below the volume. The volume is given in cubic centimeters. The Müllers fluid does not appear to have caused as much shrinkage of the cortex as the alcohol.

TABLE VII.

		Entire area.	Medulla.	Cortex.	Per cent. of cortex.	Average per cent.	Volume of kidneys.	
Cat 1.....	L	.065	.027	.038	.584		R 18 L	L 15 T
	L	.067	.027	.040	.597	.590		
Cat 2.....	L*	.088	.036	.052	.590		R	L
	T	.041	.006	.035	.853		16 L	15 T
	T	.022	.009	.013	.590			
	T	.038	.012	.026	.684	.679		
Cat 3.. ..	L*	.055	.026	.029	.527		R	L
	T	.025	.007	.018	.720		8.5 L	9 T
	T	.013	.001	.012	.923			
	T*	.025	.010	.015	.600			
	T	.032	.008	.024	.750	.704		
Cat 4. ...	L*	.094	.032	.062	.659		R	L
	L	.086	.036	.050	.581		19.5 T	18 5 L
	T*	.035	.017	.018	.514			
	T	.042	.018	.024	.571			
	T	.030	.011	.019	.633	.591		
Average per cent. of cortex....................						.641	15.5	14.4

ESTIMATION OF THE NUMBER OF GLOMERULI IN THE CAT'S KIDNEY.

The only estimation to which we had access, regarding the number of glomeruli in any kidney, was that of Schweigger-Seidel.[1] In his investigation he first tried to estimate the number of glomeruli by observing the number of tubes which opened at the papilla of the kidney, cutting sections farther up and seeing how many branches of collecting tubules were given off, and finally making an estimate of the number of tubules which joined these collecting tubules in the medullary ray.

[1] Die Nieren des Menschen und der Säugethiere in ihrem feineren Baue: Halle, 1865. pp. 48–52.

The separate results were not accurate and so he solved the problem in another way. Certain portions of the cortex of the kidney of the pig were cut out and weighed. After teasing the mass apart in HCl, the glomeruli were counted. A mass weighing 15.5 centgrm. was examined in this way and found to contain 720 glomeruli. This gave 46.4 glomeruli to every centgrm. A kidney was then taken and cut into thin sections and the cortex separated from the medulla and fat. The weight was as follows:

Cortex	102.0 gr.
Medulla	12.5 gr.
Fat and vessels in sinus renalis	6.0 gr.

The amount of cortex in the pig is very large when compared with the amount of medulla. In the entire cortex (102 gr.) there would be 473,200 glomeruli, or in round numbers 500,000. According to his previous estimation of volume, the 99,000 cu. mm. of cortex contained 473,200 glomeruli, or five glomeruli to every cubic millimeter. They are not uniformly distributed, but lie in the labyrinth of the cortex between the medullary rays.

Huschke (cited by Schweigger-Seidel) estimated there were over two million glomeruli in the human kidney. Every Malpighian pyramid of the cortex contained 700 renal lobules and each lobule contained 200 uriniferous tubules, which in a kidney of fifteen pyramids gives 2,100,000 uriniferous tubules and same number of glomeruli. Schweigger-Seidel calculated the volume of this number of glomeruli and found it to be one-eighth of the entire volume of the kidney, and hence regarded the calculation as incorrect. He thinks there are about six glomeruli to every cu. mm. The uriniferous tubules must make up in length what they lose in numbers.

No reference could be found as to the number of glomeruli in the kidney of the cat. A medium-sized kidney was well injected with Prussian blue gelatin. The cat was chloroformed and killed by bleeding. A canula was inserted in the abdominal aorta below renal arteries and the aorta was tied about one inch above the arteries. All traces of blood were washed out with physiological salt solution after which the kidneys were injected with the gelatin by a constant pressure apparatus. They were hardened in 95 per cent. alcohol. Three portions of cortex were then cut from the cortex in three different locations. One on the surface, one near the boundary line of cortex and medulla and one through the entire cortex. These were stained in toto and imbedded in paraffin. Serial sections were cut .10 mm. in thickness as this was found to be about the average diameter of the glomeruli in a former series of measurements (.1027 mm. exact). A glomerulus could not appear in over two sections and possibly in only one. The outline of each section was traced on paper with a camera lucida and a dot made on the paper wherever a glomerulus was seen. The area was found with a planimeter. The sum of the areas of the sections multiplied by the thickness gave the volume examined. Some glomeruli appeared in two sections and it was necessary to find what per cent. did so. This was accomplished by tracing two consecutive sections on paper — the under surface of one and the upper of another — and finding which glomeruli coincided. The sections were also carefully examined microscopically. On examining several sections in this manner, it was found that from one-half to 83 per cent. of the number of glomeruli in any section represented the actual number of glomeruli present. The volume of block I was calculated to be .31160 cc. The sum of the glomeruli in each section was 634, but according to the above calculation it would contain from 317 to 529 glomeruli. The average volume of the cat's kidney was found to be 12.9 cc. for both right and left kidneys. The cortex was found to be .7 of the entire volume of the kidney. For an average-sized kidney this would be 9.03 cc.

9.03 cc. ÷ .31160 cc. = 28.97.
317 × 28.97 = 9183.49 glomeruli.
529 × 28.97 = 15325.13 glomeruli.

According to block I the number of glomeruli would vary between the two figures just given.

The volume of block II was found to be .2565 cc. The sum of the glomeruli was 723. The exact number would be between 362 and 603.

9.03 cc. ÷ .2565 cc. = 35.20.
362 × 35.20 = 12742 glomeruli.
603 × 35.20 = 21226 glomeruli.

The volume of block III was found to be .2052 cc. The sum of the glomeruli was 605—making the exact number between 302 and 505.

$$9.03 \text{ cc.} \div .2052 \text{ cc.} = 44.$$
$$302 \times 44 = 13288 \text{ glomeruli.}$$
$$505 \times 44 = 22220 \text{ glomeruli.}$$

The average number of glomeruli in an average-sized kidney would be, from the above three estimates, from 11738 to 19590. The mean would be 15664 glomeruli and to give a round number we may say that an average-sized cat's kidney contains about 16000 glomeruli.

Madison, Wis.

AN EXPERIMENTAL STUDY OF FIELD METHODS WHICH WILL INSURE TO STADIA MEASUREMENTS GREATLY INCREASED ACCURACY.[1]

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INTRODUCTION.

The collection of data on this subject was begun during the field work of the International Boundary Survey between United States and Mexico, 1892–3, merely as a study of a certain phenomenon familiar to engineers under the name "boiling of the air." In the summer and fall of 1894, this systematic study was continued in Wisconsin, but was made to include an experimental study of the effect of this boiling upon the accuracy of stadia measurements.

It has been found that the boiling and other related disturbances do not differ greatly either in character or amount, even in such extreme latitudes as New Mexico and Wisconsin.

When this study was begun, it was thought that this unsteadiness of the atmosphere, called boiling, exercised a governing influence on the accuracy of stadia work, but while the investigation proves that this is not so, it has been the means of discovering what that governing factor really is.

It is generally admitted that theoretically the only errors to which the stadia method is subject are compensative errors; but it is as generally known that practically the actual results of all stadia measurements have been bristling with large systematic errors, so large as often to cover up the accidental errors.

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[1] This paper is a résumé of a thesis offered to the Faculty of the University of Wisconsin for the degree of Civil Engineer, and published in the Engineering Series of the University Bulletin.

For an explanation of the theory of stadia measurements see appendix.

A few examples of such errors may be of interest. The engineer in charge of the stadia surveys of the Chicago Drainage Canal, surveys already covering fifty square miles, states that the steel tape and triangulation checks on his work, show that all measurements are too short by about $\frac{1}{700}$. Again, the report of the recent municipal survey of St. Louis shows undoubted proof of uniform positive errors, which leads the engineer in charge to advocate a method of interval determination which would virtually subtract $0.\overset{m.}{43}$ from every stadia reading.

This paper will attempt to point out the reason for these systematic errors, and indicate how they may be greatly modified, if not entirely prevented, by an easily applied change in present field methods.

But because this subject is very intimately related to the unsteadiness, or so-called "boiling of the air," let us first briefly glance at the various conditions governing the same.

AN EXPERIMENTAL STUDY OF UNSTEADINESS.

This unsteadiness seems to be due to the irregular displacement of light rays, both in a horizontal and vertical direction. The horizontal displacement appears to affect the accuracy of stadia measurements only by decreasing the distinctness of the image. But besides having this effect, the vertical vibration furnishes other causes for errors, as is explained below.

The method of measuring this vertical vibration was as follows: The target shown in Fig. 2, Plate XVIII, being attached to the metric rod shown by Fig. 1, the rodman held same at every 100 or 150 paces, showing first the face of rod, then the target. After reading the stadia for distance, the middle crosswire was placed so as to bisect that strip of target, which equalled the amplitude of the vertical vibration, and the number of vibrations per minute was then counted; each experiment being repeated a number of times and the average result recorded.

In general, each vertical vibration was found to be made up of two classes of movements; one fast, and with short amplitude; the other slow or irregular, and with long amplitude.

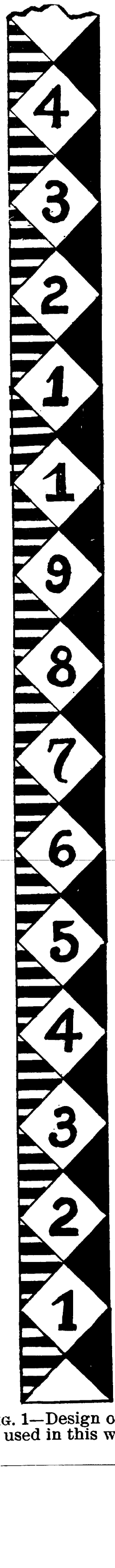


FIG. 1—Design of Stadia Rod used in this work.

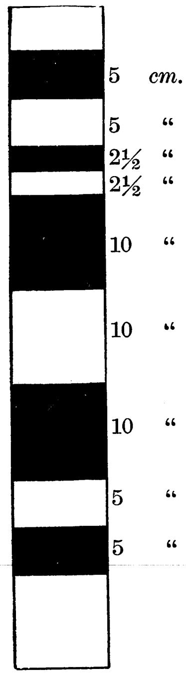
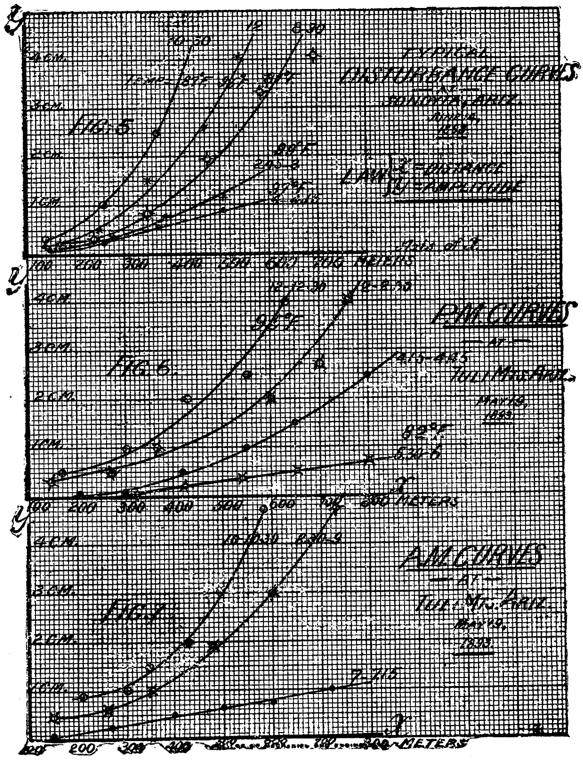


FIG. 2—Target used in this work for measuring vibration.

FIG. 3.—EFFECT OF VIBRATION ON TARGET.



FIGS. 5, 6, and 7.—TYPICAL DISTURBANCE CURVES SHOWING EFFECT OF HOUR OF DAY AND LENGTH OF SIGHT ON THE DEGREE OF UNSTEADINESS.

X=distance of sight.
Y=amplitude of vibr.

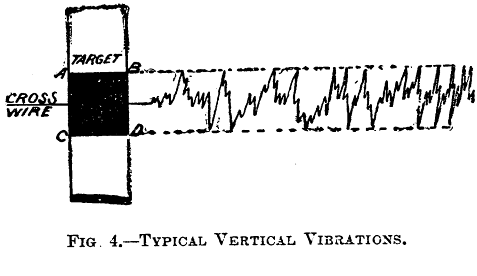


FIG. 4.—TYPICAL VERTICAL VIBRATIONS.

The latter will be called *primary*, and the former *secondary* vibrations. The effect of this unsteadiness on the appearance of the target is shown in Fig. 3.

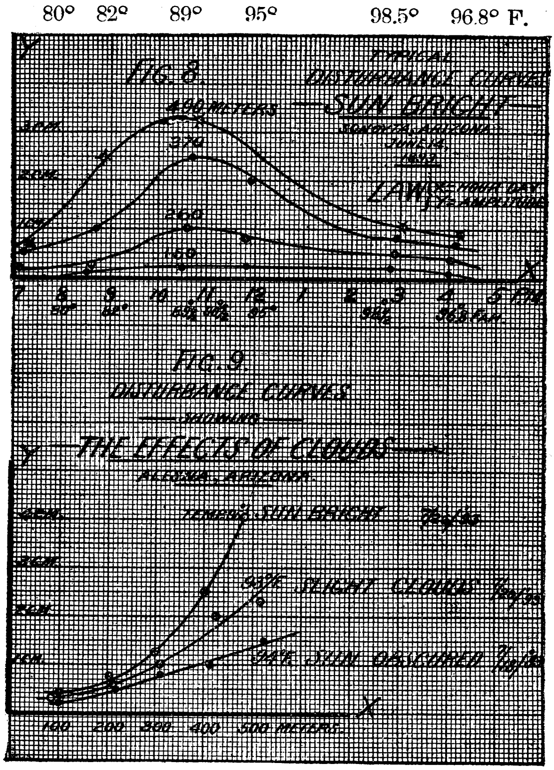


FIG. 8.—TYPICAL DISTURBANCE CURVES SHOWING THE EFFECT OF TIME OF DAY, TEMPERATURE, AND LENGTH OF SIGHT ON DEGREE OF UNSTEADINESS.
X=time of day.
Y=amplitude of vibration.

FIG. 9.—DISTURBANCE CURVES SHOWING THE EFFECTS OF CLOUDS ON UNSTEADINESS.
X=distance of sight.
Y=amplitude of vibration.

The manner in which these two systems occurred, can be best shown by a diagram. (Fig. 4.) If the crosswire could record its apparent motion it would describe a path like that in Fig. 4, where B—D limits the amplitude of the primary vibration, and the irregularities of the path constitute the secondary system. The manner in which the amount of this vibration is influenced by length of sight, hour of day, brightness of sun, temperature, etc., can be best shown by the typical curves representing the same.

In Fig. 5, the x coördinates of the curves are the length of sights in meters, and the y ordinates are the recorded amplitudes of the vertical swing of crosswire. It will be seen that the greatest disturbance comes not in the hour of maximum temperature, but in the hour of maximum *difference* of temperature between air and earth.

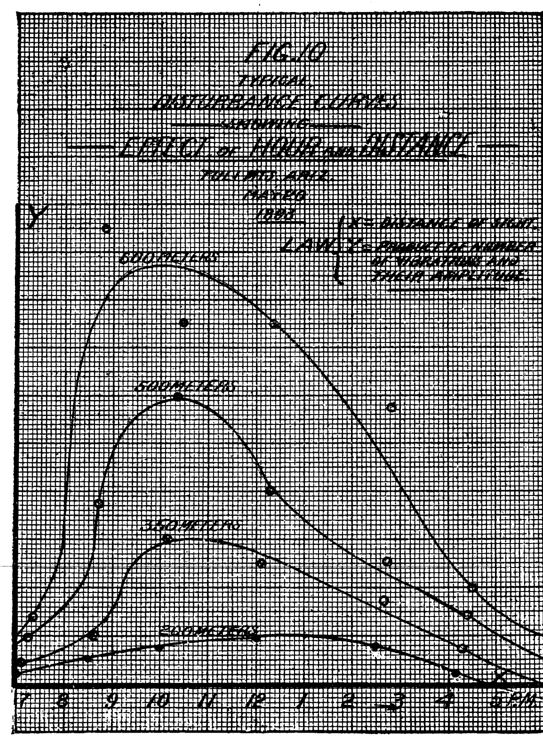


FIG. 10.—TYPICAL DISTURBANCE CURVES SHOWING EFFECT OF HOUR OF DAY AND LENGTH OF SIGHT ON THE DEGREE OF UNSTEADINESS.
X=hour of observation.
Y=product of number of vibrations by their amplitude.

