Essay on field methods and equipment. [between 1920 and 1950?]

Thwaites, F. T. (Fredrik Turville), 1883-1961
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INSTRUMENTS AND METHODS FOR DETERMINATION OF DISTANCES ONLY

General. Instruments which are used for determination of distance only comprise (a) chain and tape, (b) speedometer or odomoter; (c) Micrometer, (d) range-finder; pacing may also (and estimation, and time allowance) be considered under the same head.

~~Chain or tape.~~ ~~CHAIN OR TAPE~~ Chain or tape ~~Des~~ Construction. The most accurate method of measuring horizontal distances is by use of either a chain or a tape. The process of thus measuring is commonly called "chaining" although the use of chains is nearly obsolete.

no ¶ ~~Instruments.~~ (a) Chains are generally 66 feet long and contain 100 links. Almost all the old land surveys were made with chains and therefore the geologist must be familiar with them. They were abandoned because of rather rapid wear of the links and the tendency to catch in the brush. (b) Steel tapes can be obtained in lengths ~~from 25~~ up to several hundred feet; 100 feet is the most common. Tapes are free from wear, light and handy, but break easily if kinked. (c) "Metallic" tapes have wires ~~in one direction~~ woven into cloth. (d) Cloth tapes are cheap but soon wear out. (e) Wires or ropes ~~or cloth tapes~~ make fair home-made substitutes ~~afx~~ for the above instruments. Rope or cloth tape must be water-proofed by dipping in melted parafine to which a little beeswax has been added or by dipping in either (a) melted parafine mixed with COLD high test gasoline or by (b) soaking in tallow and washing in an alum solution or by (c) dipping in strong soapsuds and then in an alum solution. Necessary auxiliaries are pins or stakes, and a plumb bob.

Adjustment. The only adjustment of tapes and chains is to compare them from time to time with a standardized tape. On the old land surveys this appears not always to have been done for many chained distances are now found took long.

~~Chain routine~~. Use First examine the tape or chain and see where the ends are marked; some have the 0 at the end of the handle, others have it some distance from the end, while engineers tapes usually have an extra foot at one end for use in measuring fractions of a foot. It is best to have the 0 end of the tape foremost in measuring. The pins or stakes must be counted; it is best to use either 6 or 11. They must be easily driven into the ground and should be conspiciously marked so that they can be seen in grass or brush. On hard ground a piece of chalk or a colored pencil is needed. Remember that all distances must be measured horizontally, not along a slope. The following routine should be observed:

(1) Mark both ends of the line so that they can be seen.
(2) The head chainman pulls out the tape until the rear end has nearly passed the pin or stake at the beginning of the line. A pin or stake from the regular set must be placed as well as the signal that is to be left.
(3) The rear chainman then calls "chain" and the head chainman faces about and gently pulls out the tape until it has the rear end on the mark and is both taught and level so far as can be judged with the ~~ex~~ eye.
(4) The rear chainman motions the head chainman over to one side or the other until the tape is on line and is straight.
(5) In case the tape cannot be held level the head chainman comes back to such point on it as can be so held; here is where the plumb bob comes into use.
(6) When all is ready the rear chainman calls "stick" and the head chainman then plants the pin or stake and when it is in place calls "stuck".
(7) In case the end of the tape has been marked the rear chainman pulls the pin or stake, the head chainman goes on and the above is repeated until all the pins in the hands of the head chainman have been used. The number of pins in the hands of the rear chainman then measures the number of tape lengths that have been measured. The pin in the ground is never counted.
(8) In case a part of the tape was used it is left in place while the rear chainman moves up to the point marked and then the remainder of the length is measured. Every time the tape is "broken" a pin must be passed to the head chainman in order to keep count only of full tape lengths.
(9) At the end of each section which used all the pins they must be counted to see that none have been lost for such loss would cause a big error. ~~in counting.~~

If no assistant can be secured one can measure with a tape by hooking one end onto a pin or if this is impossible weighting it with a stone. Such work is very slow. ~~Insert next page~~

no ¶ ~~Chaining on very steep slopes.~~ On very steep slopes it hardly pays to break chain. It is better to hold the chain or tape on the ground and either (a) measure the angle of slope or (b) level the line to obtain differences in elevation of each mark. If the former method is used horizontal distance = apparent distance multiplied by cosine of angle of slope. If the second method is employed let b = horizontal distance, c = apparent distance, and a = difference of elevation. Then b = square root (c+a)(c-a)

Transfer

Uses. The geologist uses a tape for (a) measuring a base line for determining length of step in pacing, (b) measuring base lines for plane table surveys, (c) retracing land lines, and (d) mapping on a large scale in brushy country.

