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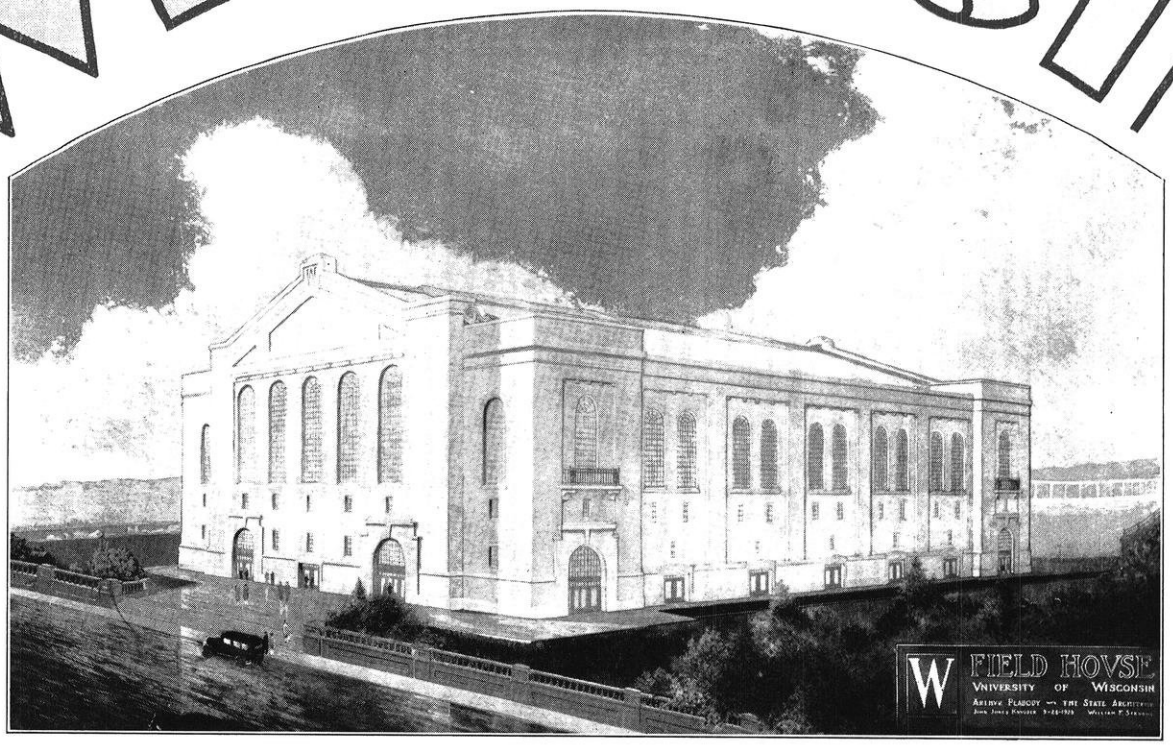

UNIVERSITY FIELD HOUSE

MEMBER of ENGINEERING COLLEGE MAGAZINES ASSOCIATED

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The Wisconsin Engineer

VOLUME 34, NO. 6 MARCH, 1930

Wisconsin's New

University Field House

By C. A. Willson
Structural Engineer for the State Architect of Wisconsin

THE new Field House for the University of Wisconsin is now being constructed and will be completed and ready for use by August of this year. It will cost about $400,000.

It is located on the plot of ground just south of the football stadium as indicated on Fig. 2. A section of concrete bleacher seats facing the football gridiron is being built at the north end of the main building. This replaces a section of wooden bleachers and adds 2,400 seats to the permanent seating capacity of the football stadium.

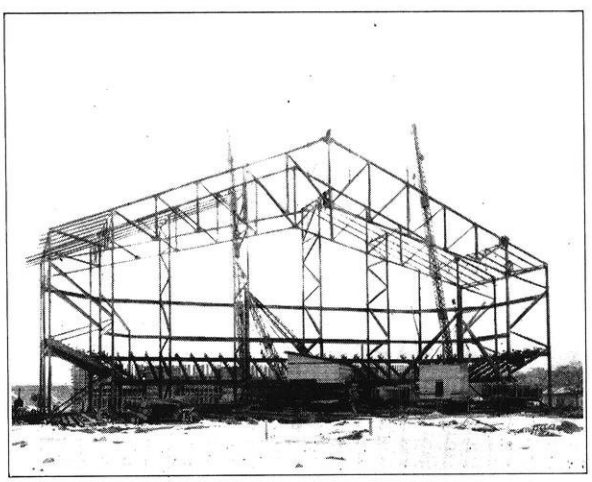

Fig. 1. *An end view of the field house during the process of steel erection. Two large derricks are being used to place the members.*

The main purpose of the Field House is to provide seats for 10,000 to 12,000 spectators for basketball games. To accomplish this, the building is being made 200 feet wide and 235 feet long with double-decked balconies 26 feet wide on all four sides of the building as indicated in Fig. 2. These balconies will accommodate 8,000 people. Removable bleachers can be added in front of the first balcony which will provide 3,500 seats, making the ultimate capacity 11,500 people. The upper balcony is not to be completed under the present contract, but will follow at a later date. Leaving out the second balcony, there remains a net capacity of 7,500. Fourteen stairways extend from the ground up to the balconies.

As shown in cover picture, the main entrances with ticket offices are located at the southeast and southwest corners of the building. Secondary entrances are located at the other two corners. The smaller doorways indicated will be used mainly for exit purposes.

By utilizing a part of the space under the concrete bleacher seats a running track one-eighth mile in length is made possible. This running track will be used for indoor meets as well as for training purposes. Two team rooms with toilet and locker facilities and two public toilets are so arranged under the concrete bleachers that they will not interfere with the running track.

These constitute the main general features of the building. Now the structural engineering design will be considered.

Three-hinged arch trusses had been used in the Michigan and Minnesota field houses and in many other buildings of this character and it was assumed that they could be used here. However, this building differed from the others because the architectural design required the use of thick plastered walls, the thickness reaching a total of 4 feet in certain places.

Furthermore, it had been decided to take alternate bids on four different types of wall construction, as follows: Solid stone rubble, stone rubble backed up with concrete, stone rubble backed up with common brick, and face brick backed up with common brick. This meant that in every consideration of wall stresses, the poorest of these four types of construction governed. After the plans were completed and the bids were opened it was found that

the lowest bid was based on the use of rubble stone backed up with concrete and this construction will be employed However, this result could not be predicted and the plans had to be drawn so that any one of the alternates could be accepted.

When the arch truss was designed it seemed advisable to compute the lateral deflection at the top of the wall and the resulting fiber stress at the base. These constituted two rather unusual problems, but with the aid of suggestions and advice from Professors Kinne and Withey of the University, methods of solution were developed.

It was found that when these arch trusses were subjected to unsymmetrical balcony and roof loadings, the horizontal movement at the top of the wall was such that the fiber stress at the base was too great for some of the materials which were being considered.

So the arch truss scheme was abandoned and the following method was adopted:

Vertical trussed frames which will stiffen the walls and support the balconies are placed around the four sides of the building at intervals of about 32 feet as indicated in

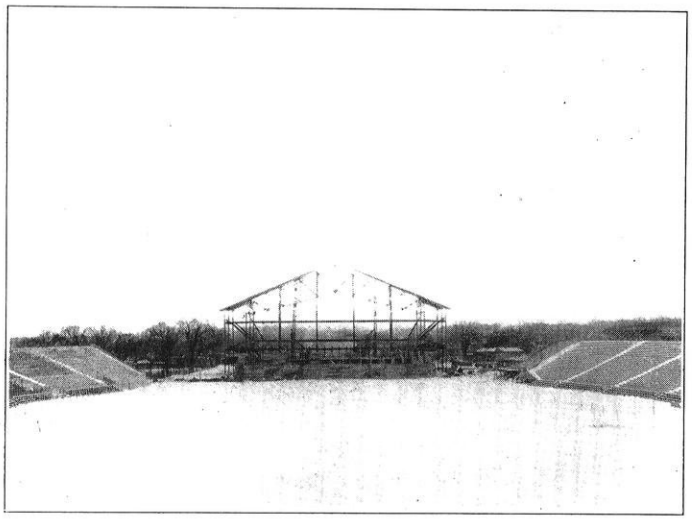

FIG. 2. *The location of the field house with respect to the stadium. The view is taken from the north. The bleachers directly in front of the field house are at the south end of the stadium.*

Fig. 1. The roof is carried on trusses which span the width of the space between these frames. This constitutes a plan of the structural layout.

A view of this framework in elevation is given in Fig. 4. The main trusses are 151 feet long, 24 feet deep in the center and 12 feet deep at the ends. These trusses are composed of 10 inch H sections weighing from 21 to 64 pounds per foot. The vertical trussed frames are 19 feet wide and they also are composed of 10 inch H sections, the heaviest columns weighing 84 pounds per foot. This framework is practically unaffected by unsymmetrical balcony and roof loadings. In fact there is very little lateral movement under any condition of loading.

The clay tile roof is supported on wooden plank which spans the 6½ foot distance between the steel channel rafters. These rafters are supported on purlin trusses which connect the main roof trusses.

The wooden balcony floor and seat planks are supported on the inclined balcony stringers shown in Fig. 3. Horizontal girders carry the stringer loads to the columns.

When arch trusses are used for the support of the roof

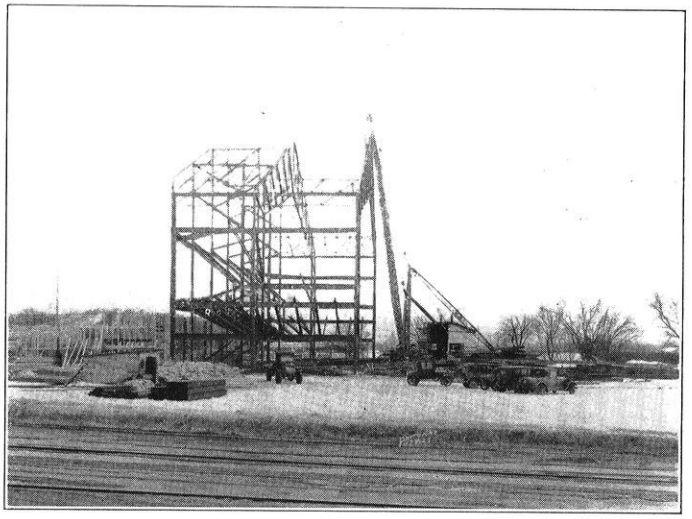

FIG. 3. *This shows the structural arrangement which supports the balconies, and was taken during the early period of erection.*

and the side balconies, the end balconies must be supported in an entirely different manner and the junction of the two is apt to be awkward. But in this building the same method of construction is used in both cases and therefore the connections at the corners are quite simple and direct. It is believed that this is the logical solution for a building which is so nearly square.

The structure will be a vast improvement over the armory which has become insufficient to the needs of the athletic department. Besides increasing the accommodations for the spectators, the building will do much to aid in the teaching of athletics during the winter months, and it will give the physical directors of the university the same calibre of equipment which other conference schools are using.

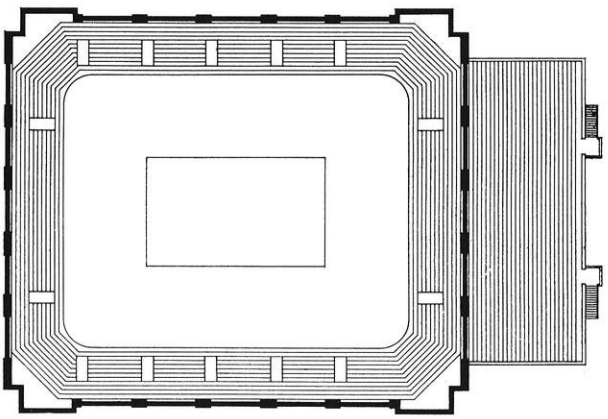

FIG. 4. *A plan of the basketball floor. The large seating capacity will permit many more Wisconsin spectators to witness the games, than did the seating arrangement of the armory.*

Mr. Arthur Peabody is the architect for the building, the writer is the structural engineer and the Christensen Construction Company of Racine is the general contractor.

A Discussion Concerning

Viscosity in Solids

By R. L. WEGEL
Member of the Technical Staff, Bell Telephone Laboratories

WHEN a solid is in a state of strain, energy is stored in its elastic deformation. When a bar is stretched slightly and then suddenly released, it vibrates and the vibrations gradually subside. A part of the energy which was thus originally stored is transformed into heat which increases the temperature of the bar. The remainder is stored in the material in the form of molecular strains incident to a permanent deformation. The rate at which energy is dissipated in heat, as well as the amount of energy which remains stored, varies with the kind of solid and the extent of the initial strain. In the design of many types of vibrating apparatus the damping effect of this dissipation must be quantitatively taken into account, and thus a determination of the nature of internal constants of materials is of importance.

The distortion of a piece of solid matter is generally accompanied by two kinds of energy losses: thermo-dynamic losses due to changes of volume, and losses due to shearing between layers of the material.

With these shearing losses, loosely called viscous losses, this article is concerned, since they are by far the larger part of the total. There are at least two properties of a solid, viscosity and plasticity, that are concerned with shear and that may be responsible for the internal transformations of mechanical energy of vibration into heat. The viscosity of a solid is its ability to transform mechanical energy of vibration into heat without the establishment of a permanent set, while plasticity is its ability to make this transformation by virtue of the establishment of a permanent set. Plasticity is thus a counterpart in the solid of what is usually called "viscosity" in a fluid. No property of fluids has been named to which the viscosity of solids is the counterpart.

Ascribing the behavior to "properties" in this way, however, does not explain the mechanism of the behavior. A real explanation is far more difficult. Several theories have been devised to provide this sort of explanation of the transformation of vibrational energy into heat, but no one of them is yet generally accepted, nor indeed theoretically completed. Three are especially valuable in illuminating the behavior of solids and clarifying the distinction between viscous and plastic dissipation.