Thus in Figs 5, 6 and 7 this hour is 10—11 A. M. The curves of Fig. 8 may be said to be typical of sunny days during all except the cold winter months. During a cloudy day, but little unsteadiness is observed. The effect of different amounts of clouds is clearly shown by Fig. 9, which records a measurement of the unsteadiness at the same hour of three different days, but under same circumstances except the degree of cloudiness. It is thought that the product of the number of vibrations per minute and their amplitude, is a better measure of the amount of unsteadiness, than either factor alone. Using this product for the values of y and the hours of day for the values of x, the curves in Figs. 10 and 11 are obtained. These curves also show that the unsteadiness of the air is greater in the forenoon than in the afternoon.

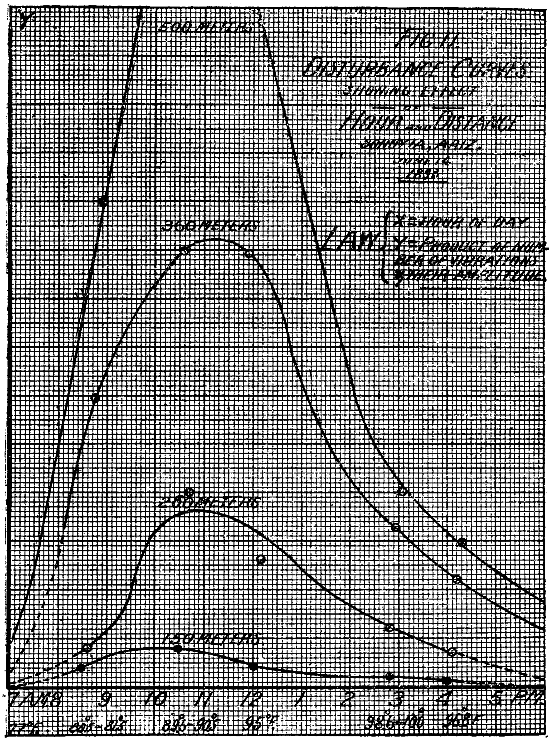


FIG. 11.—TYPICAL DISTURBANCE CURVES SHOWING EFFECT OF HOUR OF DAY AND LENGTH OF SIGHT ON THE DEGREE OF UNSTEADINESS.
X=hour of observation
Y=product of number of vibrations by their amplitude.

The irregular movements constituting this unsteadiness cause errors in rod readings, because of the inability to read both wires simultaneously; but as such errors are as likely positive as negative, they would follow the law of compensatory errors, and only the square root of the number of errors would in any case accumulate. Evidently the cause of systematic errors is not here. But while engaged in this study of the air, it was noticed that rod readings, made when such disturbances were very marked, differed systematically from readings made under steady conditions of the air; a careful study was accordingly made to discover its cause. It was soon apparent that this cause was what the writer has called *differential refraction.*

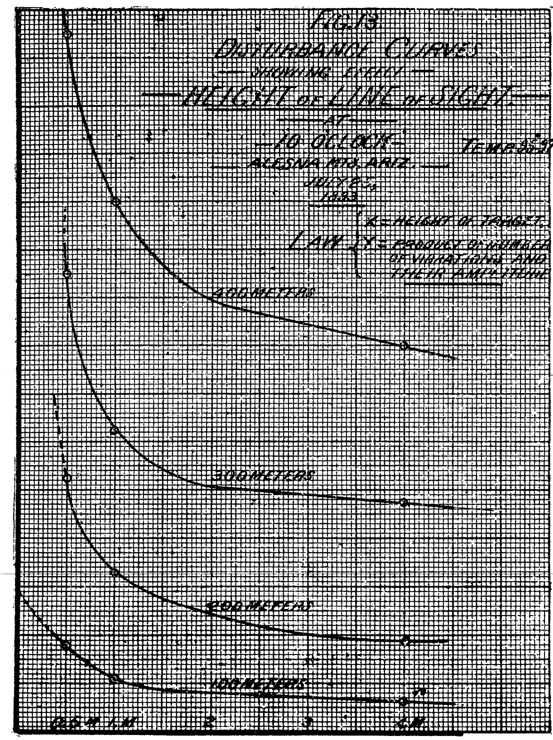


FIG. 13.—TYPICAL DISTURBANCE CURVES SHOWING THE EFFECT OF HEIGHT OF TARGET ON UNSTEADINESS. ALSENA MOUNTAINS, ARIZ., 10 A. M., JULY 25, 1893.
X=height of target.
Y=product of number of vibrations by their amplitude.

As used in this paper, the term "differential refraction" expresses the difference in the amounts which the two lines of sight, upper and lower, are refracted by the air.

As the amount of this differential refraction has been found to vary directly with the unsteadiness of the image, some careful experiments were made to determine the relative amounts of the unsteadiness in strata from one-half to four meters above the ground; the results of which are given a graphical form in the curves, Figs. 13 and 14. The x abscissas of these curves are the heights of the targets above the ground; and the y ordinates are the products of the number of vibrations per minute and their amplitude. It will be seen that, between one-half and

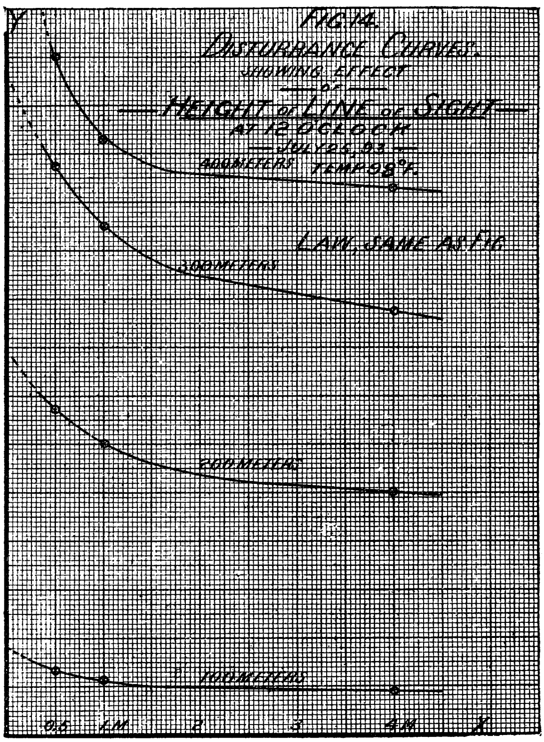


FIG. 14.—TYPICAL DISTURBANCE CURVES SHOWING THE EFFECT OF HEIGHT OF LINE OF SIGHT ON THE DEGREE OF UNSTEADINESS AT 12 O'CLOCK JULY 25, 1893.
X=height of target (in meters).
Y=Product of number of vibrations by their amplitude.

one meter, a rapid change in the amounts of unsteadiness was found; while between one and four meters, the change was very slight. Thus in Fig. 13, the 200 meter curve shows that the rate of change in the unsteadiness between one-half and one meter was 18 times that between one and four meters.

The remarkable refraction which takes place in this stratum of greatest unsteadiness may be explained by the peculiar shape of the ascending currents of air, caused by the radiation of heat from the various materials of the ground along the line of sight, a typical case of which is shown in Fig. 15.

Each belt of sand, clay, loam, gravel or covering of each will absorb and give off heat to the superimposed air according to its own absorbing and radiating power, giving rise to ascending air currents of different densities and indices of refraction. Rays of light, which traverse the lower part of such a lens, will be refracted the most, and though slight in any single lens, by successive refraction on long sights it amounts to considerable. On sights of 300 m. the writer has observed the lower line of sight to be refracted 5 cm. more than the upper.

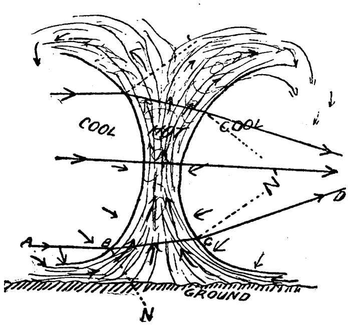


FIG. 15.—SHOWING SUPPOSED SHAPE OF AIR CURRENTS AND THEIR EFFECT ON REFRACTIONS.

Again, the almost infinite variety of ways in which rays of light traverse a large number of such currents, when influenced by every gust of wind, is sufficient to explain the peculiar fluctuations of the line of sight, called primary and secondary vibrations.

THE EFFECT OF LENGTH OF SIGHT ON ACCURACY.

The question of what length of sight will give maximum accuracy of measurement, was tested by 422 test sights, aggregating eighty-five miles, made on an accurately measured base line, during the months of July and August. Here also are the effects of "differential refraction" plainly seen. This work consisted of from twenty to thirty stadia readings on nineteen stations, 100 feet apart, distant from 200 to 2,000 feet from transit. For purpose of study, this work has been divided into two divisions, (*A*), that done during good seeing conditions—7 to 9 A. M. and 2:30 to 7 P. M., and (*B*), work executed during midday — 9 A. M. to 2:30 P. M. A record of this work may be found in Table 1, and is given a graphical form in the curves, Figs. 18 and 19.[1]

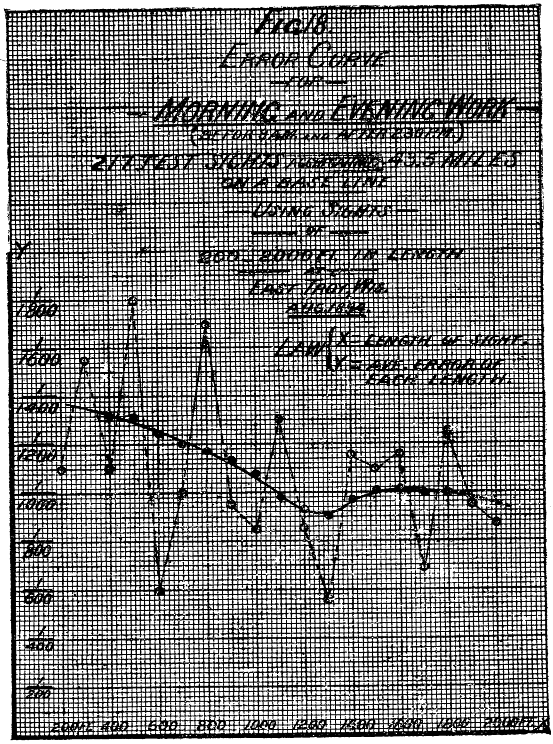


FIG. 18.—ERROR CURVE OF MORNING AND EVENING WORK.
X=length of sight.
Y=fractional error of each length sight.

It will be seen that midday work is subject to large negative systematic errors, while that of remainder of day shows very much smaller positive errors. Table 2 is a record of the interval determination, and it will be seen that work done in midday is not represented by the interval; as a result, work done during midday shows a lower degree of accuracy.

[1] Figs. 16 and 17 of the original paper are omitted.

TABLE 1.

(*A*) RECORD OF EXPERIMENTS FROM 8 TO 9 A. M. AND 2.30 TO 7 P. M., STADIA MEASUREMENTS AGGREGATING 43.3 MILES.

Good Conditions for Work; Weather.

Date.	Time.	Temperature.	Condition of Air.	Sun.	Wind.
August 4	5-5.30 P. M.	96° sun. 80° shade.	No vib. even close to ground.	Clear.	No wind.
" 6	2.30-4 P. M.	86° shade.	Only vibration a glimmering.	Cloudy.	No wind.
" 6	5-5.30 P. M.	84° sun. 82° shade.	Only vibration a glimmering.	Cloudy.	No wind.
" 15	5-5.30 P. M.	86° shade.	Rod distinct; no vibration.	Cloudy.	No wind.
" 15	5.30-6 P. M.	65° shade.	Rod distinct; no vibration.	Partly cloudy.	No wind.
" 20	8-8.30 A. M.	72° shade.	Slight vibration.		Slight breeze.
" 21	8-8.30 A. M.	67° shade.	No vibration even at 2,000 ft.	Clear.	Slight breeze.
" 21	8.30-9 A. M.	78° sun. 67° shade.	Air dusty; little vibration.	Clear.	Slight breeze.
" 21	5-5.30 P. M.	79° sun. 72° shade.	Air dusty; little vibration.	Clear.	Still.
" 21	5.30-6 P. M.	72° sun. 66° shade.	No vibration even at 2,000 ft; rod distinct.	Clear.	Still.
" 23	2.45-3.30 P. M.	120° sun. 96° shade.	Slight vibration; rod distinct.		
" 23	3.30-4 P. M.	92° shade.	Very slight vibration.	Hazy.	Still.
" 23	4-4.30 P. M.	91° shade.	No vibration; rod distinct.	Cloudy.	Still.
July 5	8-9 A. M.	70° shade.	Rod cannot be read after 426 *m.*	Clear.	Slight.

Errors of the Stadia on Distances of 200 to 1,000 Ft.

Date.	Time.	200 Ft. (60.97 m.) +	−	300 Ft. (91.45 m.) +	−	400 Ft. (121.938 m.) +	−	500 Ft. (152.423 m.) +	−	600 Ft. (182.907 m.) +	−	700 Ft. (213.390 m.) +	−	800 Ft. (243.874 m.) +	−	900 Ft. (274.358 m.) +	−	1,000 Ft. (304.842 m.) +	−
August 4	5-5.30 P. M.	0.14				0.03				0.32				0.02					0.68
" 6	2.30-4 P. M.	0.04		0.24		0.13		0.03		0.42		0.32		0.32			0.28		0.48
" 6	5-5.30 P. M.	0.04				0.13				0.32				0.12				0.62	
" 15	5-5.30 P. M.	0.04			0.06	0.13			0.02	0.37		0.42		0.02		0.42		0.82	
" 15	5.30-6 P. M.	0.04			0.01	0.03			0.07	0.12		0.22			0.10		0.28		0.18
" 20	8-8.30 A. M.	0.04			0.01	0.13		0.03		0.74		0.32			0.00				
" 21	8-8.30 A. M.	0.04			0.01			0.08		0.17		0.22			0.00		0.08		0.18
" 21	8.30-9 A. M.		0.06		0.06				0.07	0.07		0.07			0.00		0.08	0.42	
" 21	5-5.30 P. M.		0.01		0.06			0.03		0.12		0.12			0.00		0.12	0.12	
" 21	5.30-6 P. M.	0.04			0.01			0.03		0.12		0.07			0.00		0.08		0.08
" 23	2.45-3.30 P. M.	0.09			0.06	0.13		0.13		0.22			0.08		0.10		0.08		0.18
" 23	3.30-4 P. M.	0.09		0.04		0.13		0.03		0.37		0.12			0.00	0.22		0.12	
" 23	4-4.30 P. M.	0.04		0.04		0.13		0.13		0.57		0.12		0.10		0.92		0.32	
July 5	8-9 A. M.		0.06		0.11	0.13			0.37		0.18		0.47		0.18		0.58		
Sum of errors on each length sight.		0.64	0.13	0.32	0.39	1.10	0.00	0.49	0.53	3.93	0.18	2.00	0.55	0.58	0.38	1.56	1.58	2.42	1.78
Average error of a single sight on each distance.		$\frac{1}{1108}$		$\frac{1}{1545}$		$\frac{1}{1108}$		$\frac{1}{1793}$		$\frac{1}{628}$		$\frac{1}{1004}$		$\frac{1}{3556}$		$\frac{1}{961}$		$\frac{1}{870}$	
Errors of closing total distance on each length sight.		$+\frac{1}{1673}$		$-\frac{1}{15680}$		$+\frac{1}{1108}$		$-\frac{1}{45726}$		$+\frac{1}{682}$		$+\frac{1}{1766}$		$+\frac{1}{17071}$		$-\frac{1}{150896}$		$+\frac{1}{5715}$	
Sum of distance measured with each length sight.		853.58 *m.*		1097.40 *m.*		1219.38 *m.*		1829.04 *m.*		2560.70 *m.*		2560.68 *m.*		3414.24 *m.*		3017.94 *m.*		3658.10 *m.*	

Errors of the Stadia on Distances of 1,100 to 2,000 Ft.