V Cautions. Every line that is chained must if possible be measured in both directions. The most dangerous error is failure to count the number of tape lengths correctly. Even tension, level tape, and good alignment are important but can scarcely cause as big an error as this. Whenever the tape is to be put away it must be wiped dry and clean. To roll a tape without a reel following this method: (a) draw in the tape in five foot lengths placing each mark the same way up over the preceeding mark, (b) this brings the tape into such a form that each length has a bend in it so that the whole coil shows a tendency to form a figure eight; (c) tie the ends of the tape, (d) allow the coils to form the figure eight and then (e) grasp the opposite sides near the crossing and force them out into an open O form, (f) by twisting the sides in a way soon learned by practice cause the tape to fall into a small coil as though it had been wound on a reel. In opening the tape reverse the above process and pay out onto the ground in 5 foot lengths. AVOID KINKS in handling a tape. Repair outfits can be purchased or a tinsmith can solder the break.

~~xxxxxxxOtherxinstruments.xxOtherxinstrxmentsxforxmeasuringxdistancesxonly~~

~~includex(a)xspeedometersxandxodometersxofxvariousxtypes,x(b)xxx~~

Other Instruments

Speedometer and odometer. Speedometers and odometers depend upon mechanical counting of the revolutions of a wheel. Ordinary automobile speedometers are useful in small scale surveys on roads which are fairly straight. The error ~~accuracy~~ is ~~within~~ 10 per cent at a maximum and is generally less than ~~within~~ 2 percent. Types which show tenths of miles are essential. In using it is necessary to have checks on distance at intervals of not over a few miles. At each check, or point of departure, it is best to reset to 0. Odometers which count the number of revolutions of a wheel have been made but are not common. In the old horse days ~~of horses~~ revolutions of a wheel were counted by tying a rag ~~handkerchief~~ to one of the spokes. The circumferance was measured with a tape. All measurments with wheels are subject to error on account of slopes amd those with pneumatic tires are affected by degree of inflation and by different makes of tires of varous dimensions.

Micrometer. The Canadian Survey uses the Rochon micrometer for measuring distances over water and in other difficult situations. This instrument requires the use of a rod of fixed length with targets at each end. It is a small telescope with a special prism inside; ~~divided objective lens~~. Movement ~~of half~~ of this ~~lens~~ makes the two ends of the rod appear to coincide and the reading is taken from a scale on the side ~~dial~~ ~~on the nut which is turned~~ ~~micrometer screw~~. A table or a curve gives the distance. As these instruments are not obtainable in this country no description of their care and adjustment can be given. They are accurate for distanes up to 3200 feet with a 6 foot rod.

Range finder. Military range finders have recently been offered for surveying purposes. These operate by having a short base line of a foot or two length from the two ends of which a trinangle is formed with the object sighted as the apex. A rod is unnecessary. ~~This~~ The small variation in angle with different distances is measured by turning a prism with a micrometer screw. ~~No details~~ The accuracy is about 3% at the limit of range, about 1000 feet. ~~are available as to the accuracy, care, adjustment, and use of these instruments.~~

~~Meto~~ Methods without instruments

Pacing. The measuring of distances by pacing dates from the most ancient times; the Roman mile was desiggated as a "thousand paces" or strides as we now define them. The use of pacing is sufficient for most geological work and in many places is the only method possible with the available funds. It is, however, not very accurate unless frequent checks are ~~avialable~~ present. Pacing depends for sucess upon striking an even gait up hill, downhill, through brush and swamps, etc. As no attempt to step a specified distance is ever sucessful for long~~, therfore~~ it is necessary to determine the length of step normally used by each individual.

Definitions. A pace is defined as the distance ~~stepped~~ covered by [redacted] one step. A stride is defined as the distance ~~stepped~~ covered by ~~each foot~~ two steps, that is the ground distance from the [redacted] mark of one ~~tax~~ foot to the next [redacted] mark of the same foot, that is two paces. A talley is defined by geologists as 1/20th mile ~~or~~ (about 100 paces or 50 strides with most people); by woodsmen it is defined as 1/16 mile or ¼ of a "40" (¼ mile).

Determination of length of ~~stride~~ pace. The mean length of pace must be determined by walking several times over a course of known length laid out in country like that to be encountered in actual work. It is best to divide this line so as to included walking of different degrees of difficulty and to determined each portion separately. It may be that the departures from the average will be found to be so large that a correction must be applied for the different conditions. Nearly everyone steps farther on a good road than on grass and in swamp the pace is always shorter than anywhere else. It is very desirable that the determination be made with the outfit and clothing to be worn in the field for this may indluence the result.