It is generally agreed that heat is a rapid motion of certain ultimate characteristic particles, the atoms, of the heated matter. Heat content depends on the energies of these moving particles—on their masses and velocities—and in any one substance increases with increase in the velocities of these particles. In gases the ultimate particles to be considered are more strictly molecules and these are capable of a motion which is restricted only by collisions with other molecules. In solids the atoms vibrate about relatively fixed positions. Envisaged in these terms the phenomenon to be explained is that of the transfer of the energy from the gross or acoustic vibration of a bar, for example, to the refined vibration of the atoms.

One of the first-proposed mechanisms, an extension of a theory of electrical conduction in solids, makes use of those electrons which are bound most loosely in the solid. When a gas is locally heated and the molecules in the heated region are thus set in more rapid motion, it is easy to see that the increase in their velocity will be communicated through the gas by their collisions and that the heat will thus be conducted throughout the entire volume of the gas. It is less easy to find a similar explanation for solids, but by ascribing to the loosely bound electrons in solids the kinetic properties of a gas, heat conduction in solids is made analogous to heat conduction in gases. Thence

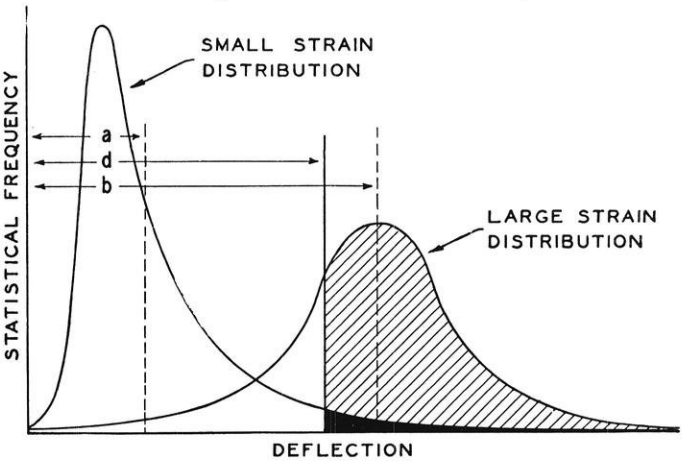

FIG. 1. *When a solid is strained, its component atoms may show different deflections whose average is the overall strain. Ratios of shaded areas to total areas under curves show proportions of atoms deflected more than their distance apart, and thus permanently set.* a *is the average deflection for a small strain;* b, *the average deflection for a large strain;* d, *the distance between particles.*

it is a simple explanation to regard the electron gas as alternately compressed and expanded in parts of the solid during vibration and to regard the solid as immersed in this electron gas and absorbing energy from it after the manner of any solid enveloped in a gas which is alternately compressed and expanded.

There is at least one obvious direction in which further development of this theory is necessary. In the conduction of electricity through solids it is supposed that the

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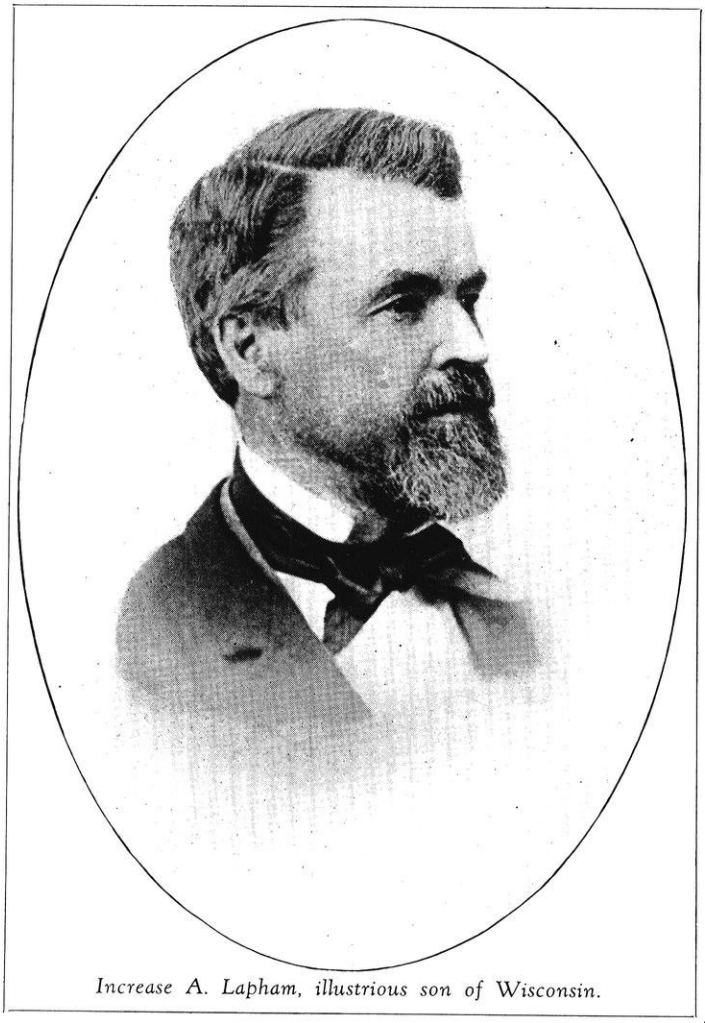
The Pioneer Land Surveyors of Wisconsin

By CHARLES E. BROWN
Director, State Historical Museum

THE important part played by the pioneer land surveyors in the settlement of the land embraced within the present state of Wisconsin is not very well known and not very well appreciated. Because I am myself a descendant of a family not a few of whose members were surveyors and civil engineers, and having myself followed this calling for a few years during my young manhood, I have ever felt a keen interest in all of my accomplishments of a profession on whose roster of distinguished men are also inscribed the names of our country's greatest presidents, George Washington and Abraham Lincoln. I may confess to a real admiration for the early land surveyors and civil and military engineers of our state. I am not displeased therefore, to have this opportunity to briefly recounting some of their achievements and of paying a small tribute to their memory. With the fur trader, lead miners and soldiers, the pioneer land surveyors of Wisconsin were among the real adventurers of their day. Compass and notebook in hand these hardy men penetrated into the little known wilderness of the Old Northwest to brave, in the course of their duty, heat, cold and wet, and such other dangers as fevers, the attacks of wild animals and the unfriendliness of some of its former Indian owners. Following the military occupation they marked out the state boundaries, established the county, township and section lines, and charted the lakes and streams, the forests and prairies, the trails and other features of the landscape, and thus paved the way for the footsteps of the pioneer settlers and of others who were to follow these. They were a keen, energetic and fearless group of men following a profession which they had learned from other men and by themselves, with for the most part only such meagre educational opportunities as the rather poor schools of the East afforded. Entering into the government or private employ they did their work and did it well.



Increase A. Lapham, illustrious son of Wisconsin.

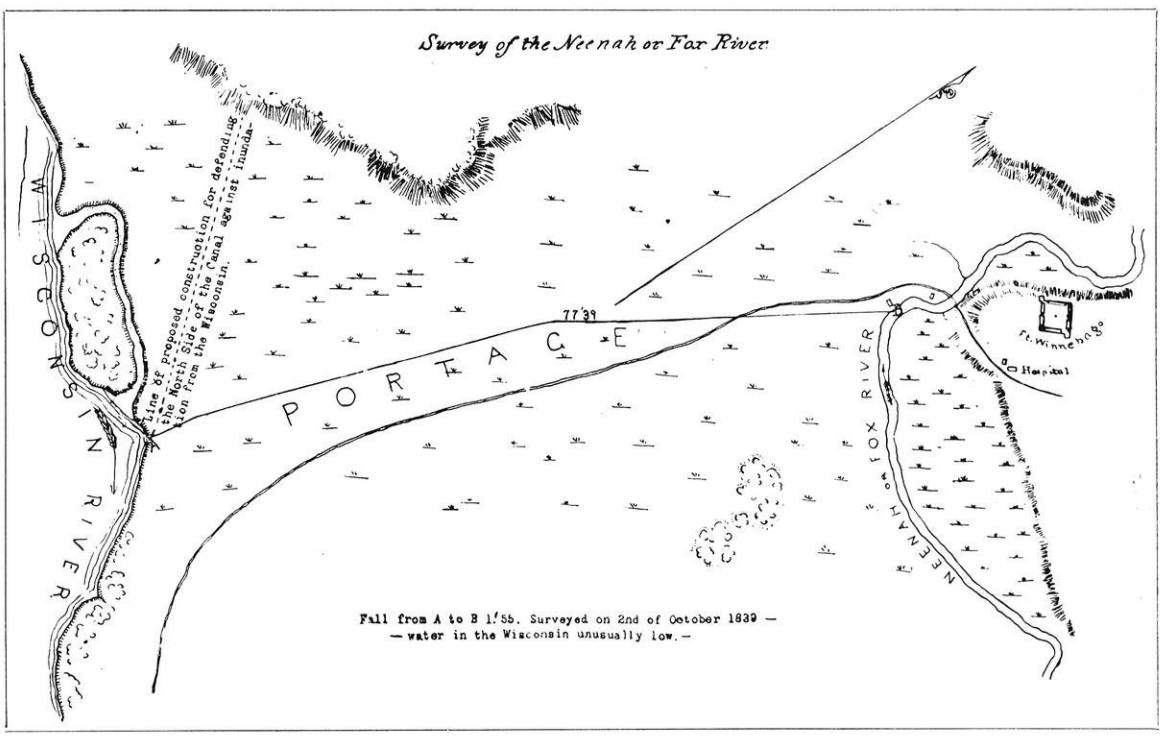
After the last of the Indian treaties — that held at Chicago in 1833 with the Chippewa, Potawatomi and Ottawa—had disposed of the last of the Indian titles to lands in southern Wisconsin, this part of the state was in readiness for government survey after which the land would be open to purchase by settlers and others who were already clamoring for an opportunity to found homes and to engage in other enterprises in the Wisconsin wilds.

At this point I take the liberty of quoting Dr. Joseph Schafer, who in his book "Four Wisconsin Counties—Prairie and Forest", published by the State Historical Society in 1927, presents this account of the early survey for settlement of the state:

"Evidently the desire to purchase land west of Lake Michigan was already widespread, for immediately after the Menominee cession the receiver of the Detroit land office urged upon the surveyor general the desirability of surveying those lands. The Sauk War of 1832 prevented the immediate execution of such a plan. But no sooner was that episode ended when preparations for the survey were begun. And now, as may be supposed, the demand for what we shall henceforth call Wisconsin lands was more intense than it had been in 1831. For the Black Hawk War introduced the country west of Lake Michigan to the people as a whole. Easteners obtained descriptions of the territory where Indian fighting was in progress; rivers and lakes, which formerly had been meaningless features of the map, took on reality in the popular mind; forest and

prairie areas were differentiated; and in a word, thousands of persons became keenly alive to the agricultural and commercial possibilities of the region. The actual survey could not start too soon.

"The years 1833, 1834, 1835 and 1836 were a time of bustling activity in land matters. The survey commenced in the older settled district; the lead region of the southwest, which was the region first ceded by the Indians as well as the most fully settled. The Fourth Principal Meridian was run due north to the Wisconsin River from the Illinois boundary as the base line. Thereafter, ranges of townships were marked off on both sides of the Principal Meridian. By the end of the year 1833 practically everything had been surveyed as far east as the Rock River, while a good beginning had already been made in the northern part of the Menominee cession, which, however, was completed later. Since the southern part of the lake-shore counties was ceded last, in 1833, (with a supplementary treaty in in 1834,) that district was also the last of the southern Wisconsin areas to be surveyed. It was separated into townships in 1835, and the process of subdividing these was completed that year and the next.



An early map prepared by Captain Cram.

"In his report of December, 1836, the Commissioner of the General Land Office was able to say: 'The office has been advised of the completion of the balance of the surveys in this district, amounting to 119 townships and fractional townships . . . surveyed and yet to be offered for sale, being all the lands in the Wisconsin territory, east of the Mississippi River, to which the Indian title has been extinguished.'

"The government survey of any given area meant much more than the creation of definitely located and numbered townships, sections and subdivisions of easy and certain identification by prospective purchasers. It supplied all that; but in addition it provided the first description of the land which was detailed enough to be of special benefit to entrymen.

"The surveyor of the township and of the sections blazed his way through the forest or sighted over the open spaces along parallels one mile apart. Since his lines crossed at right angles he necessarily looked into each square miles of land from all four sides, and — save in the densest forest — was bound to see a considerable part of it in addition to what he meandered in running the lines. And what the surveyor saw he wrote down in his notebook, a copy of which was filed at the land office of the district in which the lands were located. Prospective purchasers of lands, or in fact any one who was interested, could procure from the land office a transcript of the surveyor's notes on any given township or subdivision. The information made available in this way was basic. For the surveyor took account of the quality of the soil, the drainage and water supply, the kinds of timber, the presence or absence of stone, and the surface features such as hills, valleys, lakes, swamps, and dry level tracts. He also noted the points where his survey lines crossed trails or roads, described the location of unusual appearances, like clusters of Indian mounds, battle field, etc.

"These surveyors, who held the title of United States deputy surveyor general, were, or became, prominent and important characters. The list of the men who subdivided the lands in the four southern lake-shore counties included Joshua Hathaway, Elisha Dwelle, Sylvester Sibley, Garret Vliet, and William A. Burt. Of these Mr. Hathaway is still remembered as a leading citizen of Milwaukee during all of the years of his residence in the city, practically from his arrival in 1834 to his death in 1863. Mr. Vliet who died in 1837, aged eighty-eight years, came in 1835 from Ohio, where he had been engaged as an engineer upon the Ohio Canal. He, like Mr. Hathaway, was a prominent figure in the metropolis for many years. The most renowned of the names in the above list is that of William Austin Burt, author of works on surveying and of reports on the mineral resources of Michigan. He is perhaps best remembered popularly for his discovery in

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Engineering Society of Wisconsin Holds Convention

By GERALD C. WARD, c'29
Railway Engineering Department

THE experiment was a success! Surveyors' Day has come to stay and now promises to become one of the most interesting parts of future conventions of the Engineering Society of Wisconsin. By adding this extra day to the convention, the surveyors had sufficient time to discuss their problems without fear of being cut short, and the convention proper benefitted by having the papers on surveying, which, in the past, have taken up most of the time available to discussion, segregated thus making room for papers of more general interest.