Date.	Time.	1,100 Ft. (335.326 m.) +	−	1,200 Ft. (365.810 m.) +	−	1,300 Ft. (396.294 m.) +	−	1,400 Ft. (426.779 m.) +	−	1,500 Ft. (457.263 m.) +	−	1,600 Ft. (487.748 m.) +	−	1,700 Ft. (518.232 m.) +	−	1,800 Ft. (548.717 m.) +	−	1,900 Ft. (579.200 m.) +	−	2,000 Ft. (609.684 m.) +	−
August 4	5-5.30 P. M.			0.21					0.09				0.31				0.01			0.10	
" 6	2.30-4 P. M.		0.09		0.68		0.48	0.21			0.68		0.79	0.60		1.48		0.70		0.29	
" 6	5-5.30 P. M.			0.21				0.91					0.30				0.00				0.60
" 15	5-5.30 P. M.	.10		0.61		0.71		0.31				0.69		2.39		1.40		0.70		1.29	
" 15	5.30-6 P. M.		0.44		0.38		0.98		0.29		0.79		0.70	1.10			0.51		1.10		1.20
" 20	8-8.30 A. M.	.21		0.41																	
" 21	8-8.30 A. M.	.31		0.41		0.51		0.69		0.11		0.20		0.80		0.49		0 10		1.59	
" 21	8.30-9 A. M.		0.09	0.21		0.51		0.01		0.81		0.20			.10		0.01	0.10			0.20
" 21	5-5.30 P. M.	01		0.31		0.61		0.21		0.01			0.40	0.30		0.39		0.60			0.20
" 21	5.30-6 P. M.	21		0.51		0.81		0.31		0.71		0.00		0.10			0.21	0.99		0.78	
" 23	2.45-3.30 P. M.	11		0.51		0.51			0.09	0.11		0.69		0.10							
" 23	3.30-4 P. M.	21		0.61		1.11		0.91			0.19	0.69		1.10		0.09		0.89			
" 23	4-4.30 P. M.	01		0.41		0.81		0.41		0.31		0.19		1.10		0.19			0.30		
July 5	8-9 A. M.																				
Sum of errors on each length sight.		17	0.62	4.41	1.06	5.58	1.46	3.97	0.47	2.06	1.66	2.66	2.50	7.59	0.10	4.04	0.74	4.08	1.40	4.05	2.20
Average error of a single sight on each distance.		$\frac{1}{1322}$		$\frac{1}{866}$		$\frac{1}{568}$		$\frac{1}{1153}$		$\frac{1}{1106}$		$\frac{1}{1134}$		$\frac{1}{674}$		$\frac{1}{1262}$		$\frac{1}{951}$		$\frac{1}{878}$	
Errors of closing total distance on each length sight.		$+\frac{1}{2390}$		$+\frac{1}{1419}$		$+\frac{1}{962}$		$+\frac{1}{1468}$		$+\frac{1}{10288}$		$+\frac{1}{86581}$		$+\frac{1}{692}$		$+\frac{1}{1829}$		$+\frac{1}{1946}$		$+\frac{1}{2966}$	
Sum of distance measured with each length sight.		688.59 *m.*		4755.53 *m.*		3962.94 *m.*		5121.35 *m.*		4115.37 *m.*		5852.98 *m.*		5182.32 *m.*		6035.89 *m.*		5212.80 *m.*		5487.15 *m.*	

Sights not exceeding 304.84 m. (200 Ft. — 1,000 Ft.); Sights from 304.84 m. to 609.68 m. (1,100 Ft. — 2,000 Ft.); Totals.

Date.	Time.	Sights not exceeding 304.84 m.: Uncompensated Error. (Meters.)	Distance Measured. (Meters.)	Fractional Error in Closing.	Sights from 304.84 m. to 609.68 m.: Uncompensated Error. (Meters.)	Distance Measured. (Meters.)	Fractional Error in Closing.	Totals: Error in Closing Total Distance.
August 4	5-5.30 P. M.	− 0.17	914.53	$+\frac{1}{5379}$	− 0.10	2438.74	$-\frac{1}{24387}$	$-\frac{1}{12423}$
" 6	2.30-4 P. M.	+ 0.74	1646.15	$+\frac{1}{2224}$	+ 0.56	4725.05	$+\frac{1}{8427}$	$+\frac{1}{3425}$
" 6	5-5.30 P. M.	+ 1.23	914.53	$+\frac{1}{744}$	+ 0.22	2438.74	$+\frac{1}{11085}$	$+\frac{1}{2312}$
" 15	5-5.30 P. M.	+ 2.14	1646.15	$+\frac{1}{769}$	+ 9.20	4267.79	$+\frac{1}{463}$	$+\frac{1}{521}$
" 15	5.30-6 P. M.	− 0.23	1646.15	$-\frac{1}{7157}$	− 5.29	4725.05	$-\frac{1}{893}$	$-\frac{1}{1154}$
" 20	8-8.30 A. M.	+ 1.25	1066.94	$+\frac{1}{570}$	+ 0.62	701.14	$+\frac{1}{1131}$	$+\frac{1}{945}$
" 21	8-8.30 A. M.	+ 0.24	1524.21	$+\frac{1}{5645}$	+ 5.21	4725.05	$+\frac{1}{907}$	$+\frac{1}{1147}$
" 21	8.30-9 A. M.	+ 0.29	1524.21	$+\frac{1}{5256}$	+ 1.44	4725.05	$+\frac{1}{3281}$	$+\frac{1}{3377}$
" 21	5-5.30 P. M.	+ 0.20	1524.21	$+\frac{1}{7621}$	+ 1.84	4725.05	$+\frac{1}{2567}$	$+\frac{1}{2896}$
" 21	5.30-6 P. M.	+ 0.09	1524.21	$+\frac{1}{16935}$	+ 4.21	4725.05	$+\frac{1}{1122}$	$+\frac{1}{1453}$
" 23	2.45-3.30 P. M.	+ 0.07	1646.15	$+\frac{1}{23516}$	+ 1.94	2987.45	$+\frac{1}{1539}$	$+\frac{1}{2305}$
" 23	3.30-4 P. M.	+ 1.12	1646.15	$+\frac{1}{1469}$	+ 5.42	4115.37	$+\frac{1}{759}$	$+\frac{1}{881}$
" 23	4-4.30 P. M.	+ 2.37	1646.15	$+\frac{1}{694}$	+ 3.13	4115.37	$+\frac{1}{1315}$	$+\frac{1}{1067}$
July 5	8-9 A. M.	− 1.82	1341.31	$-\frac{1}{737}$				$-\frac{1}{737}$
Sum		+ 7.52	20210.98	$+\frac{1}{2685}$	+ 28.40	49414.92	$+\frac{1}{1741}$	$+\frac{1}{1938}$

TABLE 1—Continued.

(*B*) RECORD OF EXPERIMENTS FROM 9 A. M. TO 2.30 P. M., STADIA MEASUREMENTS AGGREGATING 41.3 MILES.

Poor Conditions for Work.			Weather.		
Date.	Time.	Temperature.	Condition of Air.	Sun.	Wind.
July 5	9–10 A. M.	72°–74° F. shade.	Very bad.	Bright.	Slight breeze.
" 5	10–11 A. M.	74°–76° shade.	Very bad.	Bright.	Slight breeze.
" 5	11–12 A. M.	76°–78° shade.	Very bad.	Bright.	Slight breeze.
" 5	2–3 P. M.	80°–80° shade.	Very bad.	Bright.	Slight breeze.
August 4	10–10.30 A. M.	86° sun. 76° shade.	100 vib. of .01 per minute.	Bright.	Slight breeze.
" 4	12 M.–12.30 P.M.	117° sun. 78° shade.	Rod indistinct at 1,000 feet, and cannot be read after 1,600 ft.	Few clouds.	
" 4	2–2.30 P. M.	82° shade.	Last four readings easily made.	Few clouds.	No wind.
" 13	10–10.30 A. M.	96° sun. 83° shade.	Vib. @ 1,100 ft. = .01 *m*.	Few fleecy clouds.	No wind.
" 13	2–2.30 P. M.	92° sun. 90° shade.	Vib. @ 426 *m*. = .02 *m*. very fast.	½ cloudy; hazy.	Slight breeze.
" 16	10–10.30 A. M.	100° sun. 76° shade.	Vib. very bad, rod indistinct.	Clear.	Slight breeze.
" 17	9–9.30 A. M.	80° sun. 75° shade.	Vib. very bad, rod indistinct.	Cloudy.	Slight.
" 23	11–11.30 A. M.	102° sun. 89° shade.	Vib. of .005 @ 122 *m*.	Clear.	Slight.
" 23	2–2.30 P. M.	120° sun. 98° shade.	@ 61 *m*. vib. = .008; @ 97 *m*. vib. = .009; @ 121 *m*. vib. = .01; @ 152 *m*. vib. = .015 *m*.	Clear.	None.

Errors of the Stadia on Distances of 200 to 1,000 Ft.

Date.	Time.	200 Ft. *m*. 60.97 +	−	300 Ft. *m*. 91.45 +	−	400 Ft. *m*. 121.938 +	−	500 Ft. *m*. 152.423 +	−	600 Ft. *m*. 182.907 +	−	700 Ft. *m*. 213.390 +	−	800 Ft. *m*. 243.874 +	−	900 Ft. *m*. 274.358 +	−	1,000 Ft. *m*. 304.842 +	−
July 5	9–10 A. M.		0.06		0.16	0.13		0.03			0.18		1.07		0.48		2.27		0.68
" 5	10–11 A. M.	0.04			0.16		0.16		0.37		0.18		0.37		0.67		1.08		5.16
" 5	11–12 A. M.	0.04			0.16	0.13			0.17	0.32			1.17		0.28		0.68		4.66
" 5	2–3 P. M.	0.14			0.16		0.16	0.03		0.32			0.48		0.18		0.28		0.68
August 4	10–10.30 A. M.		0.06				0.26			0.32				0.02					0.88
" 4	12 M.–12.30 P.M.		0.16				0.16			0.28					0.18				0.68
" 4	2–2.30 P. M.		0.06			0.63				1.11				0.02					2.67
" 13	10–10.30 A. M.	0.04			0.16	0.13			0.17	0.12			0.37	0.02			0.58		0.68
" 13	2–2.30 P. M.	0.04			0.16	0.13			0.27	0.22		0.22		0.12			0.08	0.32	
" 16	10–10.30 A. M.	0.04		0.02		0.03			0.17	0.12		0.12			0.48		2.07	0.82	
" 17	9–9.30 A. M.	0.04			0.16	0.13			0.07	0.22		0.12			0.10		0.18		0.68
" 23	11–11.30 A. M.		0.01	0.04		0.13						0.32							0.18
" 23	2–2.30 P. M.	0.04			0.16		0.16		0.37	0.12			0.38		0.10		0.08		0.20
Sum of errors on each length sight.		0.42	0.35	0.06	1.28	1.44	0.90	0.06	1.59	3.15	0.36	0.78	3.84	0.18	2.47	0.00	7.30	1.14	17.15
Average error of a single sight on each distance.		1/1029		1/682		1/677		1/831		1/625		1/462		1/1104		1/838		1/216	
Errors of closing total distance on each length sight.		+ 1/11323		− 1/750		+ 1/2935		− 1/897		+ 1/786		− 1/697		− 1/1278		− 1/338		− 1/247	
Sum of distance measured with each length sight.		792.61 *m*.		914.50 *m*.		1585.19 *m*.		1371.81 *m*.		2194.88 *m*.		2133.90 *m*.		2926.49 *m*.		2469.22 *m*.		3962.95 *m*.	
Total uncompensated error of both sets, (*A*) and (*B*).		+ 1/2838		− 1/1559		+ 1/1710		− 1/2039		+ 1/725		− 1/2916		− 1/3034		− 1/750		− 1/496	
Grand total of distances measured with each length sight.		1646.19 *m*.		2011.90 *m*.		2804.49 *m*.		3200.85 *m*.		4755.58 *m*.		4694.58 *m*.		6340.73 *m*.		5487.16 *m*.		7621.05 *m*.	

Errors of the Stadia on Distances of 1,100 to 2,000 Ft.

Date.	Time.	1,100 Ft. *m*. 335.326 +	−	1,200 Ft. *m*. 365.810 +	−	1,300 Ft. *m*. 396.294 +	−	1,400 Ft. *m*. 426.779 +	−	1,500 Ft. *m*. 457.263 +	−	1,600 Ft. *m*. 487.748 +	−	1,700 Ft. *m*. 518.232 +	−	1,800 Ft. *m*. 548.717 +	−	1,900 Ft. *m*. 579.200 +	−	2,000 Ft. *m*. 609.684 +	−
July 5	9–10 A. M.		1.29		0.58		1.68		2.48		4.48		4.29		3.58		3.00		4.68		4.49
" 5	10–11 A. M.		1.99		2.68		1.88		0.99		0.69		4.39		1.89		3 50		4.28		
" 5	11–12 A. M.		1.69		2.18		3.08		3.78		1.69		2.59		1.89		2.50		4.09		3.69
" 5	2–3 P. M.		0.69		1.38		1.48		1.09		1.59		3.00		3.58		3.00		3.59		4.19
August 4	10–10.30 A. M.				4.37		2.58		5.07		2.18		5.78		3.58		4.49				6.68
" 4	12 M.–12.30 P.M.				3.87				2.58		3.58		5.28				3.49				
" 4	2–2.30 P. M.		1.39		1.38				1.09			0.69					1.21				2.70
" 13	10–10.30 A. M.		0.59		2.58				3.08		3.38		3.49		2.38		2.29		3.59		5.69
" 13	2–2.30 P. M.	0.21		0.31					0.39		0.39		1.00		1.09		1.01		1.60		1.90
" 16	10–10.30 A. M.		0.39		1.88		5.47		2.58		Rod	can	not	be read	any	farther.					
" 17	9–9.30 A. M.		0.49		0.38	0.21			1.09		1.29		0.70		0.70		2.50		1.91		3.69
" 23	11–11.30 A. M.		0.29	0.61		0.51		0.71		1.31			0.30								
" 23	2–2.30 P. M.		0.29		0.59		1.48		2.58		0.69		0.30		2.89		2.50				
Sum of errors on each length sight.		0.21	9.10	0.92	21.87	0.72	17.65	0.71	26.80	1.31	19.96	0.69	31.12		21.58		29.49		23.74		33.03
Average error of a single sight on each distance.		1/396		1/209		1/194		1/202		1/236		1/184		1/212		1/204		1/171		1/148	
Errors of closing total distance on each length sight.		− 1/1415		− 1/227		− 1/210		− 1/212		− 1/269		− 1/192		− 1/212		− 1/204		− 1/171		− 1/148	
Sum of distance measured with each length sight.		3688.57 *m*.		4755.53 *m*.		3566.64 *m*.		5548.13 *m*.		5029.89 *m*.		5852.98 *m*.		4664.09 *m*.		6035.89 *m*.		4054.40 *m*.		4877.47 *m*.	
Total uncompensated error of both sets, (*A*) and (*B*).		− 1/1005		− 1/540		− 1/588		− 1/472		− 1/501		− 1/387		− 1/699		− 1/461		− 1/440		− 1/332	
Grand total of distances measured with each length sight.		7377.14 *m*.		9511.06 *m*.		7529.58 *m*.		10669.48 *m*.		9145.26 *m*.		11705.96 *m*.		9846.41 *m*.		12071.78 *m*.		9267.20 *m*.		10364.62 *m*.	

Date.	Time.	Sights not exceeding *m*. 304.84 (200 Ft. — 1,000 Ft.). Uncompensated Error. (Meters.)	Distance Measured. (Meters.)	Fractional Error in Closing.	Sights from *m*. 304.84 to *m*. 609.68 (1,100 Ft. — 2,000 Ft.). Uncompensated Error. (Meters.)	Distance Measured. (Meters.)	Fractional Error in Closing.	Totals. Error in Closing Total Distance.
July 5	9–10 A. M.	− 4.74	1646.15	− 1/366	− 30.55	4725.05	− 1/155	− 1/180
" 5	10–11 A. M.	− 8.11	1646.15	− 1/203	− 22.29	4115.37	− 1/185	− 1/189
" 5	11–12 A. M.	− 6.63	1646.15	− 1/248	− 27.18	4725.05	− 1/174	− 1/188
" 5	2–3 P. M.	− 1.45	1646.15	− 1/1135	− 23.59	4725.05	− 1/200	− 1/254
August 4	10–10.30 A. M.	− 0.86	914.53	− 1/1063	− 34.73	3810.52	− 1/109	− 1/132
" 4	12 M.–12.30 P.M.	− 0.90	914.53	− 1/1016	− 18.80	2286.32	− 1/121	− 1/162
" 4	2–2.30 P. M.	− 0.97	914.53	− 1/943	− 7.08	2774.07	− 1/392	− 1/458
" 13	10–10.30 A. M.	− 1.65	1646.15	− 1/928	− 27.07	4328.76	− 1/160	− 1/208
" 13	2–2.30 P. M.	+ 0.54	1646.15	+ 1/3048	− 6.86	4328.76	− 1/631	− 1/945
" 16	10–10.30 A. M.	− 1.57	1646.15	− 1/1048	− 10.32	1524.21	− 1/148	− 1/266
" 17	9–9.30 A. M.	− 0.68	1646.15	− 1/2420	− 12.54	4725.05	− 1/377	− 1/482
" 23	11–11.30 A. M.	+ 0.30	792.59	+ 1/2642	+ 2.55	2469.22	− 1/964	− 1/1449
" 23	2–2.30 P. M.	− 1.29	1646.15	− 1/1276	− 11.32	3536.17	− 1/312	− 1/411
Sum of errors on each length sight.		− 28.01	18351.53	− 1/655	− 229.78	48073.60	− 1/209	− 1/257
		Accumulative error on all distances measured by short sights.	Total distance measured by short sights during all hours.	Fractional error on all such measurements.	Accumulated error on all distances measur'd by long sights.	Total distance measured by long sights during all hours.	Fractional error on all such measurements.	Total distance measured on both long and short sights.
Grand total of distances measured with each length sight.		− 20.49 *m*.	38562.51 *m*.	− 1/1882	− 201.38 *m*	97488.52 *m*.	− 1/485	136051.03 *m*. (84.6 miles.)