Counting. In good going either paces or strides may be counted; the latter is preferred by many because it lessens the numbers to be remembered. In case strides are counted step off with the left foot and count each time the right foot strikes the ground. When the distance to be measured is long it is very easy to drop 100 paces or strides causing a big error. ~~In the~~ By Lake Superior ~~country~~ geologists the mile ~~was~~ is divided, into 20 tallies and the number of paces or strides for this distance under different conditions ~~was~~ is determined. Each tally ~~was~~ is recorded at its end which lessens this danger. In very bad going, as in swamps, it is best to count paces rather than strides for the reason that each step is a~~n~~ marked effort and some times it is only possible to advance by single steps pulling ~~the other~~ a foot ~~only~~ up to the advanced one instead of passing it as in normal walking. While counting soon becomes a habit it is very hard to do geological work and pace at the same time; best results are obtained if one has little else to do but pace. It is essential to keep to the line chosen and not go around obstacles to too great an extent but it is permissable to offset at right angles to the line to a parallel line when ~~the~~ going ~~is~~ ahead would have been impossible or very difficult. Some geologists have recommended counting only every fourth stride by saying 0,0, 0, 1; 0, 0, 0, 2, etc. Thus a very long distance may be counted without having to set down the hundreds. Count of hundreds of paces, hundreds of strides, or of tallies may best be taken by use of a notebook. Tally registers may also be used and special belts for counting tallies have been devised.

Estimation. Geologists as well as soldiers have to measure many distances simply by estimation. This is something in which practice makes perfect. It is best accomplished when objects of known size can be seen and when none of the intervening surface is concealed as it is when looking over a ridge.

Practice 100 ing at distances that have been measured. The writer has known of ridiculous mistakes from taking ravens for crows and ponies for horses! On railroads it is difficult to pace. Measure the length of rails or the distance between telegraph poles; the latter is generally 2 chains or 1/40th mile but may be more or less than that. Telephone or power line poles may be used in the same manner. Mile posts on railways and on some highways are good checks. Fence posts are generally 16 feet apart and can often be used in estimating distances.

Time allowance. Use of time of travel as a measure of distance is desirable (a) in work on horseback, and (b) in working from a boat. It is assumed that the speed is kept as uniform as possible.

General. Instruments commonly used by geologists for measurment of differences of elevation only comprise (a) hand level, (b) aneroid barometer, (c) engineers level, (d) hyposmeter

Hand level. Construction. The hand level is sometimes also called the Locke level. It consists of a tube on the top of which is fixed a small level vial. The observer holds the instrument in the hand and on looking through a small apeture in one end of it sees the bubble of the level in a mirror. ~~placed beneath it.~~ The mirror is so arranged that the image of the bubble covers half the field of view. Distant objects are seen without magnification in the other half of the field. As it would be impossible to see distant objects with the same focus of the eye as would be required to look at the nearby bubble a half of a convex lens is placed in front of the mirror; this slightly mahnifies the bubble. Some makes of instruments have this lens movable to allow of focusing it to suit different eyes. Telescopic hand levels are made but are not in common use.

Adjustment. Aside from focusing the eyepiece there is only one adjustment on a hand level; this is to make the line of sight horizontal when the bubble is centered. To do this a level line must be used. This may be determined in one of three ways: (a) the surface of a calm lake or the horizon of a large body of water, (b) the floor of a large building, and (c) the use of the level itself. The first two are self explanitory. The third method is as follows. Stand exactly midway between two stationary objects on fairly level ground. Sight to each in turn and mark the points where the line of sight strikes. These marks will be on the same level as any error in the instrument is neutralized by the position midway between the marks. Now go to one end of the line and place the instrument on the same level as one of the marks and adjust it to read level when the other mark is sighted. Instruments of different makes adjust in two different ways. Gurley instruments have small screws at each end of the level vial. Tighten one and loosen the other until the wire is properly placed. Other makes of instrument have a screw at one side of the front end. Loosen this and slide the box which carries the wire in or out until desired place is found.

Use. The hand level may be used to (a) compare the elevation of the observer with that of a distant point , (b) find elevations by the use of the number of times the observer ascends or descends his own heigth, (c) level a line with aid of a rod, (d) make sections of horizontal rocks. In use the instrument is tilted until the bubble is divided evenly by the wire; this determines the line of sight to objects on the same level as the observers eye. The accuracy of determination is goverened by (a) the sensitiveness of the level, and (b) the width of the wire ~~or other object~~ marking the line. Sights of more than a few hundred feet are of little value with most instruments.

Leveling alone. First measure the height of your eye to the nearest tenth of a foot (not inches) above the ground as you ordinarily stand. This can easily be done with a surveying rod. Leveling can be done either going uphill or downhill. In the case of the former stand at the lower end of the line to be levled. (a) Sight with the level to ~~xxxx~~ the point which is on the level of your eye; ~~xxxx~~ note some peculiarity there which will enable you to recognize this spot and then count "one". (b) Walk to the spot noted if possible without loosing sight of it; repeat the process and count "two." (c) Continue until the highest place is reached. (d) If the last sight falls above it measure the excess in any praciticable manner. (e) Now multiply the number of counts by the heigth of your eye and subtract the excess; the result is the difference of level. If it is necessary to go downhill this process is reversed in that you must mark the place your feet were and then place your eye on the same level for the next shot. It is obvious that this method can only be used (a) in fairly open ground and (b) where sights are not too long to permit recognition of small objects like clods of earth. On ordinary roads it is quite accurate and may be depended upon to yield resutls within a foot or two of correct in vertical distances of several hundred feet.