* * * *

The convention, this year, began on Wednesday, February 19, with the Surveyors' Day meeting, and continued on Thursday and Friday with the regular type of papers and discussion. It was the Twenty-second Annual Meeting of the Society, and the attendance probably set a high mark, there having been 172 engineers and surveyors present from all parts of Wisconsin. Social events were not lacking. On Wednesday evening, the surveyors met in the Paul Bunyan Room of the Memorial Union, on Thursday evening the entire membership was entertained at the University Club, and on Friday evening the convention terminated with the Annual Banquet, in conjunction with the Madison Technical Club, at the Park Hotel.

* * * *

Paul Bunyan Night, at the Memorial Union, was a distinct novelty in the way of convention entertainment. The meeting was under the direction of Dr. Charles E. Brown, director of the Wisconsin State Historical Society. Some of the able speakers of the evening were James J. McDonald, E. R. Jones, R. P. A. Johnson, Harry G. Dyer, and Ray S. Owen, all known far and wide for their intimate knowledge of the life and doings of Paul Bunyan, the doughty lumberjack. Memories were stimulated by means of lumberjack refreshments, and in some cases it would almost have seemed that the memories were overstimulated.

* * * *

At the University Club, the first item of entertainment was presented by Mr. Richard Neller, of the Letters and Science School, who proved himself a most able ventriloquist. With the aid of "Izzy", his dummy, he told some hitherto unknown facts about a number of the more prominent men present and made them like it. He concluded by whistling a duet with the dummy, which is a feat few professional ventriloquists care to attempt. Following Mr. Neller's offering, a motion picture was shown by a representative of the Relay motor truck company. The transmission of this truck embodies some new ideas and unusual features, and much is claimed for it. The picture contained very unusual shots of the trucks in service, showing the new design in action under rigorous conditions.

* * * *

An interesting feature of a large engineering project was presented by Charles A. Halbert, c'08, State Engineer, who told how, during the Michigan-Wisconsin boundary survey, he lost his faith in the American Indian as an infallible woodsman. It seems he was retracing old trails with two old Indians named Big Joe and Jim Bell No. 2. The trails were fairly easy to follow at first, but late in the day Halbert began to feel that the guides were bearing away from the proper direction. Finally Big Joe sat down on a stump and said to him, "I'm lost. If you'll get us out of here, we'll follow." Mr. Halbert

THE ENGINEERING SOCIETY OF WISCONSIN

In answer to a call letter issued and signed by a small collection of prominent Wisconsin Engineers about seventy men confronted with technical and engineering problems met in Madison on February 24, 1909, for a three day convention, the first annual meeting of the Engineering Society of Wisconsin. From that beginning the society has convened once a year with an ever growing attendance.

At the first meeting papers were presented on "The Use of Tar Oils and Emulsions on Macadam and Earth Roads", "Practical Forestry in Wisconsin", "The Highway Work of the Wisconsin Geological Survey" and other similar subjects which were of interest to the men in attendance. F. E. Turneaure, present dean of the Engineering college at the University of Wisconsin, was elected first president of the society. McClellan Dodge of Appleton was elected vice-president, and W. G. Kirchoffer, consulting engineer of Madison, was elected secretary-treasurer.

L. F. Van Hagan, professor of Railroad Engineering at the University of Wisconsin, was president of the society during the past year. With the aid of Professor Van Hagan, R. S. Owen, secretary-treasurer of the society, this year inaugurated a special session for the surveyors of the state on the day before the opening of the convention proper. The entire day was given over to the discussion of surveyor's problems. On the other two days of the convention, February 20 and 21, various topics of interest to all engineers and technical men were presented in papers and open discussion groups.

During the closing hours of this, the twenty-first annual convention, at Madison, the Society elected Leon Smith, superintendent of the Madison Water Works, as its president for the ensuing year.

claims that a lot of the prestige of the Indian is due to the fact that he keeps quiet.

* * * * * *

Another interesting side-light of the Michigan-Wisconsin boundary survey was presented by Mr. Halbert, when he told how Wisconsin inadvertently signed away 35 or 40 square miles of valuable fishing territory in Green Bay when the people who signed the pact with the State of Michigan failed to notice the insertion of the word "by" in one of the descriptions. Some "landlubber", Mr. Halbert declared, wrote "north by east" when he should have written "north-east", which not only deprived Wisconsin of the fishing territory mentioned above, but gave us several islands and a piece of the Michigan mainland. It is largely for this reason that the case is to be reopened shortly.

* * * * * *

A most interesting exhibit was presented in the lobby, during the entire run of the convention, by Mr. R. H. Lasché, of the Fairchild Aerial Surveys, Inc. The exhibit consisted of various aerial maps that this company has made, including a large mosaic map of Springfield, Mass., just as it was pasted up from the actual photographs and before being reduced to working size in a finished state. A stereoscope developed by the Fairchild people was also on exhibit. With this instrument it is possible to take two photographs of the same area, taken at different angles, and look at them simultaneously, thus giving the appearance of a third dimension, and making the topographic features of the territory stand out in distinct relief.

* * * * * *

The only other exhibit presented by manufacturers was that of the Comet airplane engine, which is manufactured in Madison by the Comet Engineering Corporation. This engine is now standing in the main lobby of the engineering building. It presents a very neat appearance, with its seven radial air-cooled cylinders and its peculiar exhaust manifold. The design appears to be quite simple and the engine of sturdy construction.

* * * * * *

A mystery that was not a mystery was uncovered by the presentation of Professor Warren S. Meade's paper on "Dilatancy". Through some typographical error, the word was printed in the bulletins of the Society as "Delatency", and all concerned were pretty much baffled, especially after Professor Meade appeared somewhat reluctant to disclose the content of his paper before the meeting. Several people were asked, but none had ever heard of "Delatency". It developed, however, that the error had been made, and "Dilatancy" is the property of substances to increase slightly in volume when their shapes are changed. The paper was most interesting, augmented by some of Professor Meade's ingenious devices for illustrating his explanation.

* * * * * *

Licensing of engineers again came in for its share of discussion, when Professor L. F. Van Hagan, retiring president, predicted more stringent regulations to "protect the profession from the competition of the incompetent". He claims that approximately one-half of present-day engineers are entering the profession through the "back door" — learning on the job — and that the public and the profession will suffer from such a condition. As long as students are required after graduation to compete with untrained men, they will be unable to afford, economically, to attend a school which enforces higher standards than those we now adhere to. Standards cannot be raised without driving students away from school, and we are compelled to accept men from high school and graduate them in four years as engineers, when we know and they themselves know that some of them are unfit for responsibility as engineers.

* * * * * *

A somewhat unusual phase of engineering practice was brought into the limelight when Lieut. D. A. D. Ogden, of the United States Army Corps of Engineers, presented a paper on "Peace Time Work of the Army Engineers". Lieut. Ogden discussed the procedure necessary to the improvement of a river or harbor in this part of the country, and explained what legal and governmental sanctities must be observed in securing such permission. He had a number of interesting illustrations of harbor work now in progress on the Great Lakes. We seldom think of the amount of work that is being done along these lines until it is presented in some such manner as this.

* * * * * *

The new officers of the Society, elected on Friday, are Leon A. Smith, superintendent of the Madison water department, and a graduate of the University of Wisconsin, president; Walter A. Pierce, superintendent of the water department of Racine, vice-president; and Professor G. L. Larson, of the Steam and Gas Department, and E. P. Gleason, chief engineer of the Nekoosa-Edwards Paper Company, Port Edwards, trustees.

* * * * * *

On Surveyors' Day, in connection with his talk on "Early Surveyors of Wisconsin", Dr. Charles E. Brown, curator of the State Historical Museum, eulogized Dr. Increase A. Lapham. Dr. Lapham was dean of the early surveyors. He was State Geologist in 1873. He published "The Antiquities of Wisconsin", in 1844, collected a wonderful assortment of state plants, and is known as "The Father of the U. S. Weather Bureau". He was a remarkable man, and a marvelous citizen, who brought much prestige to the art and practise of surveying.

* * * * * *

In connection with Surveyors' Day, Dr. Brown arranged to have a special display made at the Historical Museum, showing some of the instruments and other equipment of the pioneer knights of the compass and link chain. A number of treasures of early land and state boundary line history will be shown, representing years of effort on the part of the Museum. One of the chief items of interest will be the compass used by Dr. Lapham in laying out the streets of the city of Milwaukee and in making surveys of some of the Indian mounds and the ancient Indian enclosure of Aztalan, near Lake Mills. There are also com-

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Geophysical Explorations

By WARREN WEAVER, c'17
Associate Professor of Mathematics

A MAJOR purpose of science is to see with the aid of experiment and of the mind's eye what is otherwise unseen; for it is only thus that we discover those hidden relationships and correlations whose systematization is the central core of a successful science. It is our purpose to consider some of those branches of earth physics which enable us to see below the surface of the ground, and obtain information concerning the hidden substance and structure, whether this information be sought for its own sake, for its usefulness in drawing further conclusions in geologic problems, for its importance to the engineer in such questions as those of dam location and design, or for its use in locating ore and oil.

A cut from a translaton by Herbert Hoover of Agricola's works, showing the divining rod being used to detect valuable hidden minerals.

As we stand on the surface of the earth and observe its opacity with our eye and its dense solidity with our foot, it does, indeed, seem strange that there is any way whereby we can penetrate that solid mass save by the actual brute method of diamond drill or dynamite. Yet when one stamps his foot on the ground to demonstrate its solidity and his impotence to penetrate it, this very act sends tiny vibrational waves, quite similar to sound waves, down to great depth. And as regards the apparent opaqueness, we must remember that the human eye is sensitive over a very narrow range of color or frequency, actually only one octave; while we have instruments to produce or receive light or electromagnetic waves varying from hard X-rays of wave length 10^{-9} cm. to long radio waves of wave length 10,000 meters or more —a range of roughly 50 octaves. We remember, moreover, that the penetrating power of any such light wave into a given medium depends on the frequency, and by departing from the frequency of visible light, we can find waves which penetrate with ease such dense materials as rock or earth. Thus, both sound and light do pass easily through the rocks and earth if we but choose the proper sort of sound and light, and we may hear the echoed message and see the otherwise hidden picture if we but use the proper sort of ear and eye.

One has reason to hope, therefore, that he may explore below the surface of the ground. The process reduced to its simplest terms consists of a sending device which produces messengers which are dispatched down into the earth; and a receiving device which decodes the report when part of these messengers find their way back to us. We shout down questions and the ore whispers back its answer. Sometimes the whispers are too faint for us to hear or too confused for us to understand; but, at other times, we get a clear reply. In some cases, moreover, we get the answers without even asking the questions. Some ore bodies are the oldest of advertisers, in that they have been broadcasting for ages. To discover them, we need only a receiver suitable for understanding what they are trying to tell us.

Of the messengers which we may send, the principal ones are electrical currents, electromagnetic fields of various sorts, or mechanical vibrations. Of the messengers which are always present whether we will or no, the principal ones are gravitational attractions; the earth's own magnetic field and the fields it automatically induces in magnetic material; and the natural earth currents due to the battery-like action of certain sulphides. Corresponding to these various messengers, we have five principal methods used in the geophysical searth for ore or oil; namely: 1) magnetic method, 2) electrical method, 3) electromagnetic method, 4) gravitational method, 5) seismic method. We will consider very briefly the underlying theory of these five geophysical methods.

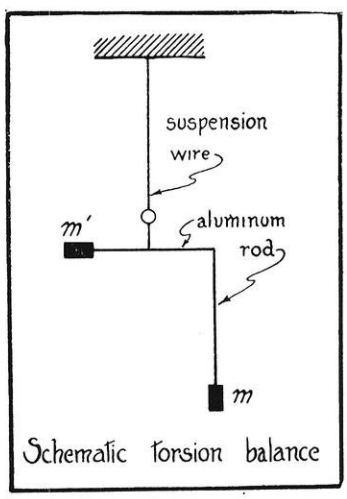
1) *The Magnetic Method.*

The magnetic method of surveying is based on two simple facts; viz., the fact that a magnet attracts or repels a compass needle; and the fact that certain substances, when placed in a magnetic field, automatically become magnetized by that field and hence become magnets. When various magnetizable substances are located in the same magnetic field the intensities of the magnetism induced in the various substances are different, and the ones that magnetize more strongly are said to possess the greater susceptibility. Granted the two effects mentioned just above, it is only necessary to have some external magnetic field present in order that the various rock or mineral masses become magnetized in amounts depending upon their various susceptibilities. We can then observe the action on a compass needle of the induced magnets thus formed, and can draw inferences as to the location, size, and constitution of the active masses.

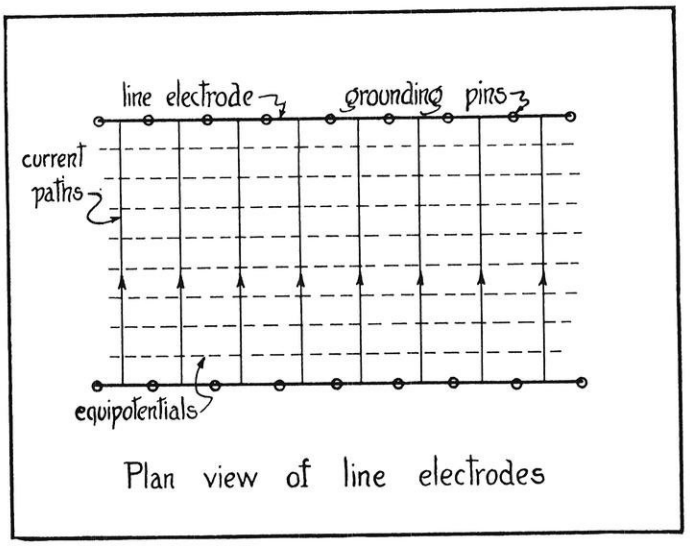
Now the vast majority of rocks and minerals have very low susceptibilities. That is to say, they are magnetized exceedingly feebly when placed in a magnetic field. Certain

of the iron compounds, on the other hand, have abnormally high values for their susceptibilities. The most striking and important example is magnetite, which has a susceptibility ranging from a hundred to a thousand or more times the minimum detectable value quoted above. Besides magnetite, ferriferous minerals such as franklenite, ilmenite, pyrrhotite, and, to a lesser degree, specular hematite, are all strongly magnetic. It is not correct, however, to assume that the magnetic method is restricted to the search for iron ore. In a copper region, for example, it may be of the greatest importance to be able to locate and trace the contact between the sedimentary rock and an igneous intrusion; and there is often sufficient difference in susceptibility to permit this. Magnetic methods have, in fact, been used to locate inclusions of iron formation in an intrusive gabbro; to locate faults in iron formations; to map distributions of lavas and intrusives; to trace copper bearing lodes; to trace igneous contacts and dikes; to trace the outcrop of a sedimentary bed; to locate gold placer deposits; and in many other connections as well.