TABLE 2.

DETERMINATION OF INTERVAL OF BUFF & BERGER TRANSIT No. 670.

Length of Sight.	July 2, 10 A. M.	July 2, 5 P. M.	July 3, 8 A. M.	July 3, 9 A. M.	July 6, 9 A. M. 70° F.	July 8, 8 A. M. 65° F.	July 24, 8 A. M. 80° F.	July 1, 10 A. M.	Average.
100 Ft.	1.00712	1.00379	*(1.01010)	1.00547	(1.01010)	(1.01040)	1.00056	(1.01010)	1.00424
200	1.00385	1.00381	1.00549	1.00368	1.00549	1.00549	1.00368	1.00713	1.00483
300	1.00492	1.00493	1.00492	1.00492	1.00383	1.00383	1.00383	1.00601	1.00465
400	1.00461	1.00453	1.00628	1.00719	1.00218	1.00388	1.00218	1.00487	1.00446
500	1.00382	1.00384	1.00514	1.00579	1.00251	1.00317	1.00251	1.00317	1.00374
600		1.00441	1.00494	1.00330	1.00112	1.00330	1.00166	1.00439	1.00330
700		1.00386	1.00384	1.00384	1.00195	1.00195	1.00195		1.00289
800		1.00385	1.00344	1.00303	1.00385	1.00229	1.00385		1.00339
900		1.00603	1.00322	1.00604	1.00349	1.00167	1.00349		1.00399
1000		1.00450			1.00221	1.00221	1.00415		1.00327
1100					1.00295	1.00000			1.00148
Average	1.00486	1.00436	1.00466	1.00480	1.00296	1.00266	1.00279	1.00511	

Average of 66 Observations = 1.00387

LOWER HALF INTERVAL.

Length of Sight.	July 2, 10 A. M.	July 2, 5 P. M.	July 3, 8 A. M.	July 3, 9 A. M.	July 6, 9 A. M. 70° F.	July 8, 8 A. M. 65° F.	July 24, 8 A. M. 80° F.	July 1, 10 A. M.	Average.
100 Ft.	.50520	.50518	(.50848)	(.50848)	.50520	(.50848)	.50191	(.50848)	.50459
200	.50521	.50519	.50521	.50549	.50602	.50520	.50549	(.50849)	.50540
300	.50410	.50598	.50519	.50410	.50301	.50519	.50301	.50519	.50447
400	.50437	.50432	.50683	.50519	.50355	.50433	.50273	.50437	.50446
500	.50554	.50454	.50388	.50514	.50454	.50388	.50514	.50454	.50465
600		.50466	.50466	.50356	.50357	.50411	.50302	.50466	.50403
700		.50334	.50380	.50380	.50239	.50380	.50286		.50333
800		.50415	.50439	.50439	.50274	.50233	.50356		.50359
900		.50484	.50458	.50484	.50411	.50229	.50411		.50413
1000		.50455	.50455		.50422	.50455	.50422		.50442
1100		.50401	.50401		.50341	.50341	.50341		.50365
1200		.50438							.50438
1300		.50446	.50446						.50446
Average	.50488	.50459	.50469	.50405	.50389	.50432	.50359	.50469	

Average of 74 Observations = 0.50433

UPPER HALF INTERVAL.

Length of Sight.	July 2, 10 A. M.	July 2, 5 P. M.	July 3, 8 A. M.	July 3, 9 A. M.	July 6, 9 A. M. 70° F.	July 8, 8 A. M. 65° F.	July 24, 8 A. M. 80° F.	July 1, 10 A. M.	Average.
100 Ft.	.50192	.49861	.50192	.50192	.49864	.50192	.49864	.50192	.50068
200	.50028	.49862	.50028	.50028	.49946	.50028	.50028	.49864	.49976
300	.50082	.49864	.50082	.50191	.49973	.49973	.50082	.49973	.50027
400	.50027	.49939	.50027	.50027	.49945	.49957	.49863	.49945	.49966
500	.49929	.49995	.50060	.49732	.49798	.49929	.49863	.49929	.49904
600		.49920	.50028	.49919	.49810	.49919	.49810	.49810	.49888
700		.49865	.49916	.49958	.49911	.49817	.49864		.49893
800		.50069	.49946	.49946	.49946	.49864	.50038		.49968
900		.50119	.49901	.50156	.49865	.49947	.49947		.49989
1000		.50029	.49930		.49864	.49861	.50038		.49945
1100		.49984	.49745		.49983	.49864	.49954		.49906
1200		.49891	.49865						.49878
1300		.49865							.49865
Average	.50052	.49943	.49979	.50016	.49900	.49941	.49940	.49952	

Average of 77 Observations = 0.49958

	Full	L. ½	U. ½
ADOPTED INTERVAL,	1.00388	0.50431	0.49957

* NOTE — Observations enclosed in parenthesis were rejected.

In Figs. 18 and 19 the x abscissas are the lengths of test sights in feet, while the y ordinates are the average or probable error of such length sights, the heavy curve being simply an average curve.

Fig. 18 records the work of midday. The decreased accuracy with longer sights, as shown by the rapid descent of the error curve to the x axis after 500 feet sights, is largely due to the excessive refraction at such times, increasing as the lower line was forced nearer the ground into the stratum of greatest refraction.

The descent was arrested at the 1100 ft. sight, because this, and the remainder of sights, were read by half intervals on the upper and clearer portions of the rod, causing both lines of sight to traverse strata of nearly equal refracting power.

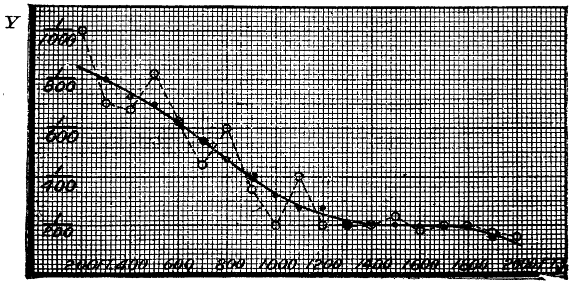


FIG. 19.—ERROR CURVE FOR MIDDAY WORK (9 A. M.—2:30 P. M.).
204 test sights aggregating 41.3 *miles, on a base line, using sights of* 200–2000 *ft. in length. East Troy, Wis., Aug.,* 1894. *X and Y are the same as in fig.* 18.

Fig. 19, representing work of morning and evening hours, presents a striking contrast, for, during its whole length, the error curve varies but little from 1 in 1000.

Not less interesting is the manner in which the error of these 85 miles of stadia measurements accumulated. The 12 miles made in morning and evening hours, using an average length sight of 600 ft., show an error of + 1 in 2,685, while same class of work done in midday shows an error of — 1 in 655. Again, the 30 miles measured in morning and evening hours, with sights from 1,100 to 2,000 ft. long, show an accuracy of + 1 in 1,741, while same class of work executed in midday shows an error of — 1 in 209.

The practical deductions to be drawn from this work are two — 1st, do not attempt accurate work under conditions not represented in the interval determination; and 2d, during the midday hours do not take sights which require the lower line of sight to pass nearer than four feet from the ground.

THE CORRECT STATEMENT OF THE PROBLEM.

Unfortunately for the interests of the stadia method, the effect of "differential refraction," in producing accumulative errors, and the use of proper methods for preventing the same, do not seem to be understood by stadia engineers. For instance, one prominent engineer argues that the best time for determining the interval, is during the *middle of the day*, for the following reasons: 1st, that during the midday, atmospheric refraction is at a minimum; and 2d, that at such times the change in refraction is slight. His misunderstanding results from the fact that he is considering absolute refraction instead of differential refraction. The writer has reason for the belief that this misunderstanding is a general one.

It would be just as sensible to give the usual remedies for pneumonia to a patient suffering from consumption. The name, or diagnosis, is important because it determines the remedy.

Absolute refraction *is* at a minimum near midday, as claimed, but differential refraction is near a maximum at such times. Stadia measurements are not concerned with absolute refraction, but instead, with the relative or differential refraction of the two lines of sight, constituting a rod reading. However, if an engineer determines his interval during a midday hour, as some advise, work done during such hours will show a higher degree of accuracy than work of other hours, but unless he intends to confine all stadia work to midday, the engineer would be inviting large systematic errors by choosing such time for the interval determination.

That this is not mere theorizing, a glance at the results of the recent survey of St. Louis will abundantly prove. The report of this survey shows that all distances were read too long, a ct which the records certainly prove. Now let us inquire into the method of interval determination. The engineer in charge gives out the following facts: The interval was determined by a single observer, and made to depend on ten observations, taken at a certain half hour of a July day, over ground, and in weather, that differed widely from average conditions met during the three years of field work. Assuming that the engineer followed his present advice and determined his interval in midday, the explanation for the excessive readings is plain to be seen. During summer months rod readings become a minimum at about 11 o'clock, so that in the common stadia equation $D = KS$ $K, \left(= \frac{D}{S}\right)$ will be too large, since S, the rod intercept, is too small for work before 9.30 and after 2.30. The inevitable result of using too large a value of K (the interval) would be the excessive readings to which this work was subject. If the interval had been determined at some morning hour the errors would have been of opposite sign, as has already been seen in the discussion of my own work. Other examples could be given.

When a survey continues through widely different conditions, such as summer and winter, it would be wise to redetermine the interval at each decided change in season, taking care that the conditions of the determination may approximate those to be met in the field. For example, if the survey is to be over ordinary soil, do not determine interval on a stone curbing; if in the field, the rodman is not to be aided by a plumb line, do not suffer such aid in the determination; and above all, let each man who is to observe with the transit, determine an interval himself for his own use, for in this way you will eliminate the systematic errors due to his personal equation.

PROOF THAT ACCUMULATIVE ERRORS CAN BE PREVENTED.

In order to discover to what extent errors would accumulate with the adopted interval, while making a long stadia measurement, under actual field conditions, thirteen independent stadia measurements of the base line were made under the conditions of time, weather, and length of sight recorded in table 3.

A glance at this table will show the actual error on each street expressed in meters and also fractionally; the fractional error on each complete measurement of the base (2,217 meters); and also the accumulated error of the thirteen measurements. It will be seen that the average error of the base line measurements was 1 in 2,250, and that the longer the measurement, the greater became the relative accuracy, owing to the compensation of errors.

Thus, beginning with an error of 1 in 2,100 on the first measurement, the error decreases, till at the end of eighteen miles the accumulated error was but 1 in 10,400. The total time spent in measuring these eighteen miles was fourteen hours.

CONCLUSION.

A somewhat wide correspondence with experienced stadia engineers, indicates that at present, hardly any two engineers agree as to the proper time for determining the stadia interval, there being almost as many opinions as there are hours of the day. If the conclusions of this paper are correct, all are individually wrong, and yet collectively right. *Determine your interval not at any one hour, but during many,* so as to approximate as closely as time allows, the average conditions for the field work. The degree of accuracy which will result will correspond closely to the degree of such approximation.

Many engineers will say that the present method is accurate enough, and so it is for a large class of work; but for a much larger class of work it is not accurate enough. The stadia method is such a convenient and economical one to use, that it would seem a step of progress to widen its field of usefulness. This can be done by using additional care in determining the interval.

The chief objection to this added care, both in the original interval determination and also to any subsequent ones rendered necessary by decided change in field conditions, will doubtless be the *cost* of repainting the rods in the latter case and the *cost* of such added care in both cases. The first objection would be entirely removed by not incorporating the interval in the rod design, as it is at present so generally done; but, instead, using rods divided into standard units of length, and then computing true distances by means of an *interval factor*. By means of a table, such computations can be made very quickly. All the measurements discussed by this paper were thus computed. This point is very ably discussed by Mr. J. L. Van Ornum, of Washington University, in a paper on stadia work to be read before the coming convention of the American Society of Civil Engineers. He names the following as some of the disadvantages of the present method, as compared with that method employing an interval factor.

1st. Subsequent tests of interval cannot be made without the expense of repainting and regraduating the rod.

2d. Rods cannot be interchanged among transits.

3d. Old rods cannot be used with new transits.

4th. Rods cannot be used in leveling without computing the necessary correction.

5th. Leveling rods cannot be used as stadia rods.

6th. Observers with different personal equations cannot use the same rods without causing accumulative errors.

These disadvantages of the present system are so evident, that the adoption of the interval factor method seems only a question of the time necessary "to teach old dogs new tricks."

The second objection to exercising greater care on the interval determination is more apparent than real. Increased accurracy of any work generally involves increased care or money, or perhaps both. The real question is, will the results of such care justify the increased cost? It has been shown, that such care prevents, in great measure, the large systematic errors, which up to the present, have confined the use of the stadia method within narrow limits. As a matter of fact, on some of the surveys with which the writer is acquainted, the cost of the steel tapes worn out in making measurements, where the stadia method should have been employed, has exceeded the cost of either repainting the rods or the cost of the increased care in the interval determination.

Again it should be noted, that in surveys furnishing frequent triangulation or steel tape checks on the stadia measurement, each check may be used as a determination of interval, and the average of a number of such determinations would give the very best value for the interval, without the expenditure of an extra dollar or an extra hour of time.

Madison, Wis.

APPENDIX.

THEORY OF STADIA MEASUREMENTS.

An explanation[1] of the theory of Stadia measurements is here given, that the general reader may better understand this paper.

The stadia[2] is an instrument for determining the distance of a point from the observer by the visual angle subtended by an object of known size, placed at the point. Ordinarily, not only the distance but also the horizontal and vertical angles are observed; these three being sufficient to determine the direction, distance, and elevation of the point upon which the rod is placed.

A graduated rod and a mounted telescope are used, the latter containing two extra horizontal cross wires. When the objective of the telescope is fo-

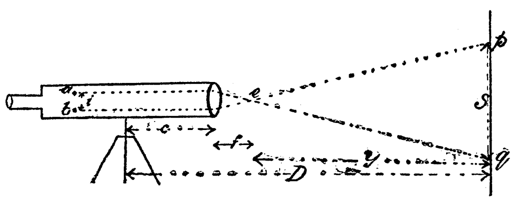


FIG. 21.

cused on the rod, these wires seem projected on it. Thus in Fig. 21, *a* and *b* represent the stadia wires, *i* the distance between them, *s* the distance p—q on the rod intercepted between the wires, *f* the principal focal distance of the telescope objective, *e* a point at a distance *f* in front of the optical center of the objective (*e* is the principal focus of the objective), *c* the distance from the plumb-line of the instrument to the optical center of the

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1 This explanation is taken mainly from Prof. Ira O. Baker's "Engineer's Surveying Instruments."

2 The word stadia was first applied to the rod, but as now generally used means both alidade and rod as a whole. In Great Britain the instrument by which the observation is made is called a tacheometer, and the rod is called a stadia. On the U. S. C. & G. S. the term telemeter is used instead of stadia.

objective, y the distance from the outer focus e to the rod, and D the distance from the instrument to the rod.

From the principles of optics, we know that all rays of light which pass through e are parallel to each other after emerging from the objective. Therefore, there is some point q which will emit a single ray of light that will pass through e, and, after traversing the objective, will strike the cross wire a. If the telescope is focused for the point q, the objective will bring all rays emitted by q to a focus at a; and hence it is immaterial whether we consider the real course of the rays, or assume that all the light from q passes along the line $q\ e\ a$.

Similarly, we may assume that all the rays from p pass along the line $p\ e\ b$.

In Fig. 21 we have from similar triangles, $s : y = i : f$ from which

$$y = \frac{f}{i} s = Ks \qquad (1)$$

Notice that K, $\left(= \frac{f}{i}\right)$ is a constant co-efficient peculiar to each instrument; and also that the intercept s on the rod varies as y, the distance of the rod from the outer focus of the objective.

Since the two rays from p and q are parallel after entering the telescope it is immaterial where the cross hairs are; and, therefore, the distance of the rod from e is always proportional to the intercept s.

The distance of the rod from the plumb-line is $y + f + c$ or

$$D = Ks + f + c \qquad (2)$$

Equation (2) is the fundamental one of stadia work. The values f and c can be measured directly on the instrument, and K is determined by observing a number of values of s on known distances.