Leveling with assistant with or without a rod. It is evident that the foregoing method could be applied more accurately if the observer has an assistant who marks the spot sighted to. If the ground is ~~xxxxxx~~ either (a) obstructed with grass or brush or (b) so level that points on the obervers level are too distant for recognition then a rod is needed. With so crude a line of sight it is not necessary to have an engineers leveling rod; any straight board or stick will do. ~~Mark on it the~~ Divide it into feet . A rag on a short stick will serve as a target. Sights should never exceed ~~xxxxxxxxxxxxxxxx~~ two tallies in length (528 feet). Sights back to a point of known elevation are called Backsights (B. S.) Sights to a point where the elevation of the bottom of the rod is not yet known are Foresights (F. S.) Enter all notes in following form.

Station No.	B. S.	H. I.	F. S.	Elev.	Remarks.

H. I. stands for height of instrument, in this case elevation of observers eye. Backsights are + and Foresights are -. Giving attention to these signs the notes must be computed at once in the field. An office check on computation is that the algebraic difference of the sum of all back sights and the sum of all foresights is the net difference of elevation ~~at~~ between the ends of the line.

Section making. In measuring sections of nearly horizontal rocks the geologist finds many uses for the hand level: H~~e uses it~~ (a) to connect together different sections, ~~as well as~~ (b) to measure the thickness of thick beds of rock, and (c) to check measurments of the total thickness of a number of beds each measured with the hammer handle or foot rule.

Cautions. Do not expect the hand level to yield accurate results at great distances. Do not carry it without its case ~~if it is~~ in the same compartment with hard objects or in the hip pocket. Set the adjusting screws up firmly and there is little reason to expect that it will get out of adjustment very soon. The ~~f~~ commonest source of error is keeping incorrect count of number of shots. Always follow exactly the same routine in counting.

Barometer.

General. The pressure of the air decreases with altitude and ~~it~~ is measured with a barometer. Barometers are of two kinds, mercurial and metallic or aneroid. ~~The~~ Mercurial barometers are ~~most~~ more accurate but their size and delacy render use by geologists in the field almost out of the question. Aneroid barometers alone are considered here; they are frequently called simply "aneroids".

Construction. The aneroid barometer consists of (a) a metal ~~case~~ box from which the air has been partially exhausted, (b) a system of levers and a chain, ~~etc.~~ to magnify the movement of the cover of this box as it changes with the pressure of the atmosphere, (c) a scale of inches giving the same readings as a mercurial barometer, (d) a scale of feet for reading differences of elevation, all enclosed in a case. In ordinary aneroids the readings are indicated by a long hand which revolves but in the new Paulin instruments a spring is used to force the cover of the box to a certain normal position and the amount of pressure to produce this is registered on the dial. These instruments are much larger and more expensive than the ordianary ~~type~~ type. although tests indicate that they are only slightly more accurate

BA

<u>Adjustment</u>. The only field adjustments of an aneroid are (a) to move the foot scale to correspond to changes in local atmospheric pressure, and (b) to adjust the pointer so that its readings on the inch scale agree with those of a mercurial barometer. The first requires no special explanation; grasp the outside of the face and turn it to desired reading. Check several times. The second adjustment is made only at the begining of the season. Take the aneroid to a good mercurial barometer. Read the latter by ~~first~~ (a) adjusting the screw at the base until the mercury in the well just touches the pointer; (b) ~~then~~ setting the vernier at the top so that its base is just tangent to the top of the mercury column in the tube; (c) reading the heighth of the column in inches and the temperature of the instrument; (d) from a table of temperature corrections for the particular barometer used correcting this reading. Then take the aneroid and with a small screw driver adjust it by means of the screw seen through a small hole in the back until its inch scale reading agrees with that of the mercurial. This is the only use of the inch scale on the aneroid.

Use. ~~Ordinary barometers are read on the foot scale only~~. After reaching a station it is best to wait a few minutes before reading since there is a lag in the adjustment of the instrument to the changed pressure. Generally this need not delay work since there are other things for the geologist to do. Gentle tapping or shaking will hasten the adjustment. Note that the position of the instrument affects the reading; it is essential that the instrument be treated exactly the same and held in exactly the same position every time it is read. This causes a "personal equation" that affects the readings. Instruments generally have individual characteristics of their own. Some prefer to settle the instrument by tilting it before reading. The foot scale is movable and may be set so as to make the needle read correctly. It is sometimes desirable to read with only one eye open as the needle is not very close to the scale. You need not hold the instrument on the ground. Read always at same heigth above the ground. ~~Never use a hand lens to read with; the instrument is not worthy the trouble and the big errors will be forgotten if too great refinement is sought.~~