The magnetic method, although a simple one, is in many particulars characteristic of other geophysical methods, and it will be illuminating to trace in a little more detail how it proceeds. Suppose the cross hatched region in Figure 2 represents a magnetic ore body while the surrounded dotted material is relatively inert. Due to the earth's magnetic field, indicated by the arrow, the ore body becomes magnetized, the north and south poles of the resulting magnet lying, as indicated, on a line which has approximately the direction of the earth's field; and there is a resultant distortion of the earth's magnetic field. If the ore body were absent, the magnetic field of the earth would be sensibly uniform over the region in question. Due to the ore body, the field is distorted. An instrument measures the entire field, composed of the earth's field plus the field due to the ore body. If, however, one subtracts from the total measured field the normal earth's field, he obtains the portion due to the ore body itself. This abnormal part of the field due to the disturbing presence of the body is called the magnetic anomoly; and since it is a force, one may resolve it into a horizontal anomoly and a vertical anomoly. The solid and dotted curves show the variation of the vertical and horizontal magnetic anomolies, respectively. For example, at a point A approximately above the south pole of the ore magnet, the field of the ore magnet is directly downward, so that the horizontal anomoly is zero while the vertical anomoly is large. A similar situation exists at B over the north pole except that the vertical anomoly is reversed in sign. The fact that the faulted end N of the ore body is more deeply buried is revealed by the fact that the vertical anomoly at B is considerably less than that at A. If the indicated fault were not present so that the north pole of the ore magnet were very deeply buried, the negative value of the vertical anomoly would be entirely absent. It is clear that the quantitative interpretation of such data involves a large amount of theoretical information concerning the exact way in which bodies of various shapes magnetize, and concerning the fields which they then cause.



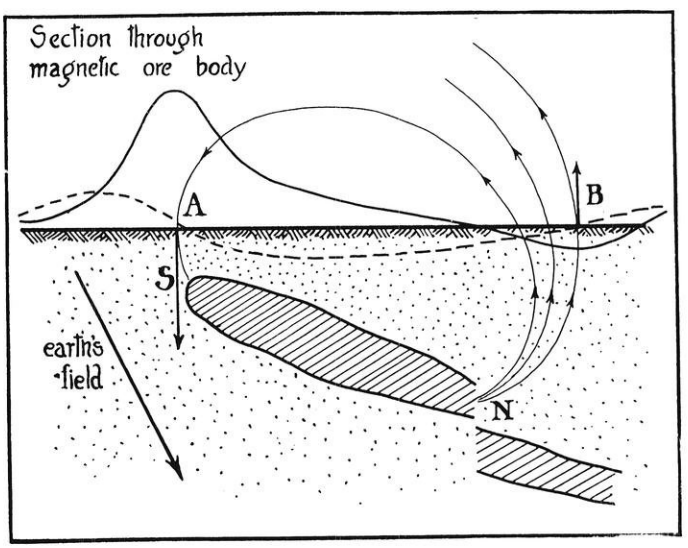
Schematic torsion balance



Plan view of line electrodes

2) *The Electrical Method*

Let us now turn to the electrical methods. The electrical methods may be divided into the natural-current method (where the messengers are furnished by nature) and the power-electrode method (where we must furnish the messengers). The electric current that flows between any two points of a conducting material is directly proportional to the difference of potential or "electrical pressure" between these two points. If the potential difference is decreased, the current decreases, we can conclude that the potential difference has decreased. Thus to any current distribution there corresponds a definite distribution of potential and vice versa; so that if we measure one we can deduce the other.



(Continued on page 227)

Side Shots

SHORT STORY

Pat was tired of War and longed to go back to his friends. He had served in the army of the Potomac for two years and was anxious to be free for a few days at least. Se he went to the captain and said: "Captain, I have been in the army two years without a furlough; I would like to go home for a few days to see my dear wife and children. I am sure they would all be very glad to see me. May I have a two weeks' leave of absence?"

"No, Pat," replied the captain, "I have just had a letter from your wife asking me to keep you here as long as possible. While at home you get drunk and beat her; I think you had better serve your term."

Pat turned around and asked the captain: "Captain, will you put me in the guard house if I tell you one thing?"

"No, Pat."

"Captain, two of the biggest liars in the Army of the Potomac are in this tent; I am one of them. I have no wife."

And the two English profs who were in a train wreck:

"Goodbye, pal," said one, "I am done for."

"For heaven's sake, don't end your last sentence with a preposition."

I bought a shirt that was advertised as being one that would laugh at laundry treatment.

It certainly did; it came back with its sides split.

"Terribly bad eye you've got. Get it through an accident?"

"Naw, through a key hole!"

The old doctors watched each move of a student doctor as he amputated the man's leg. Upon finishing, the student said:

"Well, was it done correctly?"

"Yes, it was done correctly, but you have made one slight mistake; you amputated the wrong leg."

A PUN

The problem of slippery sidewalks does not bother the engineers because they have slide rules.

"Why, this office is a regular oven."

"It ought to be. It's where I earn my daily bread."

Son: "Father, what is college bred?"

Father: "College bred — that made from the flower of youth and the dough of old age."

Customer (discovering he has no money with him): "Sorry, old top, but I can't pay you for the ride, I have no money—you know you can't get blood out of a turnip."

Taxi driver (rolling up his sleeves): "Yes, but you're no turnip."

Salesman: "Is your mother home?"

Little girl: "Yes, but so is daddy."

Engineer Seminar is always good for a few new definitions. Here are some of the latest attempts of the juniors to explain their understanding of the meanings of various technical terms:

Annular—pertaining to an island.

Empirical—that which is alike when pertaining to the same thing.

Resiliency—opposition to change.

Moritorium—funeral parlor.

Modulus—quantity of motion; elasticity; a figure to multiply by.

Friable—capable of being frozen; plastic; capable of being fried; capable of being bent or twisted.

Toxic — stimulating; strong; self-imposed; soothing drug; pertaining to germs.

Quay—marsh.

Fiscal — pertaining to the calendar; consisting of a whole.

Igneous—a soft rock; pertaining to original; capable of being ignited.

Pretty One: "Can I entertain you in any way, shape or form?"

Dumb One: "The last two seem promising."

A DEFINITION

Bachelor: One who didn't own a car when he was young.

First: "Pull your shades at night. Why, just last night I saw you kiss your wife."

Second: "Joke's on you! I wasn't home last night!"

Prof's Wife: "Dear, it's thirty-three years ago today that we were engaged."

Absent-minded one: "Well, I say—it's about time that we got married, don't you think?"

Girl friend: "Would you like to see where I was vaccinated?"

Boy friend: "Yes, indeed?"

Girl friend: "Well, just keep your eyes open—we'll soon drive by it."

We can almost equal some of those Paul Bunyan stories told at the convention by telling the one about the Philipino student at Devils Lake (supposed to be bottomless) who drove into the lake and was never seen again—but sometime later Prof. Owen received a letter from the Philipines asking Ray to send the diver his clothes.

She was only a miner's daughter, but oh, what natural resources.

1st Eight Ball: "I guess I wins — I'se got three treys!"

2nd Dusky: "No you don't — I've got two aces and a razor!"

1st One: "My, but you're lucky, ain't you."

Prof. Van Hagan: "Hutton, what did you find to be the derivation of the word auditorium?"

Hutton: "From the Latin, audio, to hear, and taurus, meaning bull."

It is said that Warner Oksanen has the largest feet of any one in the University — when he goes to take his trousers off, he has to pull them over his head.

Why does the geology prof who thinks a million years a short time, send the students home who come a few minutes late?

Prof. Van Hagan: (To student having a great variety of electives on his record) "Just which course do you expect to graduate in?"

Student: "Er, in the course of time."

The senior who said that a moratorium is the place where dead are buried has since found out that only the dead of night are buried there.

We also have with us the absent-minded professor who, on leaving his home, banged his wife and kissed the door.

We have in the hydraulics department a young man who reports that the baby at home weighs 8 pounds, 12 ounces, 2 clothes pins, and 4 buttons.

When is a cow not a cow?
When turned into a pasture.

First Engineer: "Where'll we eat?"

Second Tough One: "Let's eat up the street."

FAIRY STORY

Once upon a time there was a man who fell in love with a doctor's wife, so he sent her a barrel of apples.

"You say she is an admiral at the hospital? What does the admiral do?"

"Takes charge of all the vessels."

Statistics show that 67.234 per cent of the women at the university are here to get their M. A. N.

Liza: "Mandy, why does you call yo' chile Opium?"

Mandy: "I done read where opium comes from wild poppy, and Opium's poppy sure is wild."

Voice-on-phone: "Is Boo there?"

Sweet one: "Boo who?"

V. O. P.: "Don't cry little girl."

Rastus (riding in a street car): "Ah wants to be procrastinated at de nex' corner."

Conductor: "You want what?"

Rastus: "Don't lose youah temper, I had to look in the dictionary my s'f before I found out dat procrastinate means to put off."

Senior: "By hard work I have completed my four years of college."

Frosh: "Honestly?"

Senior: "Shut-up! Not so loud!"

Izzy: "Did you was by the army?"

Abie: "Oh, yes."

Izzy: "Did you get a commission?"

Abie: "No, only my vages."

Pity the poor Scotchman who drove up to a free air station and blew out the tires.

I. C. S. FORMULA FOR MAKING FUR COATS

1. Take an ordinary slicker — yellow preferred
2. Coat it quite heavily with Le Page's glue.
3. Roll on the floor of most any barber shop.

A young man had been away from home for several years and having made his fortune decided to take unto himself a wife. He, however, wrote to his father for advice. This is the reply he received:

Dear Son:—

In reply to your letter, I wish to say that marriage is a wonderful institution if you can find the right woman. The only comparison that I may suggest is to have you compare your girl with your mother with whom I have so ideally lived for the past thirty-five years. If she compares favorably with your mother, I wish you would marry her at once.

Your loving father.

P. S. Your mother has just left the room; don't be a Damn fool, stay single!

A minister once announced in his church: "Next Sunday my sermon will be on "Liars". I want every one here to read the 17th chapter of Mark before you come to church next Sunday."

The following Sunday the minister announced: "Today my sermon is on "Liars". I asked that you read the 17th chapter of Mark. How many have done so?"

A number of hands went up.

Said the minister: "I want those people who raised their hands to pay particular attention for there is no 17th chapter of Mark."

This little line was seen above a humor page in some sporting magazine:

"We humor editors may dig and dig till our finger tips are sore; but we'll always meet the boob that says, 'I've heard that one before'."

At a peace conference held in London some time ago, an Italian representative told a funny story. The Frenchman didn't laugh because he didn't think it funny. The Englishman didn't laugh; he had to think it over. The American didn't laugh; he had heard it before.

Many a poor alley cat may feel proud when it sees the hides of its ancestors on the back of some college student.

Blackstone, the magician, isn't so good—most any of us can turn a car into a driveway.

The L and S students may laugh at the breaks we make in Seminar, but think of the girl, who in describing Lee's surrender, wrote: "Lee was neatly attired in a grey Confederate uniform; Grant wore only a ragged union suit."

The most ambitious person in the world is the street cleaner who got kicked in the eye.

Proudfoot: "How do they figure the population of a Swiss village?"

Drew: "Oh, I guess they count the number of echoes and divide by the number of mountains."

Guth: "I went home to see my folks last week."

Lacher: "And how did you find them?"

Guth: "Oh, I always knew where they lived."

Matthias: "Have you ever seen a mosquito weep?"

Plotz: "No, but I have seen a moth ball."

Co-ed: "Could I see the Captain?"

First Mate: "He's forward, Miss."

Co-ed: "I'm not afraid. I've been out with college boys."

L & S: "Here comes an Engineer, let's kill him."

Second Fool: "Aw no, let him work himself to death."

Alumni Notes

Successful Wisconsin Engineers

Leon A. Smith

By R. L. VAN HAGAN, c'32

Leon Albert Smith, Wisconsin '12, civil engineer, has just been elected to the presidency of the Engineering Society of Wisconsin for the ensuing year. The position is one of responsibility and honor, for the society has a membership of about four hundred and represents all branches of engineering. In elevating Mr. Smith to its chief office, the society is giving formal recognition to the fact, already well known to his associates, that Leon Smith is one of the outstanding engineers of Wisconsin. He has to his credit a fine career of public service.

Mr. Smith was born in Elgin, Ill., on August 3, 1890. He was graduated from the Elgin high school in 1908 and entered the University of Wisconsin as a freshman in the fall of that year. The necessity of working during all available spare time prevented him from going into any activities other than joining the old Civil Engineering Society. His scholastic work, however, did not suffer because of the necessity of working, and he was honored by membership in Tau Beta Pi.

After graduation, Smith went to work for L. G. Arnold, Wisconsin '09, who was then city engineer for Chippewa Falls. He laid out the sewer and water systems and prepared plans for paving the village of Cornell and handled miscellaneous jobs for other small municipalities in that district. In October, 1912, he became assistant city engineer of Madison under Mr. E. E. Parker, Wisconsin '07, who had been appointed city engineer the preceding April. In February, 1916, Mr. Smith was made superintendent of the water department and he has held the position continuously since that time except for a short interim during the war when he was assigned to duty as engineer at the San Diego Concrete Ship Yards.