In this paper getting the value of K is called determining the stadia interval.

The explanation here given applies only to those measurements made with *horizontal* sights. Only a slight modification is necessary, however, for extending the discussion to inclined sights.

THE ORIGIN OF THE DELLS OF THE WISCONSIN.

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The reports of the State Geological Survey of Wisconsin show that the Paleozoic formations constitute a gentle southward plunging anticline the axis being a north-south line near the center of the state. Doubtless the axis of the anticline is also curved, which implies a bending in a direction transverse to the more conspicuous bending.

So far as observed, in the south central part of the state the prominent joints are approximately in east-west and north-south directions, with, however, a good deal of local variation and in places another set of joints in a third direction. That there is a connection between this jointing and the folding is at once suggested, the joints being a rectangular system of fractures produced by the folding, and their directions being controlled by it, as explained by Daubrée and amplified by others.

The well known Dells of the Wisconsin constituting a cut through a broad flat ridge of Cambrian sandstone have been described by Chamberlin as eroded subsequently to the glacial epoch, this river finding a new channel, because of a dam of glacial deposits which obstructed its old passage through the Baraboo quartzite range. In what follows the courses of the dells of the minor streams which flow into the Wisconsin are first considered, the course of the Wisconsin itself being excluded. A close examination of these dells show that they were controlled in their location by the rectangular system of joints above mentioned. For instance, in following one of the side streams, one may first go in a north-south direction, then turn to an east-west direction, then again in a direction north and south, and then in a direction east and west, etc. While the main creek or brook thus has a rectangular course, at any one of the turns a lesser stream may come in along the other system of joints. The dells of the creeks and branches alike may head in a col into which the water falls from the comparatively level land above in times of melting snow or abundant rainfall. In the dry season in many of the branches no water falls from the plain above. Such a dell thus starts almost at once as a canyon from 15 to 50 feet deep. The head of the col is found to be located upon a joint, which widened by erosion at the head of the col may be traced back to a mere seam. This slit ahead of the col and in the direction of the stream plainly controls the backward cutting. Other dells end by opening out and rising with a gradual or steep slope to the plain above but these have a set of right angles turns the same as these which head in a col. As the streams become of larger size in the lower reaches, that there is a rectangular turn in passing from one set of joints to the other may be obscured by the fact that the corner has been worn off, thus making a curve, camparable to a curved joint in a stove pipe when it takes a new direction, rather than the rectangular joint which used to be so common, and which the stream undoubtedly had at first. However, in the newer dells the rectangular system is almost perfectly preserved, and at several places along each dell one may see the beginning of new side streams, which have opened up a joint a few feet to many feet from the main dell. The different dells vary in length from those which have just begun to follow the joint back from the Wisconsin to those which show a half dozen or more right angle turns. The older any given stream, the larger the area of the plain above which has become tributary to it. In some cases the dells follow joints other than those of the rectangular system.

Because the dells are located on joints, erosion is easy downward and gorges are cut very quickly to the level of the main stream. This easy vertical cutting as compared with the side cutting is the cause of the picturesque features of the dells, which are perhaps fifteen to fifty feet deep, and in places barely wide enough for a person to walk through. The downward cutting soon results in a base level, and makes the chief work of erosion the corrasion of the sides of the canyon. A dell which has just begun to develop along a joint, and has a length of only 50 or 100 feet, may be cut down to the level of the water of the Wisconsin. Taylor's Glen below Kilbourn and Artist's Glen, Cold Water Canyon, and Witch's Gulch above Kilbourn show very well the features described.

About three miles above Kilbourn City are the so-called narrows of the Wisconsin. The river at its narrowest place is 42 feet wide, whereas the average width away from the Narrows is 150 to 200 feet. The Narrows are due to the fact that the Wisconsin has here changed its course since glacial time. The length of the Narrows is about ½ mile. Above the Narrows the old course of the stream may be seen to leave its present channel, and below the Narrows to again join the present course. While this old channel has not been followed personally, it is said to be about 1½ miles in length. Because of the peculiar conditions which result in almost immediate base levelling of the side dells, and the rectangular system of joints, it is thought probable that side dells at the beginning and end of the Narrows began to develop; that because of the system of joints in two directions their heads intersected, and thus made the beginning of the new channel. At times of flood the Wisconsin backs water in some of the dells to a distance of from ½ mile to 1 mile or more. Two dells on different systems of joints so far developed as to be base levelled back to the point of intersection, would allow a part of the water of the Wisconsin at flood times to pass through the new channel, thus furnishing a course for a part of the water. In this shorter course the erosion would go on more and more rapidly, and finally the old longer course would be abandoned for the shorter one. Thus the Narrows, in rocks no harder than those confining the remainder of the course of the Wisconsin in the vicinity, are explained, and we have the unusual phenomenon of strong river in a gorge abandoning its course to follow another gorge made by two small weak tributary streams which had no advantage in slope.

Steamboat Rock, a large island in the river above the narrows, is doubtless explained in a similar fashion. The main stream and the old course of the river is south of the rock.

North of the rock is a narrow swifter channel, which it is believed has been produced by the intersection of two short dells developing along joints.

Whether the Wisconsin itself through the dells, except along the narrows, can be considered to be controlled by joints is uncertain. This stream is so large and powerful that it has well rounded curves. It may be said that in its windings its longer stretches seem to conform to some extent to a rectangular system, its course being for the greater part of this distance approximately east-west or north-south, and the stretches in the intermediate directions being shorter.

My conclusion is that adjacent to the Wisconsin river the minor and perhaps the major drainage developed in post-glacial time, on the broad flat ridge of Cambrian sandstone at Kilbourn City and vicinity, is largely controlled by regional sets of joints produced by the slight foldings of the Paleozoic formations of Wisconsin.

The dells of the Wisconsin also exhibit a magnificent example of current bedding. This may be followed from below Kilbourn City to the Witch's Gulch, five miles above. The most common phenomena are as follows: The horizontal beds of sandstone just above the water are horizontal. When followed to higher horizons these are seen to curve upward until they have an inclination of 15°, 20°, or even 30°. One may follow mile after mile up the stream and find the beds curving from a horizontal to an inclined position, the dips usually being down the river. After the current beds were deposited it appears that there was a time of erosion during which they were cut to an almost perfect horizontal plane. Resting upon the truncated edges of these beds is horizontal sandstone. In some places the current beds run in different directions, two different sets truncating each other before the overlying horizontal sandstone which always truncates the upper set of false beds is reached. The appearance of the discordant set of beds is very strongly that of unconformity, and the scale is such that if only a part of the phenomena were seen, i. e., the tilted and overlying beds, the lower horizontal beds and their transition into the inclined beds being concealed, an observer would be very likely to conclude that a true unconformity existed between the truncated current bedded layers and the horizontal layers above. Such a mistake would be particularly likely to occur if the beds seen had been subjected to folding together.

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A. B., A. M., Ph. D. (Hamilton); LL. D. (Ohio). Prof. of Geology, Ohio State University; State Geologist of Ohio.

Peet, Stephen Denison, Good Hope, Ill.

A. M., Ph. D. (Beloit). Clergyman and Editor.

Potter, William Bleecker, 1225 Spruce st., St. Louis, Mo.

A. B., A. M., M. E. (Columbus). Mining Engineer and Metallurgist.

Power, Frederick Belding, 29 Grove Terrace, Passaic, N. J.

Ph. G. (Phila. Coll. of Pharm.); Ph. D. (Strassburg). Director of Manufacturing Chemical Laboratories of Fritzsche Bros., N. Y. City.

Safford, Truman Henry, Williamstown, Mass.

B. A. (Harvard); Ph. D. (Williams). Prof. of Astronomy, Williams College.

Salisbury, Rollin D., Chicago University, Chicago, Ill.

A. M. (Beloit). Prof. of Geographic Geology, University of Chicago; Geologist, State Geological Survey, New Jersey.

Sawyer, Wesley Caleb, Asbury st., College Park, Calif.

A. B., A. M. (Harvard); A. M., Ph. D. (Göttingen). Prof. of Speculative Philosophy and Dean of the College of Liberal Arts, University of the Pacific.

Shipman, Stephen Vaughn, 269 Warren av., Chicago, Ill.

Architect.

Somers, Amos Newton, Lancaster, N. H.

A. B. (Roanoke). Clergyman.

Steele, George McKendall, Auburndale, Mass.

A. B., A. M. (Wesleyan); D. D. (Northwestern); LL. D. (Lawrence). Instructor and Lecturer, Lasell Seminary.

Stump, J. W., Address unknown.

Tatlock, John, Jr., P. O. Box 194, New York, N. Y.

(No further information furnished.)

Tolman, Albert Harris, Chicago, Ill.

A. B. (Williams); Ph. D. (Strassburg). Assistant Professor of English Literature, University of Chicago.

Tolman, Herbert Cushing, Nashville, Tenn.

A. B., Ph. D. (Yale). Professor of Greek, Vanderbilt University.

Townley, Sidney Dean, Observatory, Ann Arbor, Mich.

B. S., M. S. (Wisconsin). Instructor in Astronomy, University of Michigan.

Trelease, William, Botanical Garden, St. Louis, Mo.

B. S. (Cornell); D. Sc. (Harvard). Director of Missouri Botanical Garden, and Professor of Botany, Washington University.

VAN DE WARKER, Ely, 404 Fayette Park, Syracuse, N. Y.
M. D. (Albany Medical and Union). Surgeon Central New York Hospital for Women; Consulting Physician St. Ann Maternity Hospital.

VERRILL, Addison Emory, 86 Whalley av., New Haven, Ct.
B. S. (Harvard); A. M. (Yale). Professor of Zoology, Yale University.

WINCHELL, N. H., 120 State st., Minneapolis, Minn.
A. M. (Michigan). State Geologist of Minnesota.

YOUNG, Albert Adams, Cobden, Ill.
A. B., A. M. (Dartmouth). Clergyman.

DECEASED MEMBERS.

ALLEN, Hon. W. C , Racine.

ALLEN, Wm. F., Prof. of History, University of Wisconsin (President of Wisconsin Academy, 1887–1889).

ARMITAGE, W. E., Rt. Rev., Bishop P. E. Church, Milwaukee.

CARPENTER, S. H., LL. D., Prof. of English Language, University of Wisconsin.

CASE, Hon. J. L., Racine.

CHAPIN, Dr. A. L., President of Beloit College, Beloit (President of Wisconsin Academy, 1878–1881).

CONOVER, O. M., LL. D., Madison.

COPELAND, Prof. H. E., Whitewater.

DADD, John Alfred, Pharmacist, Milwaukee.

DEKOVEN, S. T. D., Warden Racine College, Racine.

DELAPLAINE, Brigadier General George P., Madison.

DEWEY, Governor Nelson, Madison.

DRAPER, Dr. L. C., Madison.

DUDLEY, Wm., Madison.

DURRIE, D. S., Librarian Wisconsin State Historical Library, Madison.

EATON, J. H., Ph. D., Prof. of Chemistry, Beloit College, Beloit.

ENGLEMAN, Prof. Peter, Director German and English Academy, Milwaukee.

FEULING, J. B., Ph. D., Prof. of Philology, University of Wisconsin.

FOSTER, Prof. J. W., LL. D., University of Chicago, Chicago.

FREER, J. C., President Rush Medical College, Chicago.

GREENE, Thomas A., Wholesale Druggist, Milwaukee.

HAWLEY, C. T., Milwaukee.

HERITAGE, Lucius, Prof. of Latin, University of Wisconsin.

HOLTON, Hon. E. D., Milwaukee.

HOY, Dr. P. R., Racine, Wis. (President of Wisconsin Academy, 1876–1878).

IRVING, R. D., M. E., Prof. of Geology, University of Wisconsin, and U. S. Geologist. (President of Wisconsin Academy, 1881–1884).

JEWELL, J. S., A. M., M. D., Prof. in Chicago Medical College, Chicago Ill.

KNAPP, Hon. J. G., Milwaukee.

KUMLEIN, Prof. Thure, Albion College, Albion.

LAPHAM, I. A., LL. D., State Geologist, Milwaukee.

LAWLER, Hon. John, Prairie du Chien, Wis.

LEWIS, Mrs. H. M., Madison.

LITTLE, Thomas H., Supt. Institution for the Blind, Janesville.

MAXON, Rev. H. D., Menominee.

McDILL, A. S., M. D., Supt. State Hospital for the Insane, Madison.

MILLS, Simeon, Madison.

NEWBERRY, Dr. J. S., Columbia College, N. Y.

NICODEMUS, W. J. L., A. M., C. E., Prof. of Engineering, University of Wisconsin.

OLDENHAGE, Prof. H. F., Milwaukee High School, Milwaukee

PAUL, Hon. Geo. H., Milwaukee.

PAYNE, Alfred, Artist, Hillsdale, Ill.

PUDOR, Christian Cornelius, Civil Engineer, Ass't Engineer C. & N. W. R. R. Company, Madison.

REID, Hon. George, Manitowoc.

SMITH, Hon. John Y., Madison.

SMITH, Hon. Wm. E., Milwaukee.

STIMPSON, Wm., M. D., Secretary Chicago Academy of Sciences, Chicago.

THORP, J. G., Cambridge, Mass.

WHITE, Hon. S. A., Whitewater.

WINCHELL, Prof. Alexander, University of Michigan, Ann Arbor, Mich.

WILLARD, S. W., De Pere.

WHITNEY, William Dwight, Prof. of Sanscrit and Comparative Philology, Yale University.

WOLCOTT, E. B., M. D., Surgeon General, Milwaukee.

PROCEEDINGS.

REPORT OF THE SECRETARY.

TWENTY-FOURTH ANNUAL MEETING.

MADISON, WIS., WEDNESDAY, Dec. 27, 1893.

MORNING SESSION.

The meeting was called to order at 9:15 A. M. at the rooms of the Academy in the capitol. In the absence of the president, C. R. Van Hise, first vice-president, occupied the chair. As the report of the secretary had been printed in the Transactions, the reading of minutes was omitted. The secretary announced that no notice had been received of the death of any member of the Academy. Four active members have removed their residence from the state, viz., Mr. J. C. Foye of Appleton, to Armour Institute, Chicago; Prof. A. H. Tolman of Ripon, to the University of Chicago; Prof. H. C. Tolman of Madison, to Chapel Hill, N. C., and Prof. H. B. Loomis of Madison, to Northwestern University, Evanston, Ill.

The treasurer's report was then read and Gen. G. P. Delaplaine and Prof. H. W. Hillyer were appointed by the President a committee to audit the report. (See p. 591.)

As the librarian's report had appeared in the Transactions its reading was omitted. The librarian announced the completion of the work of binding the books of the library, and referred to the plan suggested in his printed report for the distribution of books to members.

The President appointed the librarian and Professors Blaisdell and Marsh a standing committee to consider this matter and report later in the meeting.

The report of the committee on revision of the constitution was then read by the secretary. Dr. Birge thought that there were some points in the existing by-laws which should be brought into harmony with the proposed constitution, and Prof. Hendrickson moved that a committee be appointed to so alter the constitution as to effect this. See p. 591.

The President appointed the following committees:

On nomination of officers, Prof. E. A. Birge, Mr. Willard Hodge and Prof. C. D. Marsh; on nomination of members, the Secretary, Professors Birge, Barnes, Blaisdell and Marsh; to consider the librarian's suggestion regarding the distribution of books to members, the Librarian, and Professors Blaisdell and Marsh. The literary program was then begun and the following papers read:

On the speed of reduction of ferric chloride by stannous chloride, a study in chemical dynamics, by Louis Kahlenberg, discussed by Professors Kremer and Daniells.

A system of classification of the nitrogen derivatives of the paraffin hydrocarbons, by Edward Kremers, discussed by Professors Daniells and Hillyer.

On a new species of the genus *Latona*, Straus, from Northern Wisconsin, by E. A. Birge.

The Academy then adjourned.

AFTERNOON SESSION.

The Academy re-assembled at 2:15 p. m. with Vice-President Blaisdell in the chair. The committee on new members presented the following candidates for membership:

Active Members.

J. Morgan Clements, Madison.
V. E. Coffin, Madison.
A. S. Flint, Madison.
F. R. Jones, Madison.
E. R. Maurer, Madison.
A. W. Richter, Madison.
H. L. Russell, Madison.
B. W. Snow, Madison.
C. S. Schlicter, Madison.
Frederick E. Turneaure, Madison.