Correction of readings. Were barometric readings dependent only on elevation field work with the aneroid would be easy. Unfortunately the atmospheric pressure is ~~always~~ unstable; temperature, moisture, as well as storms, ~~both general and~~ ~~localse~~ both large cyclones and local thunderstorms, cause great and sometimes sudden changes. Any system of correction must take the element of time of observation into account. A watch is always a necessary adjunct to a barometer. Corrections may be made in two general ways (a) by keeping a record of changes of atmospheric pressure at a fixed point either by a self-recording instrument or by an observer, and (b) by comparing the aneroid readings with the correct elevations of points visited during the day. Aside from cyclonic storms there is a normal diurnal change. From dawn to 9 or 10 A. M. there is a growing + correction; after that hour this decreases until it becomes 0; then an increasing - correction commences with its maximum at 4 to 6 P. M.; after that the correction decreases throughout the night. Authorities differ as to whether ~~cxx~~ to the foot scale to read correct elevations when work is started every morning or to set the 0 on that scale to 31 on the inch scale and leave it there. The writers objection to the latter plan is that while it keeps the corrections all - the figures are awkwardly large. Another error that is peculiar to aneroids is failure to record differences of altitude correctly.

<u>Correction by use of stationary instrument</u>. The simplest means of correction of aneroid readings is the use of a recording barometer or barograph that is left at a point of known elevation not too far removed either vertically or horizontally from the ~~probable location of~~ field work. This instrument is an aneroid so constructed that its hand draws a line on a graph which is wrapped around a cylinder that is driven by a clock. Objections to the method are (a) the two instruments do not ever record changes in atmospheric pressure exactly the same, (b) the pen of the barograph sticks and makes an uneven curve, (c) changes in atmospheric pressure due to storms are not the same at all locations or all elevations, this error increasing in rough country and in rapid travel over a large area, (d) the instrument makes a curve which is rather small scale for accurate work, (e) if left in a hotel room the instrument may be tampered with. When a barograph is not obtainable an aneroid may be left at one point where someone can read it at least once an hour throughout the day. Objection to this method is the extra labor and the introduction of another personal equation. In order to correct field readings by these methods it is necessary to construct a correction curve ~~which~~ to correlate readings of the instrument used in the field with that used in camp. This involves considerable time in reading the two instruments side by side and when this data has been secured through a wide range of pressures then additional time is needed to correct the curve of the stationary instrument to agree with the field instrment; this has to be done every day. Other faults are eliminated by using two stationary instruments, one above and on one side ~~of the area~~ where work is being done, and the other below and on the other side of the area.

Field readings are then corrected by the formula: A:B::C:D where A is the apparent difference of elevation of the two stationary instruments as determined by their readings, B is the real difference of elevation of the stationary instruments as determined by leveling, C. is the apparent elevation of point of observation above lower stationary instrment as determined by readings, and D is the true value of the ~~above~~ last quanity. This ratio could easily be worked out with the aid of a slide rule but it cannot eleminate instrumental differences. It hardly seems suitable for geological work unless other methods are not feasable.

Correction by checks. Correction by checking on known elevations may be made by changing the foot scale at every point of known elevation; elevations at intermediate points can then be corrected in proportion to the elapsed time. This method is applicable only when the times involved are short, as for instance in measuring the elevations of ~~xxxxxxx~~ contacts from nearby bench marks. It is of little value for all day work. A much better way is to leave the foot scale alone(after setting in the morning if desired) and to construct a curve of corrections. Time is shown horizontally and departure from conditions in the morning in feet is shown vertically. From this curve, which should be a smooth one, corrections for observations at other times can be taken. It is evident that if many checks are present in an area and they can be visited at fairly regular intervals through the day the method is very accurate. An improvement on this method is that of Lahee who uses comparison of readings taken at the same point during the day to aid in shaping the curve between checks on points of known elevation. Choose a vertical scale of not over 100 feet to the inch. Plat first the corrections determined at points of known elevation. Then above the place ~~abx~~ where the curve will lie plat ~~abxxt~~ an assumed correction for each time that the same point (other than a point of known elevation) has been visited during the day. For instance if the reading ~~correction~~ is 10 feet less at the time of the second visit the second correction at this point will be made 10 feet less than the first. Then join these points with straight lines; these lines will indicate the average slope of the main curve between the times concerned. Now use these as an aid in forming the true curve of atmospheric change for that day. Another method of applying the same method of "cross checks" is to assume a curve to the first time a cross check point is reached. Then look ahead to the time it is revisited and compute the difference in readings. Next plat a point for the curve at the time of revisit so placed that it will yield the same elevation as did the first correction. It may be necessary later to revise the curve to make it as smooth as possible but in every case it must be so drawn that the same elevation is obtained by correcting all the readings at the same station. This method may even be used when there are no checks on known elevations except in the morning and at night. When the change in pressure throughout the day is slight it is sometimes possible to estimate the corrections without drawing a curve but the practice is bad. Poor instruments do not yield smooth curves and this serves to distinguish them. Lahee's method is the best known for geological work but like other methods has the disadvantage that the results are not known until the days work is over. Results need only be computed to nearest five feet.