The excellent water supply system of Madison is the monument which Mr. Smith has erected to himself. When he took charge of the department, the plant was valued at approximately $1,000,000, pumped less than one billion gallons yearly, and had an annual net profit of less than $25,000. At the present time the plant is valued in excess of $2,500,000, pumps over two and one-half billion gallons yearly, and earns an annual net profit of nearly $125,000. In spite of the substantial profits, Madison enjoys the lowest water rates in Wisconsin with the exception of Milwaukee and West Allis. Since 1916, the pumping plant has been rebuilt, many new wells have been sunk, and a six-million-gallon high-pressure reservoir has been constructed.

Leon A. Smith

Mr. Smith's mind and capacity for work have inclined the city fathers to lay upon him various duties outside of his department, and he has been foolish enough or wise enough—have it your own way—to render much valuable service to his community. He is a member of the mayor's cabinet. He has worked actively with committees on the proposed metropolitan sewer district, on the traffic and safety situation, and on the proposed extension of University Avenue. He has represented the city in all public utility cases before the railroad commission. For the past five years he has been chairman of the local Fire Prevention Committee, during which period the annual fire losses in Madison have decreased from $250,000 to $50,000.

The able administaration of his department has won for Mr. Smith the respect of his colleagues in the engineering profession. He is a member of the American Waterworks Association and director from Wisconsin. He is also a past-president of the Technical Club of Madison, which numbers among its three hundred members the leading engineers and architects of the city.

A number of papers have been contributed to the technical press by Mr. Smith. His writings cover methods of deep-well pumping, the organization of the water department, and the analysis of water rates.

Besides his technical affiliations, Mr. Smith is a Mason and a member of Rotary. He likes golf and hand ball, but admits that he doesn't find time to indulge in either recreation as much as he would like. He was married in 1919 to Elizabeth Wilson of Madison. They have two children, a girl of eight and a boy less than a year old.

ELECTRICALS

Baumgarten, Harry L., e'27, who is with the Wisconsin Power and Light Company in Madison, is planning to help Professor Kelso in the meter school this year.

Conley, B., e'18, has resigned as electrical engineer for the Holtzer-Cabot Electric Company of Boston and is now chief engineer with the Sunlight Electrical Manufacturing Company at Warren, Ohio. Address: The Buckeye Club, Warren, Ohio.

Gerks, Irvin H., e'27, is a radio instructor at the Georgia School of Technology. Address: 84—4th Street, N. W., Atlanta, Georgia.

Hartenburg, Richard S., e'28, is studying aero-dynamics at Aachen, Germany.

Holmes, H. C., e'25, former business manager of the "Wisconsin Engineer", writes: "I am up to about the same things around here — still with the Consumers Power Company trying to keep a lot of statistics straight." Address: 535 Wildwood Avenue, Jackson, Mich.

Kates, Willard A., e'21, former editor of the "Wisconsin Engineer", resigned his position as engineer for the United Engineers and Constructors, Inc., and is now located in Corning, N. Y., with the Corning Glass Works doing developing work on glass products. Address: The Baron Steuben Hotel, Corning, N. Y.

Kietzman, W. A., e'12, address: 29 Overhill Road, Scarsdale, N. Y.

Miller, Burton F., e'26, is with the Electrical Research Products, Inc., a subsidiary of the Bell System in Los Angeles. He has been appointed to the position of recording engineer and has about forty associates in the West Coast Division. From his letter one would gather that he likes life in Hollywood more than a little. Address: 515 N. Larchmont Blvd., Los Angeles, California.

Puelicher, R. T., e'28, is working with Westinghouse, specializing in central station engineering. Address: 455 Biddle Avenue, Pittsburgh.

Rabbe, John A., Jr., e'26, writes: "Wish I could tell all of the Wisconsin engineers about our industry which is so little understood in the North. Would like to show anyone down this way what miracles are wrought with a cotton seed and how many articles of daily use have their origin in a cotton seed." Address: Buckeye Cotton Oil Company, Selma, Oklahoma.

Rubinstein, H. W., e'27, is assistant chief engineer of the Central Radio Laboratories of Milwaukee. Address: 20 Keefe Avenue, Milwaukee.

Rufsvold, Arnold S., e'23, is still with the Westinghouse Company as general engineer specializing on industrial applications work. Address: 7936 Susquehanna Street, Pittsburgh.

Schmidt, John R., e'29, is in the inspection development department of the Western Electric Company at Chicago, operating A. C. bridges for testing inductance, capacitance, and resistance. Address: 3231 Warren Blvd., Chicago.

Tjoflat, Gerald B., e'24, associated with the firm of Green and McCallister, Patent Attorneys, announces the arrival of a son, Gerald Bard, December 6. Address: 168 Inglewood Drive, Mt. Lebanon, Pennsylvania.

Wollager, Louis A., e'28, is on the engineering staff of the Central Radio Laboratories, Milwaukee.

CIVILS

Beebe, Gordon A., c'13, CE'24, address: State School of Mines, Rapid City, South Dakota.

Burmester, Everett A., c'11, construction contractor, has just completed a municipal water filtration plant at Saint Clair, Michigan. Address: 3795 Taylor, Detroit.

Grupp, Herbert C., c'30, who completed his work in February, is engineer for the Henkel Construction Company. Address: 728 M. B. A. Bldg., Mason City, Iowa.

Hopkins, Lt. William T., c'13, is with the commander scouting fleet of the Navy stationed in the Caribbean.

Landwehr, Edgar A., c'27, former instructor in the department of railway engineering, is in the valuation department of the St. Louis Street Car Company. He writes: "We are installing a property record which we hope will do away with inventories whenever a valuation is desired. **Mr. Wm. B. Bennett**, c'04, is the director of research and the idea of a property record is his brainchild." Address: 3939 Castleman Avenue, St. Louis, Mo.

MacLeish, Kenneth C., c'25, has been presented with a new daughter, born February 3rd.

McWethey, H. E., c'09, who has been on the engineering staff of the Minnesota Railway and Warehouse Commission, has joined with a Mr. Burch in establishing a consulting firm specializing in statistical research in the public utility field. The firm is located in Minneapolis.

Moe, Clarence M., c'26, is in the Youngstown, Ohio, office of the Carnegie Steel Co.

Moehlman, W. F., c'22, address: 413 Chamberlain Avenue, Madison.

Pratt, Leo F., c'0, is living at the Y. M. C. A., 2 South Clinton Ave., Trenton, N. J.

Ruf, Harold W., c'28, is research assistant in sanitary engineering at Wisconsin and is working toward his master's degree.

Rust, Thomas H., c'12, is designing engineer with the Union Terminal Company which is erecting the great group of railway bridges in the heart of Cleveland. Address: 1900 East 26th Street, Cleveland.

Staack, John G., c'04, chief topographic engineer of the U. S. Geological Survey, has just returned to Washington from an inspection trip to the Pacific Coast, conferring with state officials and inspecting field parties at Denver, Sacramento, Los Angeles, and in Texas and Oklahoma. Address: c/o U. S. Geological Survey, Washington, D. C.

Thiel, Walter C., c'22, has been promoted to efficiency engineer with the City of Los Angeles (Bureau of Budget and Efficiency). Address: 120 City Hall, Los Angeles, Calif.

Torgeson, O. W., c'24, address: 610 Emerson Street, Madison, Wis.

Wasson, J. H., c'12, is engineer representative for the Peerless Cement Corporation of Detroit. He is also president of the Detroit section of the A. S. C. E.. Address: 4852 Cortland, Detroit, Michigan.

Zimmerman, James G., c'04, has just been granted a patent on a process for color photography. He has been working on the process for several years and has already received patents on various phases of the process. The new patent completes the process. Mr. Zimmerman is a resident of Madison and is on the technical staff of the Burgess Laboratories.

Zufelt, Jerome C., c'26, has left Consoer, Older and Quinlan and is with **Jerry Donohue**, c'07, consulting engineer of Sheboygan, Wis.

MECHANICALS

Hartwell, H. T., m'24, address: Railroad Commission, State Capitol, Madison, Wisconsin.

Naujoks, Waldemar, m'26, claims he is still a hard working M. E. with the Steel Improvement and Forge Company of Cleveland. Address: 1303 East 134th Street, East Cleveland, Ohio.

Richtmann, William M., m'25, is in the experimental department of the Barber-Colman Company on temperature control equipment. Address: 1502 National Avenue, Rockford, Illinois.

(Continued on page 222)

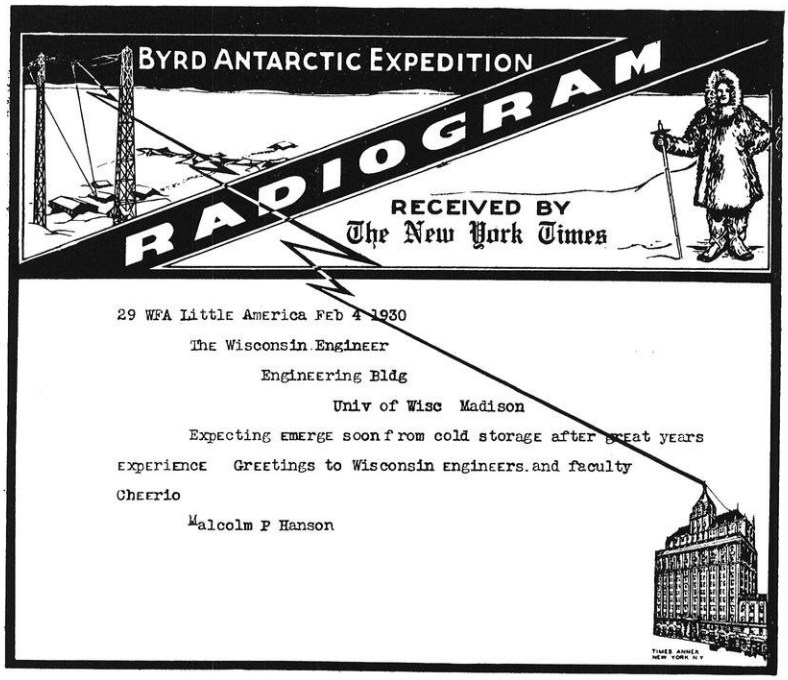
Campus Notes

Radiogram from the Byrd Expedition

By GERALD C. WARD, c'29

Strange messages from friends in far-off places have been received by Madison folks, but perhaps one of the strangest and most interesting is a radiogram received by the *Wisconsin Engineer,* university student publication, from one of its good friends in Little America — the bottom of the earth!

The message reached Madison by devious ways. It was first sent by Mr. Hanson, sitting at his key in Little America, to the New York Times by short-wave radio. From there it was relayed to the *Wisconsin Engineer* by the New York Times.



Mr. Hanson's career reads like a story book, particularly since his contact with Madison. Rated as one of the outstanding students in the mechanical engineering department of the university, his studies were interrupted, in 1918, by our entry into the World War. During the war, Mr. Hanson developed a keen interest in radio work, and he was assigned to one of the Navy stations,, emerging with a commission in the Navy when peace was declared.

With the increasing interest in aircraft radio, Mr. Hanson's field became more specialized, and soon he became associate radio engineer in the aircraft radio section of the Naval Research Laboratory, at Anacostia, D. C., where he has specialized in short-wave studies.

During the inception of Commander Byrd's flight over the North Pole, it was desired to keep in touch with the base of operations throughout the flight, and short-wave radio was determined upon because of the extreme lightness and flexibility of the equipment. Naturally, Mr. Hanson was called in consultation, with the result that he had complete charge of equipping Commander Byrd's plane for the Arctic flight.

Due to lack of space, or for some other unexplained reason, however, it was found that there was no space for Mr. Hanson on the boat bound for Spitzbergen, so he was to be left behind. But the decision meant little to him, in the face of his ambition, and three days later he walked out of a clothes closet on board ship and announced himself as a member of the party. It was too late to turn back, so they took him along. He succeeded in rendering invaluable services to the expedition ,and during Byrd's entire flight he kept in touch with the lone plane on its hazardous quest.

During the Arctic expedition, and upon his return to the States, Mr. Hanson was closely attached to Commander Byrd in all his exploits. When the trans-Atlantic flight, in the ill-fated Miss America, was planned, the radio work was in Mr. Hanson's hands, and his efficiency and ability were attested by the communication maintained during the entire course of the hazardous flight.

Who, then, was the logical man for Commander Byrd to chose to maintain contact with the outside world when he set forth upon the most exacting adventure of all? None but our friend Malcom P. Hanson, who had done such valuable work in the other two expeditions. And there he sits today, under his hands the one slender thread of contact between America's representatives at the bottom of the world and a nation of their well-wishers.

It can well be imagined with what a whoop of joy Mr. Hanson will "emerge soon from cold storage" because it will be the occasion of his introduction to his son, who has been born since his father's departure for Little America. The young man, it will be recalled, paid a visit to Madison last summer in the company of his mother, who, before her marriage, was Miss Euphraise Jeanne Raffo, of Washington.

Mr. Hanson's work has brought great credit both to himself and to the university, and his many Madison friends will be pleased to hear of his most recent adventure.

NEW OFFICERS FOR A. S. C. E.

Alfred Wickesburg '30, was elected president of the Wisconsin chapter of the American Society of Civil Engineers for the spring semester at a meeting in the Engineering building Feb. 12. Other officers chosen were George Washa '30, vice president; Robert Wertsch '31, secretary-treasurer; and Walter Tacke '30, publicity director. Gerald C. Ward, instructor in railway engineering and an alumnus of the society, spoke on "The Use of Electric Arc Welds in the Construction of Steel Structures."

CROCKETT LECTURES ON SALES

Patience, lack of fear, and a full knowledge of the product he is selling are the prime requisites of a good salesman, according to Mr. A. E. Crockett, manager of the bureau of instruction of the Jones and Laughlin Steel corporation, who spoke in the auditorium of the Engineering building Feb. 12. The lecture, "The Psychology of Sales in the Steel Industry," was given under the auspices of Polygon.

DEAN TURNEAURE HONORED

Frederick E. Turneaure, dean of the College of Engineering, was recently awarded the Henry C. Turner gold medal by the American Concrete Institute "for distinguished service in formulating sound principles of reinforced concrete design." The medal is awarded not oftener than once a year for "notable achievement or service to the concrete industry."