F. H. Wilkins, Madison.
F. W. Woll, Madison.
L. W. Austin, Madison.
J. W. Decker, Madison.
W. F. Giese, Madison.
J. D. Mack, Madison.
W. S. Marshall, Madison.
Geo. W. Saunderson, Madison.
F. C. Sharp, Madison.
H. A. Sober, Madison.
L. C. Urban, Madison.
E. B. Van Vleck, Madison.
O. G. Libby, Madison.
H. F. Stecker, Madison.
E. R. Buckley, Madison.
J. L. Mead, Madison.
H. H. Swain, Madison.
Harry Kuhn, Madison.
Edw. D. Eaton, Beloit.
G. L. Collie, Beloit.
H. D. Densmore, Beloit.
Rob't C. Chapin, Beloit.
T. A. Smith, Beloit.
A. W. Burr, Beloit.
C. E. Pearson, Beloit.
George Bacon, Beloit.
C. A. Bacon, Beloit.
A. S. Mitchell, Milwaukee.
R. J. O'Hanlan, Milwaukee.
Emil Dapprich, Milwaukee.
Christian Preusser, Milwaukee.
John A. Dadd, Milwaukee.
H. Ruenzel, Milwaukee.
A. Conrath, Milwaukee.
W. S. Johnson, Milwaukee.
H. F. Lueders, Sauk City.
R. C. Ramsay, Peshtigo.
A. T. Lincoln, Montfort.
Ruth Marshall, Baraboo.

Corresponding Members.

Mr. J. C. Foye, Armour Institute, Chicago, Ill.

Pres. John M. Coulter, Lake Forest Univ., Lake Forest, Ill.

Prof. A. H. Tolman, Chicago, Ill.

Prof. H. C. Tolman, Chapel Hill, N. C.

Prof. H. B. Loomis, Evanston, Ill.

The secretary was ordered to cast the ballot for the above candidates.

The auditing committee reported the treasurer's accounts and vouchers correct. The treasurer's report was thereupon approved.

On motion of Prof. Van Hise the report was accepted and the resolution adopted.

The committee on the library reported that Mr. R. G. Thwaites, the secretary of the State Historical Society, offered to aid the librarian and his assistant in the distribution of the books, by instructing some member of the staff of the State Historical Library to charge and ship books of the Academy to members on occasions when the librarian or his assistant cannot be in attendance at the library. If this were found to be a considerable burden, the Historical Library would expect a return in money to pay for the clerical assistance rendered. This offer of Mr. Thwaites was thankfully accepted by the Academy and the details of the plan were left with the Library committee. The council was authorized to expend money for care of library.

The literary program was then resumed and the following papers were read:

3. The geographical distribution of the vote on the ratification of the federal constitution (1787–8), by O. G. Libby, Madison.

Discussed by Prof. Turner, the secretary, Prof. Van Hise, the presiding officer and the author.

4. Notes on a study in English colonial government, by Victor E. Coffin, Madison.

5. The transcontinental exploration of Lewis & Clark, by James D. Butler, Madison.

6. Maximum stresses in bridge members, L. M. Hoskins, Palo Alto, California.

7. The statistical method in psychology, by Joseph Jastrow, Madison.

8. The desirability of a state physiographic survey, by G. L. Collie, Beloit. Discussed by Prof. Van Hise.

9. Notes on glacial abrasion, by G. E. Culver, Madison. (Read by title.)

Prof. Van Hise moved that a committee be appointed to memorialize the legislature at its next session with reference to the appropriation of funds for a state geological survey. Dr. Birge desired to amend by including a biological survey and the amendment was accepted. Mr. Cheney spoke of the importance of a botanical survey in connection with necessary forestry legislation.

Prof. Van Hise then put his motion in the form of the following resolution:

Resolved, That a committee be appointed to draw a bill to present to the next legislature for the following purposes:

1. For a state physiographic survey.
2. To supplement the state geological survey.
3. For a biological survey.

The committee is instructed to present this bill to the Academy at its annual meeting in 1894 and to disseminate information upon the importance of the proposed survey.

The above resolution was adopted and the appointment of the committee was left to the council. The presiding officer then appointed Prof. A. J. Rogers on the committee on nomination of officers, owing to the continued absence of Prof. Marsh.

Academy then adjourned until 7:30 p. m.

EVENING SESSION.

The meeting was called to order by Dr. E. A. Birge at the request of the vice-president, at 7:30 o'clock. On behalf of Dr. Birge, the chairman of the committee on nomination of officers, the secretary read the following report:

The committee on the nomination of officers for the Wisconsin Academy of Sciences, Arts, and Letters submit the following report:

For President, C. R. Van Hise, Madison.

For Vice-Presidents:

Department of Science, C. Dwight Marsh, Ripon.

Department of Arts, A. J. Rogers, Milwaukee.

Department of Letters, J. J. Blaisdell, Beloit.

For Secretary, C. R. Barnes, Madison.

For Treasurer, S. D. Hastings, Madison.

For Librarian, F. L. Van Cleef, Madison.

For Curator, G. E. Culver, Madison.

Respectfully submitted,

E. A. Birge,
Chairman.

The secretary was instructed to cast the ballot of the Academy for the above candidates.

Prof. Birge then presented the following resolution: In view of the valuable services of the secretary and librarian, Prof. Hobbs, in the preparation of the catalogue and of the library and in promoting in many other ways the welfare of the Academy.

Resolved, That Dr. Wm. H. Hobbs be elected a life member of the Academy.

The retiring secretary was therefore elected a life member of the Academy.

Dr. C. R. Van Hise then delivered an address "On the Evolution of the North American Continent." At 8:30 the meeting adjourned so that members might attend the reception tendered the Academy by President and Mrs. Adams of the University of Wisconsin.

THURSDAY, DECEMBER 27TH.

The meeting was called to order at 9:30 a. m. by the President elect, Dr. C. R. Van Hise. The President appointed Prof. G. L. Hendrickson on the committee of publication. The following members were appointed a standing committee on nomination of members:— The secretary and Profs. Rogers, Blaisdell, Marsh and Collie.

Prof. Collie, on behalf of the president and faculty of Beloit College, invited the Academy to hold its next summer meeting at Beloit. After discussion by the president and secretary, the invitation was accepted. Prof. Birge moved that the secretary send out blanks to determine proper titles of members. Carried. The following papers were then read:

10. Notes on some New Jersey eskers and accompanying gravel deposits, by G. E. Culver, Madison. Discussed by Prof. Van Hise and Mr. Sinnott.

11. On the occurrence of diamonds in Wisconsin, by Wm. H. Hobbs, Madison. Discussed by Profs. Kremers and Van Hise.

12. On the so-called "Inca's Eyes" (illustrated by specimens), by W. S. Miller.

13. Two new species of *Diaptomus*, by C. Dwight Marsh, Ripon. (Read by title.)

15. The relation of motives to freedom, by Edw. H. Merrill, Ripon. (Read by title.)

16. On a new type of overthrust faulting, by Wm. H. Hobbs, Madison. Discussed by Prof. Culver.

17. Allotropy and its relations to the periodical system, by J. L. Mead, Madison. (Read by title.)

18. An optically inactive menthone, by L. C. Urban. (Read by title.)

After remarks by the president the meeting adjourned *sine die*.

On Thursday evening the members of the Academy and their ladies sat down to supper at the parlors of Christ Presbyterian church, twenty-seven being present. After the supper the president, Dr. Van Hise, called upon Dr. Birge to open the discussion of the question, "How can the meetings of the Academy be made of greater interest?" In the informal discussion that followed nearly every member present took part.

WM. H. HOBBS,
Secretary.

SECOND SUMMER MEETING.

BELOIT, Wis., June 7th, 1894.

EVENING SESSION.

The meeting was called to order by President Van Hise, in the Auditorium of Pearsons Hall. After announcements by the secretary and by Professor Collie of the Local Committee, the members of the Academy were addressed by President Eaton; subject, "Wordsworth—a forerunner of the scientist."

FRIDAY, June 8th.

MORNING SESSION.

The meeting was called to order by President Van Hise at 0 a. m. in the Physical Lecture Room of Pearsons Hall.

The minutes of the twenty-fourth annual meeting were read and approved. A communication from the Scientific Alliance of New York City was read, asking the Academy to memorialize the postoffice department for a reduction of the rates of domestic and foreign postage on natural history specimens. On motion of Dr. Birge, the council was directed to prepare and forward such a memorial. The following papers were then read and discussed:

1. The organic structure of the mind, with particular reference to the sensibilities. *J. J. Blaisdell.*

2. The recent epidemic of typhoid fever in Ashland, Wis., and the water supply of the city. *W. W. Daniells.*

3. Standards of purity for portable waters. *E. G. Smith.*

4. General property tax in Rock county. *R. C. Chapin.*

5. State banking in Wisconsin from 1852 to 1865. *Clarence B. Hadden.*

6. Criticism of a pendulum problem in Barker's physics *T. A. Smith.*

7. An improved harmonograph. *Charles H. Chandler.*

10. Account of the triangulation work done in Wisconsin to the present time. *J. E. Davies.*

In the afternoon at 2 o'clock the members of the Academy met at Pearsons hall and went thence to the boat landing, where a steamer was in readiness to convey them up the Rock river. The trip covered several miles. Landings were made at points of interest along the way, and the party returned at 6 o'clock well pleased with the excursion.

EVENING SESSION.

Meeting called to order in Pearsons Hall at 8 p. m., President Van Hise in the chair. Prof. T. C. Chamberlin of Chicago University was introduced and gave an address on "Ancient Ice Invasions." At the close of the address a reception was tendered the Academy by President and Mrs. Eaton at their home. Refreshments having been served, there followed a brief discussion of the proposed natural history survey of the state.

JUNE 9, 1894.

MORNING SESSION.

Meeting was called to order at 8:40 a. m., President Van Hise in the chair. The Committee on Membership reported the following names:

W. F. Goodhue, Milwaukee.

Edwin Bartlett, M. D., Milwaukee.

E. P. Salmon, Beloit.

Prof. Wm. Porter, Beloit.

Clarence B. Hadden, Madison.

Fred D. Heald, Madison.

Charles J. O'Connor, Madison.

Samuel Weidman, Madison.

The secretary was directed to cast the ballot of the Academy for these persons. It was so done and the gentlemen declared elected. The following papers were then read:

8. Recent changes in the great red spot of Jupiter. *C. A. Bacon.*

9. Note on the progress of transit observations for stellar parallax at the Washburn Observatory. *A. S. Flint.*

11. The color of Lepomis gibbosus. *E. R. Downing.*

12. The so-called accessory intestine of Phascolosma Gouldii. *E. R. Downing.*

13. On the vertical distribution of the pelagi c Crustacea of Green lake. *C. Dwight Marsh.*

14. New facts in regard to the heart of the common crayfish. Illustrated by models. *W. S. Miller.*

15. On the cause of pole-burn in tobacco. *James B. Pollock.*

16. The comparative anatomy and movements of the motor organs of the leaves of certain Leguminosæ. *F. D. Heald.*

17. On the speed of liberation of iodine in mixtures of potassium chlorate, potassium iodide and hydrochloric acid. *Herman Schlundt.* (Read by title.)

18. Rotary power of solutions of lead oxide in normal tartrates of the alkalies. *Louis Kahlenberg.* (Read by title.)

19. Geology of the Conanicut island, R. I. *G. L. Collie.*

20. Notes on Dikellocephalus crassimarginatus, Whitfield. *Charles J. O'Connor.* (Read by title.)

21. On the petrographical character of some greenstones from the Lower Quinnesec falls, Wis. *A. T. Lincoln.* (Read by title.)

22. On the quartz keratophyre of the northern range of Baraboo bluffs. *Samuel Weidmann.* (Read by title.)

The committee on Membership reported the names of

Charles L. Mann, Milwaukee;

Prof. J. P. Iddings, Chicago;

Mr. E. R. Downing, Beloit,

as active members. The Secretary was directed to cast the ballot for these persons. It was so done and they were declared elected. The final papers were then presented as follows:

23. Ancient volcanoes of the Yellowstone Park region. *J. P. Iddings.*

24. Old Quarternary deposits in the Rock river valley. *Ira M. Buell.*

25. The dells of the Wisconsin. *C. R. Van Hise.*

26. Ice ramparts of the Madison lakes. *C. R. Van Hise.*

The meeting then adjourned.

C. R. Barnes,
Secretary.

TWENTY-FIFTH ANNUAL MEETING.

MADISON, Wis., Dec. 27, 1894.

The Academy met at the rooms of the Academy in the capitol at Madison at 9:40 a. m., and was called to order by President Van Hise.

Minutes of the second summer meeting, held at Beloit, were read and approved.

Report of treasurer was read and referred to the auditing committee, consisting of Professors E. G. Smith, W. H. Chandler, H. W. Hillyer.

The report of the librarian was read and accepted.

On motion a vote of thanks was tendered to Prof. Van Cleef for his efficient services.

E. A. Birge, H. F. Lueders, and C. S. Schlicter were appointed a committee to nominate a librarian.

The secretary reported the progress of Vol. X of the Transactions. The regular program was then entered upon and the following papers read:

1. The natural waters of Wisconsin. *E. G. Smith.*
2. On the composition of spring waters from the Black Hills. *W. W. Daniells.*
3. The action of aluminum chloride on saturated hydrocarbons. *W. H. Hillyer.*
4. On the composition and feeding value of potato starch factory waste. *W. W. Daniells.*
5. On the chlorides of ortho-sulpho-benzoic acid. *A. P. Saunders.*
6. A new method of making $C_2 H_2$. *E. R. Downing.*
7. The influence of fat in milk upon the yield of cream. *S. M. Babcock.*
8. Thermometric investigation. *G. C. Comstock.*
9. Some recent experiments on the accuracy of stadia measurements. *L. S Smith.*

AFTERNOON SESSION.

Meeting called to order at 2:00 p. m. President Van Hise in the chair. Session opened with the discussion of Mr. L. S. Smith's paper, which had been postponed in the morning.

The following papers were then read:

10. The geographical distribution of the early federal and republican parties in the United States. *O. G. Libby.*

11. The Danish church in America. *John Bille.*

12. The personal equation in ethics. *Frank Chapman Sharp.* (Read by title.)

13. A semi-scientific account of ghosts. *G. C. Comstock.*

A communication from the secretary of the Historical Society was read, inviting the Academy to visit at pleasure the Library of the Society.

A communication from James V. R. Swann regarding work on sterilized eggs was read.

The secretary read a list of members who did not respond to inquiries. He was authorized to strike such from list of members.

The constitution and by-laws as reported and amended at the last annual meeting were read and put upon their passage. Adopted.

Adjourned.

FRIDAY, Dec. 28, 1894.

MORNING SESSION.

The Academy was called to order at 9:30 a. m. by the president. The report of the committee on membership was pre sented. The secretary was directed to cast the ballot of the Academy for the following persons as active members:

Maurice McKenna, Fond du Lac.

D. P. Nicholson, Appleton.

W. S. Axtell, Rochester.

W. D. Simonds, Madison.

Chas. F. McClumpha, Ripon.

Jean C. Moos, Ripon.

John S. Roeseler, Sauk City.

A. P. Saunders, Madison.

It was done and the gentlemen declared elected. The secretary was also instructed to cast the ballot of the Academy for Prof. F. L. Van Cleef as a life member, in consideration of his services as Librarian. This was done and Prof. Van Cleef declared elected.

The report of the Committee on Nomination of Librarian was presented. F. G. Hubbard was nominated by committee and the secretary was instructed to cast the ballot of the Academy for him, which was done and Prof. Hubbard declared elected.

A communication from the secretary of the Wisconsin Natural History Society was read inviting the Academy to hold its third summer meeting in Milwaukee. The invitation was accepted and the time and arrangements for the meeting referred to the Council, with power to act.

The following papers were then presented:

14. On the vertical distribution of the pelagic crustacea of Lake Mendota. *E. A. Birge.*

15. Care and maintenance of fresh water aquaria. *W. S. Miller.*

16. The vegetation of the town of Prairie du Sac, Sauk county. *H. F. Lueders.*

17. The flora of the Wisconsin Valley, preliminary report. *L. S. Cheney.* Read by title.

18. Key to the species of lichens in Tuckeman's Lichens of North America. *Fred De Forest Heald.* Read by title.

19. Abrasive action of ice. *G. E. Culver.*

20. The volcanic rocks of Marquette and Green Lake counties. *Wm. H. Hobbs.*

21. The relation of bedding to secondary structure of sedimentary rocks. *C. R. Van Hise.*

22. The bowlder trains of the Waterloo quartzite area. Read by title. *I. M. Buell.*

Adjourned.

AETERNOON SESSION.

The Academy re-assembled at 2 p. m. and was called to order by the president.

Papers were read as follows:

23. Political corruption and laws to cure it by publicity. *Charles Noble Gregory.*

24. Administration of the finances of the United States from 1775 to 1789. *Charles T. Bullock.*

25. Theories of commercial crises. *Edward D. Jones.*

In the absence of authors, Nos. 24, 25 were read by Miss Bates.