Notes. Notes for any form of aneroid work may be kept ~~in the~~ as follows ~~form.~~

Station	Time	Reading	Correction	Corrected elevation

Times need only be recorded to nearest 5 minutes. Care should be taken to mark plainly (a) every visit to a point of known elevation and (b) to mark every point on which more than one reading was obtained during the day. (c) It is also a good plan to indicate the stations than have been determined on other days.

Data for checks. Checks for aneroid readings may be obtained from (a) U. S. G. S. bench marks and road corner elevations, (b) railway station elevations mainly given in U. S. G. S. Bull. 274, (c) ~~railway~~ profiles which can be obtained from the chief engineers of railway companies or inspected either at their offices or at division engineers offices, (d) highway surveys, not all of which are given in sea level elevations as are ~~many~~ most railway surveys, (e) river surveys or elevations of lakes, (e) levels run for the purpose, (f) aneroid elevations taken for the purpose rapidly on days when atmospheric pressure is not changing rapidly or irregularly.

Cautions. Good aneroid weather is most prevalent in the summer months when the ~~change in~~ temperature does not change too much from day to night and when winds are light. High winds quite generally denote the passage of a cyclone with consequent rapid variation in pressure. Broken or flecked ~~zk~~ clouds (mackrel sky) indicate an on-coming "low" or increasing - corrections. North or northwest winds mean + corrections. South and east winds mean - corrections. Rapid increase in temperature indicates - corrections; rapid decrease in temperature the reverse. Approach to bodies of cold water changes the correction making the barometer useless near to large lakes particularly in the spring. Change in wind directions near to lakes may influence corrections. A blow against an aneroid will cause a sudden and permanent change in the correction. Aneroids must be protected from too violent jars. They should be carried on the belt or in a coat or shirt pocket, never on the absurd shoulder strap furnished by the makers for reasons unknown. Don't jump off banks or over fences while carrying an aneroid. Always use the same routine in reading. If the place of reading is reached after an abrupt descent or ascent wait a few minutes before recording; if you have traveled at essentially the same elevation for some time a wait is less needed. Do not try to read or to corect closer than the nearest 5 feet. Do not take or ship an aneroid higher than the limit of the scale indicates. Do not expect as good resuts on stormy days as on fine ones for the more rapid the change in correction the more difficult it is to estimate its true value. The requisites for good results are (a) good weather, (b) a good instrument, and ~~(a)~~ (c) experience with the use of that particular instrumant. ~~Do not expect an aneroid to yield results closer than to the nearest five feet.~~ Always check your reading; errors of 50 feet or 100 feet are common mistakes

General. Hypsometer.

~~Hypsometer~~. Explorers in the mountains frequently make use of the hypsometer which measures atmospheric ~~tem~~ pressure by the temperature of boiling water. This instrument is generally beleived to be superior in accuracy to an aneroid but is of little value for geologists.

~~Engineers level. The principle of the~~

Engineers level.

Construction. The principle of the engineers level is the same as that of the hand level but it must be used on a solid tripod since it is much more sensitive. Levels are ~~of~~ two types; (a) the ~~wht~~ wye level in which the telescope shows objects erect and which is detachable from its base, and (b) the dumpy level which generally shows objects inverted and which is firmly attached to its base. Both types are leveled by means of four leveling screws.

Adjustment. First focus the eyepiece so that you can see the wires plainly when the instrument is turned toward the sky and they do not appear to move when you move your eye slightly from side to side.

~~Adjustment.~~ In both ~~kimm~~ types of levles the wires that mark the line of sight are moved by small screws which project through the outside of the telescope. The wye level is adjosted as follows: (a) loosen the telescope in its frame and point the intersection of the wires at a distant definite point. (b) Rotate telescope 180 degrees. (c) If the intersection does not move the instrument is in adjustment. (d) If the wires move use a small steel pin to move them HALF WAY back. The wires are set on a ring which is held by four separate brass screws. Loosen one before tightening the opposite one. Keep trying until desired result is attained with screws set firmly. ~~The dumpy level is~~ (e) now center the bubble with the leveling screws. In using these first loosen all of them and turn them so that one pair is parallel to the line in which the telescope is to be set. Swing telescope

over the other pair and ~~kxxx~~ center bubble; then swing back to line desired and level again thus making the instrment stay level even if swung slightly off line. (f) lift telescope out of its support and replace with ~~other end~~ ends reversed; if the bubble ~~daxxxxat~~ centers again the instrument is in adjustment. (g) if the bubble moves off center bring it HALF WAY back with the leveling screws on top of the tripod and the rest of the way with the nuts at one end of the level vial using an adjusting pin to turn them. (h) check adjustment until is is correct. Dumpy levels adjust in much the same way as a hand level. (a) Set the instrument midway between two firm objects on which the rod can be set and read rod on each in turn with bubble centered. Figure true difference of elevation of the two points. (c) Take the level to one point and set up very close to it. (d) determine heigth of instrument above ~~xxxxof~~ the mark by leveling it and measuring the heigth by sighting backward through the telescope to rod held close to eyepiece, marking point with a pencil. (e) Compute what reading should be ~~if~~ on the other mark if instrument is in adjustment. (f) Sight rod on other point and if reading is not what it should be move wires with adjusting pin until it is being careful to keep bubble centered. The dympy level is more apt to keep its adjustment for a long time than is the wye.