FACULTY ATTENDS CONVENTION

Approximately 200 engineers attended the 22nd annual convention of the Engineering Society of Wisconsin, held Feb. 19-21, in the Engineering building.

Prof. L. F. Van Hagan, of the College of Engineering faculty, has served as president of the society for the past year. He delivered the opening address of the Thursday morning session.

Other faculty members who appeared on the program of the convention as speakers were Prof. Warren Weaver, Prof. W. S. Kinne, Prof. W. J. Mead, Prof. Edward Bennett, and Prof. R. S. McCaffrey.

TO WORK! TO WORK!

Edward A. Meisenheimer has accepted a position with the Louis Allis Company, Milwaukee; and Gilbert Jautz will teach in Milwaukee Technical High School. Ed. B. Doescher, John A. Johnson, Leslie C. Westphal, Lawrence J. Onsrud, James W. Arnold, Roger W. Stevens, and Robert W. Hutton have not reported their connections.

GRADUATING CLASS FINDS JOBS

Approximately one half of the students graduated from the College of Engineering in January have already secured positions, according to an announcement from the office of Prof. G. L. Larson.

Five of the eight graduates from the civil engineering department have secured positions, while the remainder have not indicated the work which they intend to take up.

The mechanical engineers who have accepted jobs are: James E. Kahlenberg, employed by the Pittsburg Plate Glass Company; Harold W. Gerlach, by the Fairbanks Morse Company, Beloit; George W. Mueller, by the Proctor and Gamble Company, Cincinnati; Robert G. Walker, by the General Electric Company, Schenectady, N. Y.; and Arthur H. Wedmeyer, by the Norberg Manufacturing Company, Milwaukee.

Of the civil engineering graduates, Herbert C. Grupp has been named to the engineering staff of the Henkel Construction Company, Mason City, Iowa; Clayton F. Paschen to the Paschen Construction Company, Chicago; Bernardo Veslasquez has gone to Colombia, S. A.; Vernon Hamel has elected a law course; Marcus B. Hunder has been named a research assistant in the university; and Philip McCaffrey will also do graduate work.

WISCONSIN MEN IN AVIATION

Four Wisconsin men have filled out applications for admission to a government training course in aviation after hearing Capt. Chester J. Peters, of the U. S. Marine Corps reserve, talk on the course. Capt. Peters flew here from the Great Lakes Naval station Feb. 10 to explain the plan by which the government hopes to train 50 young men during the coming year.

Applicants must be college graduates or possess its equivalent; be a citizen of the United States; be between the ages of 20 and 27; be physically qualified according to naval standards; and agree to continue the course if they meet other qualifications.

After elimination flight training as enlisted men of the U. S. Marine Corps reserve at Great Lakes, Ill., the men will go to Pensacola, Fla., for primary and advanced flight training. One year of training duty in aircraft squadrons, U. S. Marine corps, as a commissioned officer of the corps reserve completes the course.

AERONAUTICAL SOCIETY ELECTS OFFICERS

A. M. Tuttle, grad, has been chosen president of the University Aeronautical Society. Other officers elected were Raymond Wagner '33, secretary; Ed Page '31, treasurer; Fred Hanson '32, and Gustave Blatz '33, members of the board of directors.

PAUL BUNYAN NIGHT ESTABLISHED

"The first liar hasn't a chance" was the motto of the evening when surveyors of Wisconsin gathered in the Paul Bunyan room of the Wisconsin Memorial Union Wednesday evening, February 19, for the first annual Paul Bunyan Night. One of the high lights of the evening was a talk by Mr. Charles E. Brown, of the State Historical Society, who is know far and wide as a teller of Paul Bunyan tales. The subject of his talk was "Early Land Surveyors in Wisconsin,"

The meetings were extremely informal, and in order to stimulate discussion, questionnaires had been sent out to the county surveyors and other engineers interested in land surveying, and many questions were received which served as fuel for the fire. Surveyors were asked to submit their pet questions to be discused and their pet peeves to be aired — and what an airing they did get.

GROUND SCHOOL PLANNED

A ground school for airplane pilots is planned by the university extension division, which is to offer two courses for fliers and others interested in atmospheric and meteorological conditions.

Eric Miller, meteorologist at the university, will be in charge of the courses. The classes are planned to meet a demand for instruction in aspects of flying which must be learned on the ground.

Engineering Review

FLORIDA ROCK PROVES SATISFACTORY FOR CONCRETE

Concrete construction in Florida, especially in the southern part, has long been handicapped because of the belief that the materials had to be imported from out of state because of the softness of the native rock. Desirous of seeking economic relief, engineers experimented with the Florida rock and built various concrete roads, buildings and seawalls. The success of these experiments was proven by the condition of the concrete used after a long period of time. Due to the wear of hard and abrasive substances and iron tired wagon wheels and chains on automobile tires, many engineers dismissed Florida rock as unsatisfactory because of its questionable softness. Others pointed out the fact that iron tired wheels are now extinct in Florida and that chains are never used on the automobiles that traverse its highways. This fact alone helped pave the way for more extensive use of the rock. Geologically, Florida is of very recent origin, accounting for the nature of its rock. Gravel is found only along the Alabama and Georgia boundaries. Elsewhere soft materials such as limestone offers the only material for concrete, except for small deposits of so-called flint. The durability of the concrete has been proven by the stretch of concrete paving at Ft. Myers. This pavement has been in operation for twenty years and has yet to show signs of wear. Another project using Florida cement is the Florida East Coast Railway bridge to Key West, and the massive boat slips at the Key West terminal. There are also many beautiful concrete buildings at Fort Augustine, some of them 43 years old and yet show no signs of disintegration. A twenty-year old seawall at Tampa is still in good condition. In 1925, B. M. Duncan, city engineer of Miami, built a stretch of experimental paving at North Miami Ave. About a dozen individual sections were built utilizing all combination of mix, from pit run of the quarry to designed mixes of definite proportions of local stone and local fine sand. These test sections proved so satisfactory that in 1927 and 1928 the city laid more than 300,000 sq. yds of 8-in., 3,000 lb. concrete paving that cost them on the average of $1.60 a sq.-yd. The concrete was laid without expansion joints and has proven satisfactory. It cannot be said that all constructions using Florida rock has proven satisfactory, but in all cases of failure the cause of failure was laid to poor workmanship or the failure to live up to specifications for this rock. Disintegration because of badly honeycombed concrete, or because the reinforcing rods had been placed too close to the forms, would have occurred regardless of the material. A more detailed, pictorial account of this project of experimentation with concrete can be found on page 279 in the February 13, 1930, issue of the *Engineering News-Record*.

GAS ELECTRIC BUSES

Electric drive is coming into use for house-to-house delivery trucks, large buses, and even pleasure cars. The smooth acceleration and easy handling secured by the use of a generator and electric motor in conjunction with a gasoline engine are of great advantage in commercial use. For house-to-house delivery, the trucks combine advantages of the horse and wagon with conveniences of the automobile. Quick starts and stops can be made without the necessity of shifting gears. The use of electric drive in buses has the advantage of a powerful starting torque. For buses operating in busy cities, where numerous stops must be made, the freedom from shifting gears and the ease in starting more than offset the extra first cost of the gas-electric equipment.

RADIO ALTIMETER

A method of depth by means of radio impulses has been found to reduce the hazards of "blind flying" considerably. The apparatus consists of an oscillatory circuit the constants of which vary as the height of the plane changes. This variation is due to change in capacity of the circuit as it moves with respect to the earth. A meter in the circuit is calibrated in feet, suitable corrections being made for varying conditions.

The instrument is especially valuable for flying in fog such as is encountered in trans-oceanic flights. Under such conditions the pilot is more interested in keeping away from the ground than in knowing his exact height. Distinctive signals are given out as the plane approaches the earth. The ordinary barometer is not sufficiently accurate to record minute variations; the radio altimeter is quite accurate at short distances from the earth, however.

TEMPERATURE OF CONCRETE DAM AFFECTED BY COLOR

The color of the waterproof coating may seem to be of little importance to the engineer, but recent tests made on the Florence Lake dam in California indicated that the temperature of the concrete surface was very much higher for a dark than for a light coating when the sunlight struck the surface. The reason for the investigation was the flaking of the waterproofing compound used to reduce leakage. The fact that the paint flaked only when the atmospheric temperature was low caused the investigation of temperature changes as a possible cause. Three thermometers were placed at different positions in the dam, and the relation of the temperature of the dark surface, the surface where the protective coating was covered by an aluminum paint, and the temperature of the air was observed. It was found that areas painted with only the black waterproofing compound differed by as much as 60 degrees from the air temperature, and that areas where the black substance was covered with aluminum paint differed by only 20 degrees from the air temperature when the sun shone on the surface. It is thought that the use of a lighter colored paint will reduce the flaking.

Editorials

MANAGER AND EDITOR

THE scene shifts. The curtain rises. A new business manager and a new editor are standing awkwardly on the stage with the *Wisconsin Engineer* on their shoulders and the first issue on their minds. A glimpse at the wings shows the former manager and editor heading toward the stage door. The responsibility is fixed.

First thoughts. Plans for the immediate future. New policies to be introduced. New contacts to make. Revolutionary changes contemplated. The first issue looming ahead. The first issue looming ahead. The first issue looming ahead.

We are glad of the opportunity of serving the readers of the *Wisconsin Engineer*, of producing a technical magazine which holds its place among those of other universities. It is not a small opportunity. Nor is the responsibility small either. We have to uphold a reputation earned by years of success and excellence.

It is our fortune to have three former editors, and a former business manager on the campus. Experience accumulated over a considerable period should be ours through suggestions. We also do welcome advice from any of our alumni, and all of our student subscribers. The subscribers make the magazine and are responsible for the existence of the manager and the editor. The editor and the manager without the circulation would be as hopeless as an engineer without a slide rule, or a slide rule without an engineer. We are servants, not leaders, and unlike most servants, are willing to serve. The magazine is yours.

The *Wisconsin Engineer* consists largely of student articles. As such it provides an opportunity to any of the students and alumni to have their articles, ideas, and fanticies published. There are many students and alumni who have witnessed great engineering accomplishments. An account of this would be of general interest. The technical magazine is the best news-spreader and story-divulger known to the engineer. With a single run of the presses, the tale is told to a thousand readers.

We are also pleased to be able to continue the contact which exists between the undergraduates and the alumni. We believe that this is one of the most important functions of the *Wisconsin Engineer*. Many graduates cannot come back for homecoming even once a year, to see the campus and renew old acquaintances. Instead we send the campus to the graduate eight times a year. The vigorous co-operation which has existed ever since the magazine was established is indicative of the importance of this function.

COLLEGE IN THE EIGHTIES

Incidentally, I might mention also that I spent all my spare time for several weeks working on the reconstruction of railway bridges for a certain railroad, in addition to my college work, although I was carrying something like one-third extra, above the regular course, owing to irregularities in the arrangement of my schedule in earlier years. This necessitated long working hours at night; and for about five weeks, I went to bed between two and three o'clock in the morning and got up promptly at six-forty. After the first few days I became accustomed to this condition, so that, when the professor would see me every few nights in regard to his railway work, I found that I could put him to sleep every time before the evening's work was over. Several times he asked me how I could do it.

—Autobiography of Benjamin Carver Lamme.

ATTENDING CONVENTIONS

CONVENTIONS, to most vocations an interesting event, are a necessity to engineers. The calendar is continually filled with dates of engineering conventions and meetings. They begin to occur early in the autumn, and their occurrence is consistent throughout the spring until the summer vacations.

In former days engineers were somewhat averse to attending these meetings and taking place in the general interchange of newly acquired ideas. They were glad to hear about new methods in their profession, but they were very much against giving away any secrets of their own finding. The spirit of engineering was hampered by selfishness.

Now, engineers are glad to publish their works. They are not averse to attending conventions and contribution to the growing knowledge of their industry. The spirit of engineering has broadened and is a much finer one than used to exist.

The convention is not only an interchange of engineering procedure and method; it is also an employment agency and an advertising concern. Here, the ambitious man may find the employer who will give him the position of his dreams, and open for him an envied career. Here, the established employer may find the young man who will contribute successfully to his growing firm. Here, men will meet friends who may increase their volume of business through their personal contact.

Conduct in conventions accordingly is essentially important. A well delivered paper — an intelligent discussion — a few pertinent queries may start something which years of plodding has not budged.

Many famous engineers can now look back over their years of success, which was begun by some convention or other. Attending conventions is essentially important to the engineer.

PIONEER LAND SURVEYORS

(Continued from page 201)

1844 of the famous iron deposits of northern Michigan, at what was later known as the Jackson mine.

"In view of the characters and personalities of some of the surveyors, it is not to be wondered at that their advice was much sought after by the great mass of land hunters, or that some of them should have been tempted to use their special knowledge of the public lands for the purpose of advancing the interests of themselves and their speculative friends.

"The surveyor was required to put into his official notes such a description of the soil as would be helpful to the ordinary claim hunter. He was not required to describe mill-sites or the situations which nature may have intended as locations for future towns. Incidentally, however, the progress of his surveys gave him knowledge of these matters and it sometime proved to be secrets of considerable value. It was charged in congressional debate that the surveyors note every valuation lot and sell the information thus acquired to speculators.

"As the survey proceeded, land sales took place, from time to time, at the land offices located in 1834 at Green Bay and Mineral Point. At the latter office 14,336.67 acres were sold the first year. The following year the two offices together sold 217,000 acres."

The early government land surveyors were paid for their work by the mile, the compensation depending upon the character of the country to be surveyed. Their well-filled notebooks, with included small maps and field notes, were returned to the surveyor general's office and there larger maps were prepared for the use of the land offices. These and the precious original notebooks themselves are now preserved in the State Land Office in the state capitol building.

Eastern and local speculators soon availed themselves of the seeming golden opportunity to enrich themselves at the expense of the public by acquiring tracts of these new lands of the West and laying out townsites. No fewer than an eight of these "paper cities" were located along and near the course of the Rock River alone, between the foot of Lake Koshkonong and Beloit. None of these ever came into actual existence as settled communities in their time and their sites are today occupied by farm lands, or included within the present limits of large cities like Janesville. Lots in these "paper towns" were sold in the East. Now and then some purchaser came to locate his holdings only to return greatly disappointed.