The committee on membership reported the following for election as active members:

A. L. Ewing, River Falls.

John Bille, River Falls.

Freeman E. Lurton, Milwaukee.

Frank L. Rainey, Winona, Minn.

A. P. Wilder, Madison.

Miss Tillie Reul, Baraboo.

Chas. J. Bullock, Madison.

L. S. Smith, Madison.

J. G. Gregory, Milwaukee.

The secretary was directed to cast the ballot of the Academy for these persons. It was done, and they were declared elected.

The Committee on Library presented a report similar to that of the Library Committee of 1892, asking that recommendations for new library building be re-affirmed. The report was adopted and the Library Committee were directed to use all possible means to disseminate information among the legislators. (See p. 594.)

EVENING SESSION.

At 6:30, members of the Academy with several of their ladies, to the number of forty-two, sat down to the annual supper in Christ Presbyterian church dining room. After supper the bill for the establishment of a geological and natural history survey of the state was discussed. Many suggestions were made and much valuable information elicited.

A vote of thanks was tendered by the Academy to the local members for their kind entertainment.

C. R. Barnes,
Secretary.

REPORT OF THE COMMITTEE APPOINTED TO REVISE THE CONSTITUTION OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS, AND LETTERS.

GENTLEMEN: At the 23d annual meeting of the Academy, the president and secretary were made a committee to prepare a revised draft of the constitution for adoption at a subsequent meeting. In September, 1893, the committee added to its members the treasurer and Dr. E. A. Birge. The constitution which they offer for the Academy's consideration to replace the constitution and by-laws now in force, is as follows:

CONSTITUTION OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS, AND LETTERS.

Article I.—Name and Location.

This association shall be known as the Wisconsin Academy of Sciences, Arts, and Letters, and shall be located at the city of Madison.

Article II.—Object.

The object of the Academy shall be the promotion of sciences, arts, and letters in the state of Wisconsin. Among the special objects shall be the publication of the results of investigation and the formation of a library.

Article III.—Membership.

The Academy shall include four classes of members, viz.: life members, honorary members, corresponding members, and active members, to be elected by ballot.

1. Life members shall be elected on account of special services rendered the Academy. Life membership in the Academy may also be obtained by the payment of one hundred dollars and election by the Academy. Life members shall be allowed to vote and to hold office.

2. Honorary members shall be elected by the Academy and shall be men who have rendered conspicuous services to science, arts, or letters.

3. Corresponding members shall be elected from those who have been active members of the Academy, but have removed from the state. By special vote of the Academy men of attainments in science or letters may be elected corresponding members. They shall have no vote in the meetings of the Academy.

4. Active members shall be elected by the Academy and shall enter upon membership on the payment of an initiation fee of two dollars and the annual assessment of one dollar. The annual assessment shall be omitted for the president, secretary, treasurer and librarian during their terms of office.

Article IV.—Officers.

Thd officers of the Academy shall be a president, a vice-president for each of the three departments of sciences, arts, and letters, a secretary, a treasurer, and a custodian. These officers shall be chosen by ballot, on recommendation of the committee on nomination of officers, by the Academy at an annual meeting and shall hold office for three years. Their duties shall be those usually performed by officers thus named in scientific societies. It shall be one of the duties of the president to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

Article V.—Council.

The council of the Academy shall be entrusted with the management of its affairs during the intervals between regular meetings, and shall consist of the president, the three vice-presidents, the secretary, the treasurer, and the past presidents who retain their residence in Wisconsin. Three members of the council shall constitute a quorum for the transaction of business, provided the secretary and one of the presiding officers be included in the number.

Article VI.—Committees.

The standing committees of the Academy shall be a committee on publication, a library committee, and a committee on the nomination of members. These committees shall be elected at the annual meeting of the Academy in the same manner as the ther officers of the Academy, and shall hold office for the same term.

1. The committee on publication shall consist of the president and secretary and a third member elected by the Academy. They shall determine the matter which shall be printed in the publications of the Academy. They may at their discretion refer papers of a doubtful character to specialists for their opinion as to scientific value and relevancy.

2. The library committee shall consist of three members and shall include the librarian.

3. The committee on nomination of members shall consist of five members, one of whom shall be the secretary of the Academy.

Article VII.—Meetings.

The annual meeting of the Academy shall be held in Madison between Christmas and New Year. Summer field meetings will be held at such times and places as the Academy or the council shall decide. Special meetings may be called by the council.

Article VIII.—Publications.

The regular publication of the Academy shall be known as its Transactions, and shall include suitable papers, a record of its proceedings, and any other matter pertaining to the Academy. This shall be printed by the state as provided in the statutes of Wisconsin. All members of the Academy shall receive gratis the current issues of its Transactions.

Article IX.—Amendments.

Amendments to this constitution may be made at any annual meeting by a vote of three-fourths of all the members present; *provided*, that the amendment has been proposed by five members, and that notice has been sent to all the members at least three months before the meeting.

The committee also submit the following resolution:

Resolved, That the constitution and by-laws of the Academy, now in force, be repealed and that to replace the same the foregoing constitution be adopted. The repeal proposed and the constitution offered are submitted for action at the annual meeting of 1894.

Respectfully submitted,

GEO. W. PECKHAM,
WM. H. HOBBS,
SAM'L D. HASTINGS,
E. A. BIRGE.

REPORT OF THE LIBRARY COMMITTEE.

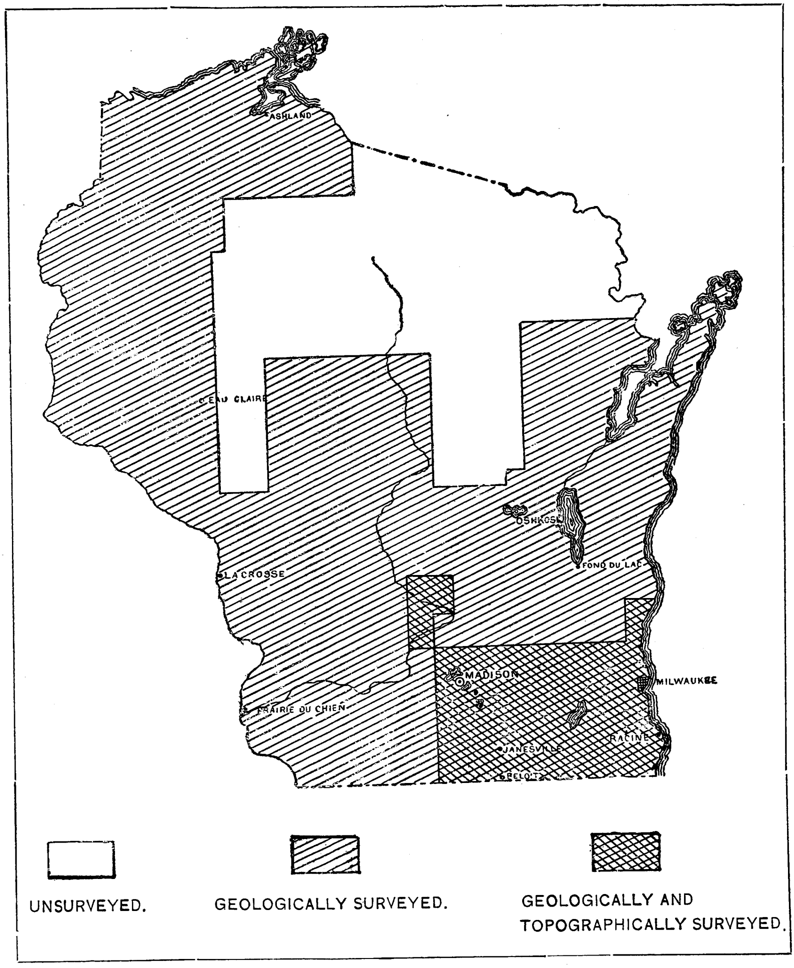
The Library Committee desire to call attention to the report of the Library Committee presented at the annual meeting of the Academy, December 29th, 1892, and to ask that those recommendations be reaffirmed as follows:

The recent binding and cataloging of the books of the Academy make it important that a more suitable place be found for the storing of these books. The present location of the books in the cases of the Academy room is undesirable for a number of reasons, most important of which are the unsafe condition of the building, the ready access of dirt and fallen plaster to the shelves and the difficulty of providing proper protection from theft. It is impossible to keep from the books the finely disintegrated plaster which is constantly falling from the walls. The free access of the public to the rooms, owing to the use of it for other purposes than those of the Academy, renders the proper protection of the books a very difficult matter. The cataloging of the books has shown that in the past many have been lost or stolen. Moreover, the space available is already crowded, while the library is growing through its numerous exchanges and through the completion of its existing series of journals.

In view of the facts above stated, we earnestly recommend that an appeal be made to the legislature at its next session, for the erection of a building to accommodate the libraries of the State Historical Society and of the Academy. If these two libraries and the library of the State University, which is greatly in need of new quarters, were under one roof, it would be greatly to the advantage of those who make use of any or all of these libraries and it would make the collections thus properly housed a just cause for state pride.

Respectfully submitted,

F. G. HUBBARD,
J. J. BLAISDELL,
C. D. MARSH,
Library Committee.



MAP OF WISCONSIN SHOWING PROGRESS OF SURVEYS.

REPORT OF THE COMMITTEE ON THE PROPOSED GEOLOGICAL AND NATURAL HISTORY SURVEY OF WISCONSIN.

Action of the Academy.—At the annual meeting of the Wisconsin Academy of Sciences, Arts, and Letters it was unanimously voted to recommend strongly to the Wisconsin legislature the bill reported by the committee of the Academy, to establish a geological and natural history survey of the state of Wisconsin. This bill is in no sense a local measure; the objects to be accomplished by the survey are the material and educational advancement of all parts of the state alike. The Wisconsin Academy of Sciences, Arts, and Letters, quartered at the capitol, is the official society of the state. Its charter specifies as one of its objects a "thorough scientific survey of the state." It is therefore the proper organization to present this subject to the state legislature. The bill submitted without doubt will receive favorable action if its merits are understood. With this end in view the committee was instructed to give an explanation of the purposes of the measure and the results to be expected from its adoption.

Incompleteness of Former Survey.—As shown by the accompanying map about one-fourth of the northern part of the state was covered only by the most general preliminary work of the previous geological survey. Moreover, it is in this part of the state, if anywhere, that new mineral resources may be developed. The region ought especially to be surveyed in reference to the possible occurrence of iron-bearing formations. There are good reasons for believing that such formations exist at several localities. During the last survey the northern region was for the most part an unbroken forest. Since that time it has been cut through by railroads in every direction. From these railroads highways radiate. Towns have been built. A survey of the area can now readily be made, whereas a few years ago this would have been attended with very great difficulty and expense.

Occurrence of Iron Ores.—It has been said that geological surveys do not often discover iron ore bodies. This is true. What a geological survey can do is to map and limit the possible iron-bearing formations, and thus sharply outline the area which it is profitable to explore. It has been demonstrated beyond question that all of the iron ore deposits of the Lake Superior region occur in a certain definite kind of formation, which can be accurately mapped where there is not too much surface covering, by combining the study of the rock outcrops with the results of magnetic surveys. The exact positions of the ore bodies within these areas can only be ascertained by prospecting. However, very definite rules have been formulated by the Lake Superior division of the United States geological survey for prospecting within the iron-bearing formations. As an illustration of what a survey may be expected to accomplish, it may be said that the part of the Gogebic range lying in Wisconsin was studied and accurately mapped by the late Prof. Roland D. Irving. His report and detailed maps, on the scale of 3.6 inches to the mile were published in 1879, five years before the opening of the first mine. Thus far, every mine which has been discovered on this range in Wisconsin lies within this belt, about 1,000 feet wide, located by him. The value of this report as is well known was thoroughly recognized by prospectors during the time of opening up the Gogebic range, and very large sums of money were saved by confining prospecting within the possible productive area.

Road Materials.—The importance of good roads has recently been strongly emphasized in this state. A high authority has estimated the loss on account of bad roads for each state of the Union at millions of dollars per annum. An eminent foreign writer has said that only a new and rich country like the United States can afford bad roads and streets. The subject of road materials was scarcely touched by the first state survey. The sources and qualities of materials adapted for good and permanent roads and streets will appeal to every community. This, it will be noted, is one of the special objects for investigation.

Soils.—The soils of the state were considered only in the most general way by the previous survey. The men doing the geological and natural history work can collect the soils from various parts of the state. These can be sent to the state agricultural experiment station for its use. Thus, at comparatively small expense there can be furnished to the farmers important information in reference to the qualities and capacities of the soils of the various districts of the state.

Work of Previous Survey.— In what has been said there is no intention of criticising the previous state survey. In the amount of work accomplished and systematic results published, the reports of the Wisconsin survey can be compared favorably with the reports of any other state survey. Within the brief time allotted for this survey, from 1873 to 1879, with the amount of money furnished, and considering the inaccessibility of the northern part of the state, it was absolutely impossible to do more than was done.

Our Forest Wealth.—The forest wealth of the state is rapidly diminishing and care ought to be taken to utilize the forests which remain so that they may be at the same time most profitable to the state and most valuable for commercial purposes. Moreover the decrease in natural forest areas renders desirable the protection of the young trees which spring up on stripped lands, and the replanting of so much of such lands as is not available for agriculture. By such care otherwise worthless land can probably be made to yield to the state a steady revenue and to furnish annually a large quantity of lumber. But though some of the general principles of forest culture have been already worked out in other countries, notably in Germany, the exact conditions which confront the forester in Wisconsin, and the modifications from European practice necessary in this state are not known and cannot be guessed at profitably. They must be discovered by examination of the particular region involved. Unless this is done, any attempt at forest culture is likely to result in wasteful expenditure, and ultimate failure or delayed success.

Forage Plants for Sandy Regions.—There is considerable land in the state which is too sandy for successful agriculture under present conditions. Some native forage plants are known, nutritious and much liked by cattle, which grow and thrive on just such soils. It is not improbable that judicious experiments might show these and others to be adapted to our poor soils.

Windbreaks.—Some of these sandy areas however are already known to be well adapted to certain crops, such as potatoes, but their cultivation is hazardous by reason of the drifting of the sands under the action of the winds. They are subject to this drifting not only in dry seasons but even within a few days after heavy rains. It is beyond question that this danger can be greatly reduced, and probable that it can be entirely obviated by the planting of proper windbreaks. What trees or shrubs are suited to such use, and how they can be arranged best, are questions of immediate importance for such areas—questions which can only be answered by observation and experiment.

Food and Enemies of Fish.—The zoological portion of the proposed survey would concern itself chiefly with the life of the waters of the state. In no direction are we more ignorant than in regard to the life, food, and enemies of our fish. Yet from the standpoints both of profit and sport a knowledge of these things is necessary. Our state, bounded by two of the great lakes, and studded with numberless smaller bodies of water, will always find her fisheries a leading interest. We now expend thousands of dollars annually to raise and plant fish in our waters. We know little of their food and enemies and the other conditions for their preservation, growth, and multiplication. As an example, we may refer to the whitefish. No one knows anything of the life or fate of the millions of fry planted in the lakes by this and adjoining states. No one knows anything of the food, enemies or habits of the young whitefish. It is not to much too say that the cost of a study of the lower animal and plant life of the lakes, such as would give the conditions for intelligent action in planting whitefish, would be immediately repaid.

Nor are the questions less important which are connected with our thousands of smaller lakes. From these the population of Wisconsin will draw a continually increasing supply of food. But ignorant management of our waters is as irrational and wasteful as ignorant agriculture. We should enter upon the study of the problems of water-life with the same union of practical and scientific aims as is shown in the handling of the problems of agriculture.

Pearls.—One question of minor importance—yet by no means unimportant—deserves special mention. Wisconsin has produced pearls in the past half-dozen years to a value of $500,000 or $600,000, as estimated by Mr. George F. Kunz, the highest authority in the United States. These pearls come from the clams in the Sugar river district, and have hitherto been collectcd by the wasteful process of killing the clams. There is no need for this waste. The pearls can be removed without injuring the clams, and information as to the manner of doing this would be published by the survey. Thus the supply of pearls can be renewed, and the animals continue to reproduce their kind. Not impossibly the clams will be found to flourish in other streams in other parts of the state, so that the revenue rom this source can be increased in the future, instead of decreasing greatly, as it has already done under present conditions. If present methods are continued the pearl producing clam will be soon exterminated in Wisconsin.

Educational Value.—We do not like to leave this topic with a presentation of merely financial reasons—important as they are—for a study of the life of our animals. There are no subjects of which our people and schools are more ignorant than of the wealth and variety of the lower life of our waters. No subjects offer more interest to the student; none are better fitted to broaden the mind than these topics of animal life. The survey can do no better educational service to the people than to make them acquainted with these neglected subjects.