Use. The engineers level is used in the same way as the hand level with the rod. Geologists rarely need elevations closer than to the nearest tenth of a foot so that there is no object in reading the rod any closer than that. The engineers level in the hands of an experienced man is much faster than the hand level in level country since sights up to a half mile can be taken. On steep slopes the advantage is lost since the time to set up for each shot is much greater. On steep slopes from 100 to 200 set-ups in a day is very good work. Much time is saved in setting up by making the plate at the top of the tripod as nearly level as can be estimated with the eye. Avoid standing so that your shadow falls on one of the legs of the tripod. Never touch the instrument while taking a sight. Never complete a long sight without looking back to check the centering of the bubble. At great distances and against the sun it is impossible to see the divisions on the rod and a target must be used. At such distances it is also hard for the rodman to see signals. He must either be provided with field glasses or the instrument man must use a handkerchief to make his hand show. Throwing the handkerchief out to the side means hold position of target, waving in a circle means clamp target, and waving up and down indicates that the sight has been completed. Notes are kept in same way as with hand level and rod.

Cautions. The engineers level is a delicate mechanism and must be handled gently. Be sure the tripod is firm when it is set up. Never go away from the instrument and leave it unprotected; that is when something will knock it over. Never set up on floor or pavement where the tripod might slip. Don't get leveling screws too tight or leveling becomes slow. It is a good plan to keep the total distance of foresights and back sights about equal in order to comsemsate for any possible error in adjustment of the instrument. It takes much practice to be come proficient with the engineers level.

General.

Estimation. A geologist is often called upon to estimate elevations which requires constant practice in looking at known heigths. Feet and inches marked on a hammer handle are very useful in measuring sections but the practice of leveling with a hammer held in the hand outstretched supposedly on the level of the eye is about equal in accuracy to the weighing of the early fur traders who are reputed to have used their hands or feet as substitutes for weights! The mere effort of standing on a slope is enough to throw off anyones sense of level. If elevation is distant heigth can be estimated by comparison with objects of known heigth.

measure one on these on a pencil held at arms length and see how many times that goes into total elevation

Transit.

General. The engineers transit may be used as a level in much the same way as the dumpy level. It can also be used with a stadia rod and differences of elevation obtained by reading the vertical angle. In this case the operation is exactly the same as that of the telescopic alidade and so need not be here given. It is superior to the plane table in being less affected by wind and in being handier to carry, besides which it is harder to put out of adjustment by jolts and jars.

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~~locations are needed or very accuarate elevations are required. The latter is the case in oil work. It could profitably be used to give a control over mapping where no topographic map is available, or where the land survey is unusually inaccurate.~~

INSTRUMENTS FOR MEASURING DIRECTIONS ONLY

¶ ~~Methods of measuring directions.~~ Magnetic compass. General ~~The compass is the commonest method of obtaining directions with reference to the cardinal points.~~ ~~Such~~ Directions are commonly given as so many degrees East of North, West of North, East of South, or West of South. Directions thus described are called "bearings". Sailors formerly used another system of bearings. The liability of error in reading and recording bearings and the difficulty of computing the angles between different bearings have led to the use of "azimuth". Two different systems of azimuth are in use: that of astronomers who divide the circle into 360 degrees clockwise, starting at the ~~xxxxx~~ south and that used on many compasses which starts at north ~~going~~ also clockwise.

~~Types of Compasses~~. construction Most geologists employ the Brunton compass. In this instrument the object sighted is seen by looking down into a mirror attached to ~~the~~ one side of the compass, the line of sight being fixed by a line on the mirror and the center of a slot in a vane on the opposite side of the instrument. The needle can thus be observed at the same instant that the line of sight is on the object. The principal disadvantage is that objects cannot be clearly seen in a mirror and that the instrument is held at a different elevation than the eye so that brush, etc., which does not obstruct the observers vision is troublesome at the level of the instrument. The usefullness of the Brunton for other purposes offsets this difficulty. Attachments for use as a plane table alidade can be obtained The prismatic compass has a card attached to the needle which is read through a reflecting prism and a lens. The object sighted can be readily picked up even if of low visibility since the instrument is sighted by direct vision. Other forms of compass need a support if they are to be read accurately. Some kinds may be pointed at the object while being read much as a gun can be aimed from the hip. Compasses with a card on the needle are less accurate than those without because of the greater weight on the pivot.