John A. Fletcher was engaged, in the year 1839, in staking out a townsite he had purchased in Johnstown, east of Janesville. He had just driven his last stakes when a Milwaukee land-hunter came by. He stopped to view the scene of Squire Fletcher's labors. Addressing him he remarked, "It must be very sickly around here?" "No it isn't," replied Fletcher, "it's the healthiest country in the United States. What makes you ask such a fool question?"

"Well," said the man, "I only ask because you are laying out such a thundering big burying ground."

The owners of these early townsites were very public spirited. On their plats they reserved blocks for "State Purposes" and "County Purposes", and the "Academy", and other public buildings. They located bridges across streams where there were none. (Horace McElroy, The Forgotten Places, in Rock County History.)

Four such towns were located about the Madison Lake, the "City of Four Lakes" on the northwest shore of Lake Mendota being the most promising of these in an early day.

Among the young men who came to Wisconsin as settlers in the early years of territorial and state history were some who had had at least some surveying experience in their home states in New England, New York, Pennsylvania and Ohio. In some instances their fathers had been surveyors, or part-time surveyors, before them. Some brought the family compass with them. To them the use of the compass, link chain, arrows, flag, level and rod presented no mysteries. To them came the duty of staking out the bounds of farm lands, lying out the early roads, laying out city streets and staking out lots, and preparing the way for proposed canals, and future railroads. Many became men of considerable or great prominence in their communities, the first county surveyors, railroad engineers and city engineers. As a boy I sometimes carried the chain for some of these surveyors and came to know others personally. I thought them wonderful men — and possessed of remarkable memories. Standing on the hard surface of a gravel road, one of these men, William H. Nuhlman of Milwaukee, later city engineer of Topeka, Kansas, once said to me, "Ten years ago I drove an oak hub here. It must be here now." Five feet or more of gravel and dirt had been filled over it in improving the country road. We dug down and found this stake. No engineer who has worked in Wisconsin has ever made more accurate or beautiful maps and plats than this same man; they were artistic masterpieces and I have seen them framed and hung in more than one engineering and real estate office. He was apprenticed as a boy to an engraving firm, hence his remarkable skill with pen, ruling pen and brush.

In Memoriam

In memory of these men and of many other early and past knight of the transit and level, who by their services assisted in Wisconsin's settlement and progress, the State Historical Museum of Wisconsin has set aside in its precious exhibition halls several cases for the preservation of historical materials connected with their engineering service. This valuable collection is continually being added to by gifts received from the families or friends of former Wisconsin engineers.

Among these treasures is the compass (Clark Williams, Cincinnati, manufacture) brought by Increase A. Lapham from Columbus, Ohio, and used in surveying in Milwaukee in 1836. With it are his chain, arrows, level rod, draughting instruments and other tools used by him in his early land and mound surveys.

Here is another compass (Burt's Patent) used by Col. John G. Clark of Lancaster in government and other surveying in Wisconsin, Minnesota, Iowa and Missouri. Another (Ellis and Isaac Chandler, Nottingham, England, instrument makers) was used by "General" Beggs, another early surveyor who brought his compass from Ohio, to Adams Township, Green County, in 1838. It was later used by Hiram Gabriel, another early surveyor. A fourth compass (O. Hanks, Troy, N. Y., make) was brought from Ferrisburgh, Vermont, to Big Bend by L. M. Martin, a well-known former Waukesha County land surveyor. Here is a scribe used by William H. Canfield of Baraboo, a book of tables and treatise on surveying which belonged to Joshua Hathaway and other equipment of Moses Strong, Theodore D. Brown and others.

Here is the original approximate estimate in Dr. Lapham's own handwriting, on two sheets of blue paper, of the cost of preparing the original roadbed of the present Chicago, Milwaukee, St. Paul and Pacific Railroad from Walker's Point, in Milwaukee, to the Stone Quarries, about five miles west of the center of the city — total cost $20,223.00. This bears the date of August 31, 1849.

A section of the trunk of a pine tree from the shore of Trout Lake, in Vilas County, shows a large blaze on which are deeply cut the names of Capt. Thomas J. Cram and Daniel Houghton, name giver of Houghton, Michigan, and the date, August 11, 1841. A printed circular letter issued June 1, 1858, by Dr. Lyman C. Draper, secretary of the State Historical Society, asks the assistance of the surveyors of the state and of other intelligent citizens in locating and platting the Indian mounds and other aboriginal remains of the state.

Preserved in the map and manuscript department of the State Historical Society are notebooks, letters, plats, and maps written and prepared by the pioneer land surveyors of Wisconsin. These are priceless memorials of their service to history, industry and education.

ENGINEERING SOCIETY OF WISCONSIN HOLDS CONVENTION

(Continued from page 203)

passes used by Col. John G. Clark, "General" Beggs, Hiram Gabriel, and Louis Martin, all famous early-day explorers and surveyors who had a hand in running our state and county boundary lines.

* * * * * *

An unusual concept of concrete making was presented by Mr. D. B. McMillan, director of Research, The Portland Cement Association. His contention is that the art of making concrete has been made entirely too complex, and that some simpler concept is necessary in order that the man at the mixer may be more thoroughly conversant with the science back of his work. Mr. McMillan proposes to do away with fineness moduli, for instance, and substitute the idea of there being a certain amoung of cement paste, in which the maximum amount of aggregate is to be embedded, without reference to gradings. This idea is presented in a recent book gotten out by the Mc-

Graw-Hill Publishing Company, entitled "Modern Principles Applied to Concrete Making", which is a collection of several articles which appeared some time ago in the *Engineering News-Record.*

* * * * * *

The matter of geophysical activities, which have always been more or less obscure to most of us, was cleared up in a remarkable style by Professor Warren Weaver's paper on geophysical exploration. His likening the activities of the geophysicist to those of a human eye peering into the depths of the earth was inspiring, and it enables the average engineer to understand something hitherto occult. Professor Weaver sends a light-wave into the earth, interprets the result, and finds the pot of gold.

ALUMNI NOTES

(Continued from page 209)

Shoemaker, William T., m'26, address: 331 Cherry Lane, Upper Darby, Pennsylvania.

CHEMICALS

Pitzner, Alwin F., ch'21, has been admitted to partnership in the firm of Chindall, Parker and Carlson, with whom he will continue the practice of the law of patents, trademarks, and unfair competition. Address: 1015 Monadnock Block, Chicago.

Rheineck, Alfred E., ch'28, is a research fellow in the department of chemistry and chemical engineering at Lehigh University doing research work on linseed oil. Address: 518 West 3rd Street, Bethlehem, Pennsylvania.

Soll, R. H., ch'24, is metallurgist for the Emsco Derrick and Equipment Company of Los Angeles. Address: 6205 Stafford Avenue, Huntington Park, California.

VISCOSITY IN SOLIDS

(Continued from page 199)

loosely bound electrons act as current bearing agents. On this supposition, non-conductors are those substances in which no electrons are loosely bound. Experiment shows, however, that non-conductors dissipate energy through viscosity as effectively as do the conductors. Much theoretical work is now in progress toward the solution of such apparent contradictions.

A second theory makes use of impacts between the particles of the material themselves. It supposes that when a solid is strained, the material is microscopically so deformed that atoms or small groups of atoms are moved permanently into different relative positions. In the course of this motion impacts occur between adjacent atoms or aggregates. These impacts serve the same purpose as the impacts of gaseous particles, exciting thermal vibrations at the expense of initial strain. Those atoms which have been displaced and do not return after the vibration has subsided are responsible for the storage of potential energy referred to above.

This theory offers an explanation of plastic dissipation. Its picture of the motion of atoms into new permanent relative positions is precisely a microscopic analysis of the establishment of a permanent set. Dissipation, however, takes place at strains so small that it is difficult to see how permanent change in position of atoms is possible. Dissipa-

tion can be observed when a bar is strained by less than one hundred-thousandth of its length. If this bar were so magnified that two adjacent atoms appeared one meter apart their average deflection by strain would appear less than one-tenth millimeter.

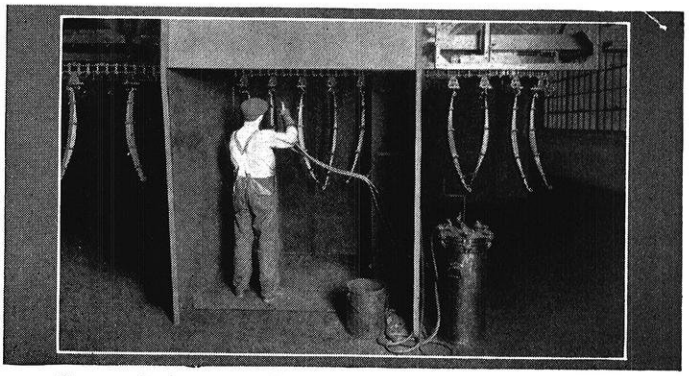
It is, however, possible that the "plastic" hypothesis may explain the phenomenon at these very small strains. Two neighboring atoms will generally be oscillating irregularly due to thermal vibrations. There is a force of attraction between these atoms tending to keep them together, while the thermal agitation tends to break them apart. The net attraction is therefore less as the temperature is increased, and it must vary also with the relative orientations of these atoms. Owing to the forces exerted more or less at random by other atoms on this pair the relative stability of the pair may be in some cases extremely critical so that it is conceivable that a strain, no matter how small, may upset the relative positions of such a pair. This will change their relative potential energy and at the same time dissipate energy in heat by further exciting their minute vibrations. Other pairs in the same sample may be under the influence of a large net attractive force such that small strains cannot displace them. This makes the problem one of statics.

If the numerousness of the extents of individual deflections follow some familiar statistical distribution law, curves of statistical frequencies of deflections might appear as in Figure 1. Here it can be seen that no matter how small the average deflection (and thus the overall strain) some atoms would still be so largely deflected as to pass over one another, resulting in permanent change in position. In this direction the impact theory must be further developed to explain how permanent displacements result from very small strains and thus to identify viscosity with plasticity.

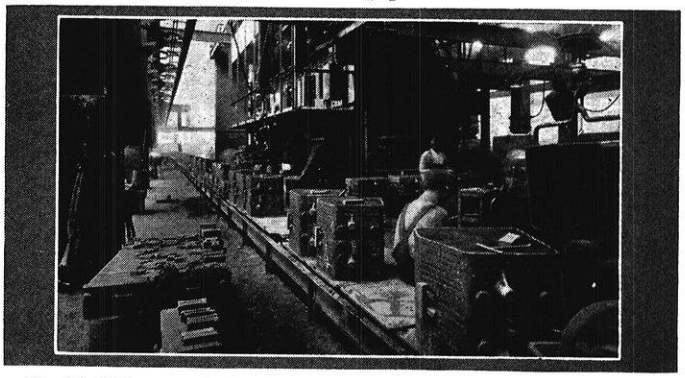
In the meantime it seems profitable to examine a third theory, offered in direct explanation of what is above referred to as viscosity. It proposes a mechanism for the transformation of energy from vibration of the bar to vibrations of the atoms without the supposition of violent impacts between atoms resulting from large relative motions. This mechanism makes use of notions from the theory of mechanical vibrators. A line of particles, each vibrating about a fixed position in the solid, is regarded in terms of the simplified analogy of a string of beads, in which each bead is free to move about a position determined by its attachment to the string. The purpose of this consideration is amply fulfilled by regarding only those motions of the beads which are transverse to the direction of the string.

A string of beads can vibrate transversely in several ways. These ways of vibration are called its "normal modes", or its "fundamental" and "harmonics". The frequencies of these harmonics increase with the number of nodes in the vibrating string and the mode of highest possible frequency is that in which there are as many nodes as beads. It is apparent that two adjacent beads move nearly alike at the low-frequency harmonics, with greater velocity

Setting the Pace *in* Automobile Assembly



Spray-painting automobile springs on Rex Trolley Conveyor in Studebaker Corp. plant.

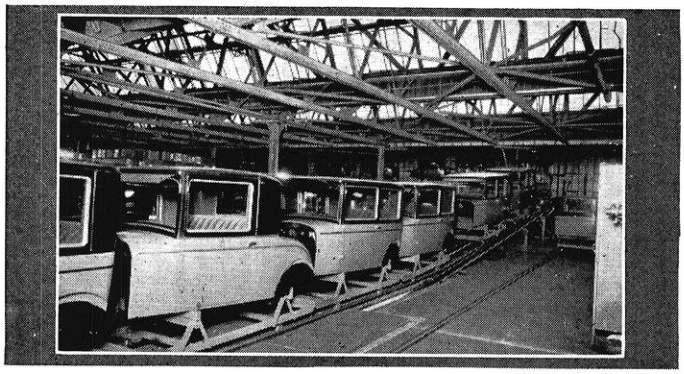


Rex Mold Conveyor in foundry of Studebaker Corp., South Bend, Ind.

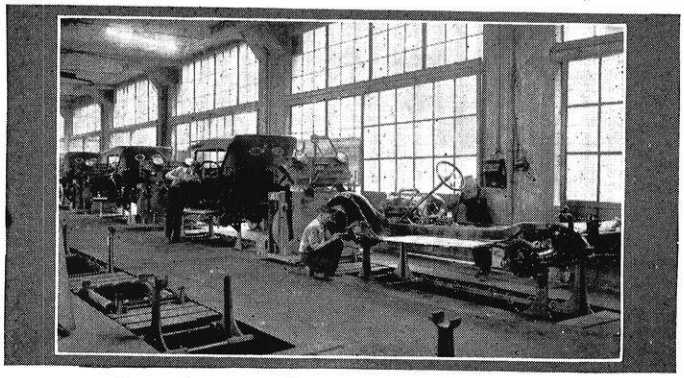
THE enormous output of automobiles per working day in America's Automobile Factories is an outstanding accomplishment of American Engineering Skill and Enterprise.

The Automobile Industry has set the pace by adopting manufacturing methods and equipment to meet new demands for greater output and lower manufacturing costs.