Topographic Maps.—The proposed act also provides for topography. For several years the United States geological survey has had one party engaged in making a topographicial survey of the state. This work began at Madison and vicinity, and extended in a broad belt eastward to Lake Michigan, an southward to the state line. Thus far there have been surveyed twenty-three atlas sheets, covering 5,200 square miles. Perhaps from other causes, but also because the state of Wisconsin did nothing in the matter, this work has been discontinued. In contrast with our own state are the states of New Jersey, Massachusetts, and Connecticut, which co-operated with the United States geological survey, and thus have secured complete topographical maps. It will be noted that no money is to be expended for topography unless an equivalent amount be expended by the United States geological survey. The chief topographer of this organization has indicated his willingness to continue work in the state of Wisconsin, if the state itself shows appreciation of what has already been done, by contributing to the work as other states have done. Thus, if the bill is adopted, for every dollar which the survey can put into topography, the United States will give an equal amount.

The great practical and scientific value of accurate maps which express the character of the country, need not be urged upon any member of the Academy. These maps are valuable on the practical side for the following purposes: They give at once the best location for highways; they show the feasibility of carrying natural waters of rivers and lakes to cities; they show the possibility of draining marsh and swamp lands; they show the possibility of inundating lands such as cranberry marshes and the sandy lands of the north during dry seasons; they are of value in determining the probable success of projected artesian wells; they give accurate bases upon which to place the results of the mineral surveys. Other advantages might be given, but these need not be mentioned in detail. If every man in the state could obtain a map upon which he could see at once the location and forms of all hills, valleys, streams, ponds, and lakes of any area, he would find it a great advantage to him in his every-day practical dealing with his lands. In fact, so well recognized is the value of accurate maps, that every civilized nation in Europe has made, or is making, large scale accurate topographic maps, which show all the physical features of the country, and, as has been said, this wise example has been followed by a number of the states of the Union.

Educational Value of Maps.—Upon the educational side, contour maps are of scarcely less advantage. The local maps would at once be used in every properly taught school in the state. The teacher could show how the maps express the character of the country, and thus give the child an understanding of the use of topographical maps of all the countries, so that in looking at them he would have a proper idea of the relief of any country about which he wished to know. There being for a large part of the state no topographical maps at the present time, the teacher is unable to illustrate the manner in which proper maps show the character of the country, and therefore the pupils with great difficulty understand the maps which have been published for other parts of the Union and the world.

School Manuals.—The proposed survey provides for the preparation of school manuals of physicial geography, botany, and zoology, which will be adapted to the schools of the state. The state superintendent of public instruction has repeatedly asked that manuals be prepared which would tell about the physical features, the plants and animals of the state, which he could introduce into our schools. However, it has been impossible to prepare such manuals, because nowhere is proper information available. It is the duty of the proposed natural history survey to supply this information, and to prepare the manuals. Thus the children of the state will have books which will give them accurate information upon the minerals and ores, the physical features, the plants and animals of our commonwealth.

Economic Reports.—The survey also provides for special reports on subjects of economic importance. These shall be prepared in such form as to be of direct service to the people; that is, after any subject is worked up, a bulletin will be prepared in simple and plain language upon the subject, so that any person wanting information upon it can be supplied with this bulletin. Scarcely a week passes but one or more letters come to Madison directed to that non-existent officer, the state geologist, asking information upon some point of importance to the writer. These special reports are designed to give full practical information in reference to each of the individual material products of the state.

Surveys in Adjoining States.—The state survey of Wisconsin began in 1873 and continued only six years. It was therefore discontinued fifteen years ago. The policy of the states of Michigan and Minnesota is in sharp contrast with this. These states, in most respects, are like our own: their southern parts extend into the rich agricultural lands of the northwest; their central parts are heavily wooded; and their northern parts have great mineral resources. These states, in common with Wisconsin, have a wider variety of industrial capacities than many other states.

Survey of Michigan.—The geological survey of Michigan, established before our own long discontinued survey, exists as a permanent organization, with a regular annual appropriation of $8,000. Its work has gone on uninterruptedly to the present time, and doubtless will continue indefinitely in the future. The entire appropriation of $8,000 has been spent, however, strictly upon geological work. No attempt has been made to prepare a topographical map of the state. There is also a considerable additional amount appropriated for a mineral commissioner, whose excellent reports are published annually. Another appropriation under a third organization is made for the study of the plants and animals. It would seem far wiser to unite the whole survey work under a single organization, as duplication is thus avoided.

Survey of Minnesota.—In Minnesota there were early general surveys, the same as in Wisconsin and Michigan. The present survey of the state was established in 1872, and has continued uninterruptedly to the present time. There were set aside for the support of this survey the state lands known as the "Salt Spring Lands," which have been sold in part, and which have brought to the survey a large sum of money. Even with this provision for the permanent establishment of the survey, the legislature has in recent years made special supplementary appropriations: in 1887, $10,000; in 1891, $15,000; and in 1893, $10,000.

Survey of Iowa.—In 1892 the state of Iowa, a prairie state, and therefore having no such wide variety of material resources, or unknown mineral capacities, re-established a geological survey, with an appropriation of $10,000 per annum. It is to be noted that this is a geological survey only, and does not provide for topography or for natural history.

Government of Proposed Survey.—The Iowa survey, the last to be established in the northwest, is governed by a board, consisting of the governor of the state, the state auditor, the president of the state university, the president of the agricultural college, and the president of the Iowa academy of science. It will be seen that this board is very similar in its constitution to that of the proposed survey of Wisconsin. We have no separate agricultural college, and therefore the president of the university stands for the entire university, which includes the agricultural department. As the proposed Wisconsin survey provides for the preparation of school manuals, it was thought that the state superintendent should be a member of the governing body. In Wisconsin we have no state auditor, but the bills of the survey will be audited by the state auditing committee, as are all of the state expenditures. As one of the objects of the survey is a study of the foods and enemies of fish, the president of the commissioners of fisheries was made the fifth member of the board.

Cost of Survey.—Finally, attention is called to the fact that the small sum of $15,000 per annum is asked to carry on the work of the survey. The amount has been placed by the Academy at the minimum at which it will be possible to begin the lines of work planned. If the appropriation is cut down, it is certain that the superintendent will find it neccessary to concentrate the money at the outset upon some of the needs of the state, to the sacrifice of others equally pressing. To carry on the work with a reasonable degree of speed in all lines, there should be at the service of the commissioners $20,000 instead of $15,000, but it was thought that until the survey could justify its existence by material and educational returns to the state, it would be wiser not to ask for more than $15,000 per annum.

Importance of Prompt Action.—Can this work be wisely deferred? Every year which passes without a survey results in great material and educational loss to the state. Some time must necessarily elapse before any results can be obtained and published. Delay but defers the gains which we might have at once. In material returns the survey will bring back to the state many fold, and if a single new industry is organized, or an old one improved, the effect upon the general prosperity of the state will more than compensate for the expenditure.

While it is believed that the material arguments for the re-establishment of a geological and natural history survey in the State of Wisconsin are unanswerable, it is held by the Academy that the educational arguments are of equal or greater importance. Will the rich and progressive state of Wisconsin continue indefinitely to support no survey, while the adjoining states of Michigan and Minnesota are reaping the fruits of the enlightened policy of continuous state surveys, or will she establish a survey on a broader and more liberal basis than any other state in the northwest?

C. R. Van Hise,
C. R. Barnes,
E. A. Birge,
G. L. Collie,
A. J. Rogers,
Committee.

The following bill for the establishment of a geological and natural history survey of the state of Wisconsin was prepared by the committee and introduced in the Legislature of 1895. It was reported for indefinite postponement by the Committee on Claims, on account of the extraordinary appropriations necessary in other directions.

An Act to establish a geological and natural history survey of the state of Wisconsin.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

Section I. There is hereby constituted a geological and natural history survey of the state of Wisconsin.

Section II. This survey shall have for its objects:

(1) The completion of the geological survey of the state, and especially the examination of the rocks, with refer-

ence to the occurrence of iron ores, building stones, and other valuable mineral products, and in reference to their value as material for road construction.

(2) A study of the soils of the state.

(3) A study of the plants of the state, and especially of the forests, with reference to their cultivation and preservation.

(4) A study of the animal life of the state, and especially the occurrence, distribution, and production of fish in the lakes and streams of the state; and a study of foods and enemies of fish.

(5) The preparation of an account of the physical geography and natural history of the state, in such form as to serve as manuals for the public schools, and of special reports on subjects of economic importance, in such form as to be of direct service to the people.

(6) The completion of the topographic map of the state begun by the United States geological survey. This work shall be sufficiently accurate to show the character of the country and furnish a basis for the location of highways; but no money shall be expended for topography unless an equivalent amount be expended for this purpose in the state by the United States government.

SECTION III. This survey shall be governed by a board of commissioners, consisting of the governor of the state, the state superintendent of public instruction, the president of the state university, the president of the commissioners of fisheries, and the president of the Wisconsin academy of sciences, arts, and letters.

The commissioners shall meet within thirty days after the passage of this act, and organize as a commission, and adopt by-laws for their government, not inconsistent with law, and shall meet at such times and places as they may prescribe. A majority shall be a quorum. They shall receive no compensation, but each shall be reimbursed his expenses actually and necessarily incurred in the performance of his official duties, out of such appropriation as may be made by the legislature.

They shall choose from their number a president, secretary, and such other officers as their by-laws may prescribe; but no officer shall receive any compensation, except such as is herein provided for.

The commissioners shall have general charge of the survey, and shall appoint a superintendent of the survey, and, on his nomination, such assistants and employes as they may deem necessary. They shall fix the compensation of all persons employed on the survey, and may remove them at pleasure.

SECTION IV. It shall be the duty of the commissioners to prepare a report before the meeting of each legislature, showing the progress and condition of the survey, giving an account of money spent, together with such other information as may be deemed necessary and useful. The superintendent shall transmit to the commissioners, from time to time special reports, with necessary illustrations and maps, as these are completed. If approved by the commissioners they shall be transmitted to the commissioners of public printing, who are authorized to have the reports published in a suitable manner, as independent reports, as bulletins of the state university, or in the transactions of the Wisconsin academy of sciences, arts, and letters, as the commissioners of the survey deem best. If published as independent reports, it shall be the duty of the commissioners of public printing to decide as to the number of copies in the edition of each particular report. Five copies of each report shall be delivered to each of the state officers, and to each member of the legislature. The number of copies provided by law for other public documents shall be furnished to the state historical society, the library of the state university, and other state institutions. The remainder of the independent reports shall be distributed, used in exchange, or sold by the commissioners of the survey, as the interest of the state and of science demands. All moneys obtained by the sale of reports shall revert to the state treasury, as a part of the general fund. Volumes obtained in exchange for reports shall be added to the library of the Wisconsin academy of sciences, arts, and letters. The superintendent of public property shall furnish upon the requisition of the president of the commissioners of the survey, such stationery and postage stamps as may be necessary for the use of the commissioners and the superintendent of the survey in official business.

SECTION V. After material collected shall have served the purposes of the survey, it shall be distributed to the state university, the colleges of the state, the state normal schools, and the free high schools, of the state, under the approval of the commissioners of the survey, in such a manner as to be of the greatest advantage to education in the state.

SECTION VI. There is hereby annually appropriated to the commissioners of the geological and natural history survey out of any money in the treasury not otherwise appropriated the sum of fifteen thousand dollars, the first appropriation to be paid in the current fiscal year.

SECTION VII. This act shall take effect and be in force upon and after its passage and publication.

TREASURER'S REPORT, 1893.

MADISON, Wis., Dec. 27, 1893.

To the Wisconsin Academy of Sciences, Arts, and Letters:

The following is a statement of the financial transactions of the Academy during the past year:

Balance on hand as per last statement	$840 85
Received as interest on permanent fund	40 00
Received from members, initiation fees, and annual dues	74 00
Received for Transactions sold by secretary	5 00
Received from J. J. Suhr 19 per cent. dividend on donation to A. A. A. S	19 00
Total	$978 85

The disbursements on the order of president and secretary have been as follows:

1892.		
Dec. 29	Paid S. D. Hastings, treasurer, for postage, envelopes, 3 years, voucher No. 1	$8 10
	Torrey Botanical Club, bulletin, voucher No. 2	1 10
1893.		
Jan. 13	State Journal Printing Co., for printing, voucher No. 3	7 20
Feb. 3	W. H. Hobbs, for sundry expenses, voucher No. 4	11 61
	F. H. Crane, for cataloging library, voucher No. 5	25 20
April	Paul Pierrotet, directeur, Paris, voucher No. 6	4 75
7	G. Grimm, for binding, voucher No. 7	221 70
	Local treasurer, for entertainment of A. A. A. S., voucher No. 8	100 00
20	F. H. Crane, for work on library, voucher No. 9	6 40
27	Ed. Dithmar, for labeling fossils, voucher No. 10	5 00
Sept. 7	Chas. Schmid, for repairing locks, voucher No. 11	2 00
	F. C. Roberts, for work on library, voucher No. 12	3 25
9	G. Grimm, for binding, voucher No. 13	127 55
13	W. H. Hobbs, sec'y, for postage, express, etc., voucher No. 14	3 95
21	P. F. Joyce, for mailing Transactions, voucher No. 15	1 20

Oct.	13	W. J. Park & Sons, for seal and labels, voucher No. 16	$6 75
		J. W. Scott, for drayage on Transactions, voucher No. 17	1 00
		Wm. Zink, for carrying Transactions, voucher No. 18	1 25
	17	Tracy, Gibbs & Co., for printing diplomas, voucher No. 19	4 50
		S. H. Cady, for writing for Academy, voucher No. 20	3 45
	20	C. F. Crane, for work for Academy, voucher No. 21	2 40
Nov.	14	C. F. Crane, for work for Academy, voucher No. 22	2 24
		Frank S. Horner, for printing labels, voucher No. 23	1 00
		W. H. Hobbs, sec'y, for postage, drayage, etc., voucher No. 24	10 34
Dec.	21	James Conlin, for drayage, voucher No. 25	7 00
	27	Balance on hand	409 91
		Total	$978 85

Respectfully submitted,

SAMUEL D. HASTINGS,
Treasurer.

We have examined the above report and accompanying vouchers and find the same correct.

G. P. DELAPLAINE,
H. W. HILLYER,
Auditing Committee.

TREASURER'S REPORT, 1894.

MADISON, Wis., Dec. 27, 1894.

To the Wisconsin Academy of Sciences, Arts and, Letters:

The following is a statement of the financial transactions of the Academy during the past year:

Balance on hand as per last statement	$409 91
Received for interest on permanent fund	40 00
Received from members, initiation fees, and annual fees	160 00
Total	$609 91

The disbursements upon the order of the president and secretary have been as follows:

1893.		
Dec. 28	W. J. Park & Son, for binding, voucher No. 1	66 25
1894.		
Jan'y 2	C. F. Crane, writing for Academy, voucher No. 2	2 85
12	Taylor & Gleason, for printing, voucher No. 3	8 75
	George Grimm, for binding, voucher No. 4	130 90
Feb'y 12	Postmaster, Madison, for postage stamps, voucher No. 5	2 00
	Tracy, Gibbs & Co., printing, voucher No. 6	11 50
April 5	A. Zeese & Co., for diagrams, voucher No. 7	1 38
23	Prof. F. L. Van Cleef, for postage, voucher No. 8	10 00
May 1	Prof. C. R. Barnes, for freight and postage, voucher No. 9	14 98
	A. Zeese & Co., for diagrams, voucher No. 10	2 18
June 15	A. Zeese & Co., for diagrams, voucher No 11	75
30	Prof. C. R. Barnes, for postage, voucher No. 12	5 50
July 13	C. K. Leith, for 23 hours' work, voucher No. 13	5 75
	F. E. Morrow, for drawing geolog. map, voucher No. 14	2 00
Aug. 8	A. Zeese & Co., for map, voucher No. 15	2 10
Sept. 21	Tracy, Gibbs & Co., for printing sec'y, voucher No. 16.	15 25

Oct.	23	Prof. C. R. Barnes, for postage, voucher No. 17........	$2 00
		Violet Slack, for clerical work, voucher No. 18........	2 70
Nov.	3	Tracy, Gibbs & Co., for printing for secretary and treasurer, voucher No. 19........................	6 50
Dec.	27	Balance on hand....................................	316 57
		Total..	$609 91

Respectfully submitted,

SAMUEL D. HASTINGS,
Treasurer.

The auditing committee appointed by the president to examine the treasurer's accounts, report that they have examined the same and the items are correct and the vouchers accompanying the same.

CHAS. H. CHANDLER,
E. G. SMITH,
H. W. HILLYER.

GENERAL INDEX.

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