Considering these facts, it is significant that America's Largest and Foremost Automobile Manufacturers are using Rex Progressive Assembly and Mechanical Handling Equipment, manufactured by the Chain Belt Company.



Rex Conveyor transporting bodies in a Chevrolet Motor Co. plant.



Successive steps to final assembly on Rex Conveyor.

Rex Mechanical Handling Equipment has found its place in the foundry, in the shops and on into the assembly plant. It is contributing to lower manufacturing costs in automobile production by: saving floor space, increasing output, controlling mass production, reducing direct and indirect labor charges and labor turnover, and improving the quality of the product.

Rex Conveyors are serving the industry that interests you. Information on any phase of this equipment will gladly be sent to anyone interested.

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relative to each other at higher harmonics, and with maximum relative velocity at the highest harmonic.

When, as with a line of particles composing a solid, these "beads" are exceedingly numerous, there is a correspondingly large number of possible modes of vibration. Vibrating at the fundamental and at low harmonics, trains of adjacent particles move very nearly alike. This collective motion constitutes a bulk motion of the material, generally at an acoustic frequency. Vibrating at high harmonics the line of particles has many nodes and the vibrations have very high frequencies, far above those of the acoustic range. In these modes moreover adjacent particles are moving rapidly with respect to each other. Vibration in these high modes may be regarded as thermal vibration of the particles — as heat in the accepted sense. The frequencies of these thermal vibrations in solids are of the order of 10^{13} cycles per second and correspond to the frequencies of the infra-red or heat rays of the light spectrum.

Viscous dissipation, then, is a phenomenon in which the acoustic modes of vibration, excited when a solid is struck, gradually feed their energy into the thermal modes. It is assumed that energy is at all times associated with all possible modes and is distributed between them according to some law. After the amplitudes of the lower modes have been augmented by a blow or drive of any kind, those amplitudes decrease gradually and the amplitudes of the higher or thermal modes increase until the energy distribution among the various modes is again stable. Indeed the rapidity of decay of the ringing sound of a bar when struck is a measure of its viscosity.

In an ideal string of beads, and in a hypothetical solid fully obedient to the elementary laws of elasticity (Hooke's Law), any of the possible modes may be independently driven in such a way as to leave the other modes unaffected. To account for the feeding of energy from lower to higher modes which is actually observed in viscous dissipation, some type of non-linear coupling between these otherwise normal modes of vibration, a coupling which is non-existent in the hypothetically ideal solid, must be supposed to exist. The determination of the nature of this coupling and of the law of stable energy distribution awaits the results of quantative experiment and the precise development of a theory.*

Experiments are now being conducted in these Laboratories, in which a bar of the solid under study is driven longitudinally at its fundamental frequency and at a low amplitude. The driving energy is continually supplied at a rate which maintains a vibration of constant amplitude. Under these conditions the measured power supplied is equivalent to the viscous dissipation. The technique is difficult because of the necessity for accurate measurement of very low vibration amplitudes and power inputs. Coefficients of viscosity thus obtained for annealed aluminum are plotted against amplitudes (strains).

*It will be realized that the foregoing descriptions are based on the concepts of what is now called "classical" or "Newtonian" mechanics. These are undoubtedly inadequate as a basis for a quantitative theory for the same reasons that they do not apply to such properties as specific heat and radiation.

Though measurements of viscosity are still meager and theories of the viscous mechanism are incomplete, attention to the phenomenon is bringing progress. A time can be imagined when theory and measurement will together make possible the design of apparatus to a new degree of precision. This will be especially valuable with apparatus whose utility is dependent on the internal constants of its materials.

GEOPHYSICAL EXPLORATIONS

(Continued from page 205)

The other principal electrical method also involves the measurement of surface potentials, these now being due to power electrodes driven into the earth and maintained at various potentials by connecting them to the terminals of a battery or generator. These power electrodes commonly take two forms — line electrodes or point electrodes. When line electrodes are used, two rows of metal stakes are driven into the ground and all of the stakes of one row are connected together and to one terminal of the battery or generator; the stakes of the other row all being connected to the other terminal. The electric current then flows from one line to another. Only an exceedingly small fraction of the total current passes directly from one line to another along the surface of the ground, the remainder going along the curved paths, a considerable proportion of the current penetrating into the ground to depths two and three times the spacing between the line electrodes.

This point electrode method has been used in a great variety of circumstances. It is applicable to determining depths to bed rock, depths to the water table, and depths and thicknesses of horizontal strata of various sorts, as well as to locating lenses or globular masses of conducting material. It is particularly suited for stratified structures, but these need not be horizontal. In fact, the theoretical problem is practically the same, whether one has a horizontal layer or a vertical dike.*

3) *The Electromagnetic Method*

One should note that the magnetic and the electric methods utilize different physical characteristics of rock or mineral. The success of one method depends on differences in magnetic susceptibilities; the other on differences in electrical conductivity. When one shouts down to the ore, he must be careful to ask questions that are suited to the intelligence of the particular ore being sought. One characteristic of the electromagnetic method (which method we will now consider briefly) is that its questions and answers do not depend on one single electrical characteristic but rather on several. This is both an advantage and a drawback. When one shouts out a question in five languages, there is, to be sure, a good chance that some one will understand and reply; but there is also a good chance that one will get several simultaneous, and hence confused, replies.

The electromagnetic method is not one that lends itself well to simple explanation. The sending device is usually a coil or loop antennae, a good deal like those sometimes

*For further informaton concerning the electrical method, see W. Weaver, Certain Applications of Surface Potential Methods; American Institute of Mining and Metallurgical Engineers, Technical Publication, 121.

used in radio. The receiving device is similar to a radio receiving set. Through the sending coil is passed an alternating current. This alternating current sets up, for very considerable distances from it, both an electric and a magnetic field. These fields penetrate the earth, the effective depth of penetration depending on the strength of the source, the frequency of the alternating current, and on the electrical and magnetic properties of the earth and rocks. Due to these penetrating fields there are induced, in the earth and in all bodies present, electric currents, magnetizations, and electric polarizations. Thus the total effect at any point is due, in various parts, to the electrical conductivities, the magnetic susceptibilities, and the dielectric properties of the earth and rocks. There are, also, very many things that one can and should measure with his receiving instruments before he can hope to understand the message the hidden region is trying to send. One can measure the magnitude and direction of the electric field and of the magnetic field; he can measure the phase difference between these two fields, at various points; and he can observe the dependence of these quantities on variation of the frequency of the alternating current.

4) *The Gravitational Method*

All of the methods so far considered make use of the fact that various rocks and minerals have varying electrical properties. The gravitational method, as one might expect, has nothing to do with electrical effects, and depends solely upon density. The gravitational method makes use of almost unbelievably delicate instruments, called torsion balances. In essence, such an instrument is very simple. Two equal masses m and m′ are swung, at different levels, by a very fine wire and aluminum rod system. A heavy mass below this torsion balance and on the side towards the reader attracts the lower bob more than the upper (simply because it is nearer the lower). This difference in attraction results in a torque which turns the rod and mass system until a counter-torque is developed in the wire suspension. In this way regions of sub or super-normal density below and to one side of the balance cause deflections of the suspended system. It should be emphasized that this instrument does not measure gravity, as does a pendulum, but rather the *horizontal gradient* of gravity. Such instruments, although they are sufficiently rugged to be used in the field, have been so cleverly developed that they rank with the most delicate known to modern physics.

The gravitational method offers a fruitful field for research, both along instrumental and theoretical lines. The basic theory is more simple than that of any other method, but there are important and difficult unsolved problems in connection with interpretation of data and elimination of surface effects. In the year, subsequent to 1923, definitely three and possibly five salt domes were discovered, in the Gulf Coast salt dome district, by this method. It is claimed that, by unaided geology, only five domes had been discovered in the preceding fifteen years.

5) *The Seismic Method*

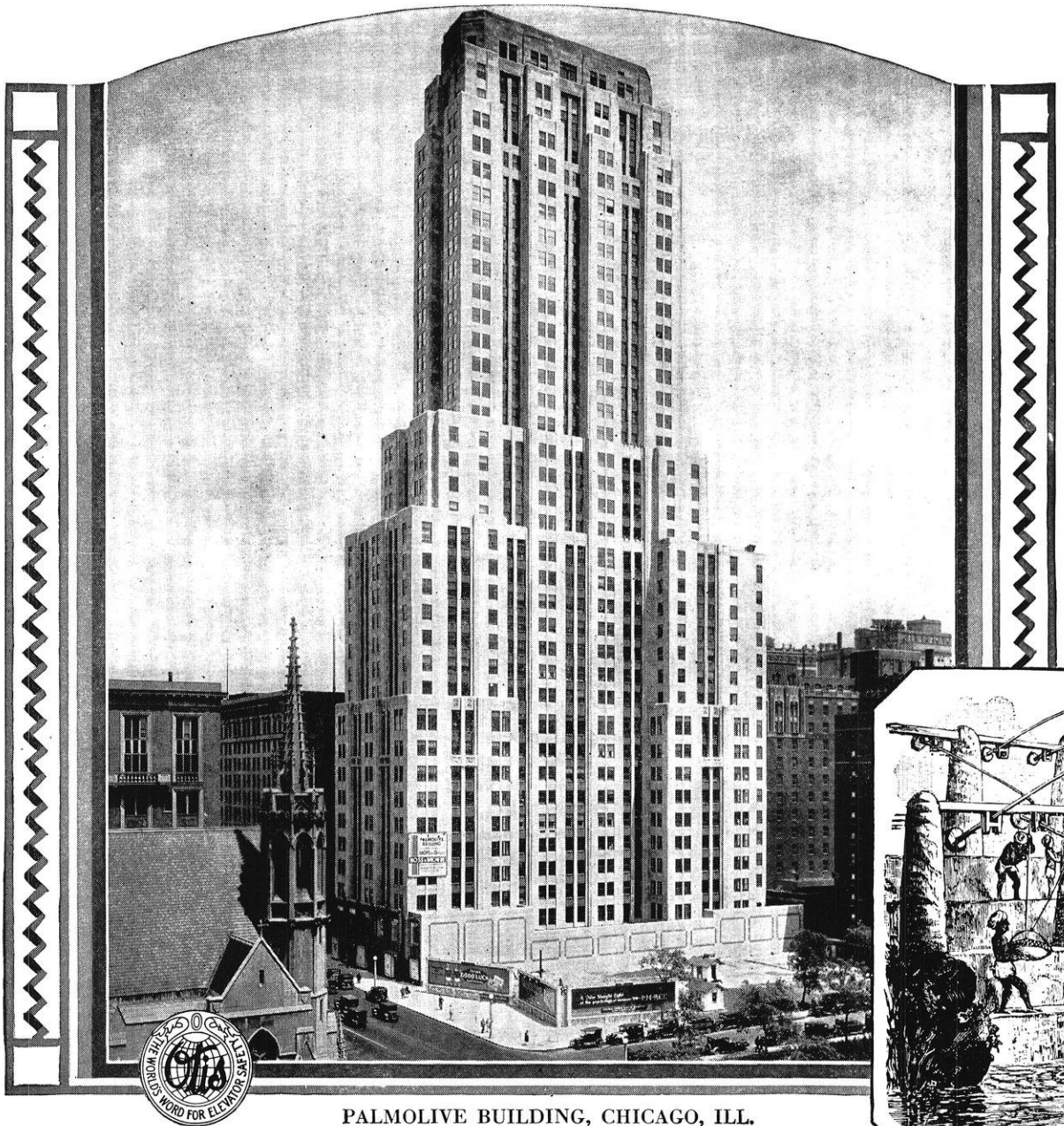
We turn now to the last of the five methods, the seismic. In this method a powerful source of vibrational waves is

obtained by exploding a buried charge of TNT. These waves are somewhat like the electric currents flowing between power electrodes, in that the vibrational waves also travel on curved paths, penetrate to very considerable depths, and eventually emerge at the surface. These waves are received by seismographs, entirely similar to those used to record earthquakes. These wave messengers are thus sent down, and return to give us their messages. And we draw our inferences chiefly from the time at which the messengers return to us; for the speeds with which they travel depend on the densities and elastic properties of the materials through which they have passed. The seismic method has been used chiefly in oil work, although it has also been used, in Sweden, to determine depth of overburden. The seismic method depends on several mechanical properties of the rocks, rather than merely on density, as does the gravitation. Unfortunately we have meagre data concerning the Young's modulus, bulk modulus, shear modulus, and Poisson's ratio for earth, rocks, and minerals, and the theoretical aspects of this method are by no means complete.*

1) *The Modern Hazel Wand*

It was remarked, in the introduction, that earth-physics is an old science. The attempt to locate, from the surface of the ground, the hidden ores, has itself an ancient history. The geophysicist, with his dip-needle, his volt-meter, his radio apparatus, his slide-rule, and his text-book on partial differential equations is but the modern counterpart of the old practicer of the black arts who went about with his forked hazel wand. Many years ago when his international fame rested solely on his ability as a mining engineer, President Herbert Hoover, together with Mrs. Hoover, translated from the Latin a very famous old treatise on mining, written by Georgius Agricola, during the twenty years preceding its publication in 1566. This book contains the first published description of the application of divining rods to the location of ore. Figure 1 shows a wood-cut occurring in this interesting (and now very rare) book. You will observe the various experts going about with their hazel wands, and the shallow trenches which are being dug to test the indications. With a freedom from superstition that seems amazing for his age, and with a scientific clarity that would grace any age, Agricola considers the evidence for and against the forked twig, and concludes, "Therefore a miner, since we think he ought to be a good and serious man, should not make use of an enchanted twig, because if he is prudent and skilled in the natural signs, he understands that a forked stick is of no use to him." We must not hastily judge, however, that Agricola would condemn the modern forked stick. His truly scientific spirit, and the attitude proper for us, are alike indicated by this ancient author's remark: "Since this matter remains in dispute and causes much dissension amongst miners, I consider it ought to be examined on its own merits."

*The reader who wishes to supplement the above very brief treatment is referred to Eve and Keyes, Applied Geophyscs (Cambridge University Press, 1929), and to the volume Geophysical Prospecting, published in 1929 by the American Institute of Mining and Metallurgical Engineers.



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