Adjustment ~~of the compass~~. The magnetic declination can be set off on many instruments so that they will read true bearings. This is generally accomplished by loosening a set screw which allows the dial to be turned. Care should be taken to see that the declination is set off in the correct direction. If east, the line of sight will be left of the north point and vica versa. If the compass is sluggish the jewell in the needle may be broken or the pivot may be dull, or the needle not magnetized. If possible, send the compass to someone who is used to repairing instruments. The pivot can be resharpened by removing it (it unscrews in all good instruments), placing in a lathe and sharpening with a bit of very fine carborundum cloth on a piece of wood. If the needle is demagnetized it may be remagnetized by rubbing gently from pivot to point on a magnet, each end of the needle being rubbed on the pole which attracts it. and Passed back away from the magnet. Never carry a compass without raising the needle. If possible, store a compass with its needle pointing with the local magnetic meridian.

Declination. All bearings or azimuths read with an uncorrected compass are called "magnetic". In few places does ~~the~~ magnetic north correspond to ~~the~~ true north. The angle between true north and magnetic north is called the "declination". It may be either east or west and any value up to 180 degrees. Lines on a map drawn through points having the same declination are called "isogonic lines." The declination is not fixed in value at any locality. It has a daily variation of less than 1/4 degree. In the United States all east declinations are slowly decreasing and all west declinations are slowly increasing. The change is in most places less than 1 minute a year. Magnetic storms (often accompanied by displays of the aurora) may cause temporary variations. Rocks containing magnetite, iron and steel, and wires carrying direct current all cause local variations.

spell out

Determination of true north. True north or the "true meridian" may be determined in several ways, Of ~~these~~ which the methods best suited to the use of geologists are given. (1) By use of as isogonic chart. Such charts are prepared by the U. S. Coast and Geodetic Survey. U. S. G. S. topographic maps of recent date give the average declination for the date of survey. Coast and Lake Survey charts give the same information and state the annual change. Land office maps also can be used. (2) By taking the magnetic direction of a line known to have been laid out in a definite direction. The true bearing or azimuth from one landmark to another can be scaled with a protractor ~~if the~~ on a map ~~is~~ which is known to be accurate. This value can then be compared with that obtained by direct observation. This is most accurately ~~done on a~~ if the map is on the Mercator ~~map~~ projection.

(3) By observation of Polaris (north star). ~~Methods as described by Hotchkiss, W. O., Bean, E. F., and Wheelwright, O. W., Mineral land classification: Wisconsin Geol. and Nat. Hist. Survey, Bull. 44, pp. 90-94, 1915.~~ The axis of the earth points toward the center of the small apparent orbit of Polaris which rotates counterclockwise. Observations can be made (1) when the star is at the farthest east or west in its

Each revolution takes 23 hours 56 minutes.

path (elongation), (2) when it is on the meridian (culmination), or (3) at any hour provided the time with reference to elongation or culmination is known. The predicted times of culmination and elongation can be determined from the ephemeris secured from makers of surveying instruments. The approximate time of culmination can also be determined by the ~~xxxxxxx~~ general method: (a) relation of other stars to the meridian. Suspend a line from a tree or other solid object about 20 feet from the ground. (b) On the lower end hang a weight. Vibration and swinging can be eliminated by putting the weight in a pail of water. A light so shaded as to not shine in the observers eyes must be cast on the plumb line. (c) At a distance south of the plumb line such that the star can be seen near the top of the line drive a stake or better, two stakes, with a level board on top. ~~on which the compass can be set.~~ (d) Set a pin or ~~other mark~~ needle on the top of the stake or board in line with the plumb line and Polaris. ~~In the first~~ If method (1) is used the angular correction for the latitude is given in the ephemeris; it ~~It varies with the latitude and~~ may be as much as 3°. It may also be computed from the table below. If the observation is at culmination (method 2) no correction is needed. If no ephemeris is at hand and as a check, reference may be made to Zeta of the Great Dipper (Great Bear) which is the second star from the end of the handle. This star crosses the vertical line through Polaris 8 minutes before upper culmination. If the time of year is such that this star passes the meridian above the pole, then Delta of Cassiopea can be used. This crosses the vertical line below Polaris 9 minutes before ~~Polaris~~ at lower culmination. This is the second star from the left end of the five as viewed when below the pole star. ~~(See diagrams in Hotchkiss, Bean, and Wheelwright)~~ The objection to this and the preceding method is that they require work at what are often inconvenient hours. ~~The third~~ Method (3) allows the observation to be made at any time that the star is visable. The number of hours before or after elongation or culmination may be determined from the ephemeris or simply estimated from the position of the line joining the pole star with one of the stars mentioned above. Note must be made of whether the star is east or west of the meridian in applying the correction. The correction is best made by offsetting the point at the south end of the line. At times after upper culmination, to the time of lower culmination, the star is west of true north. At other times it is east. Make offset in same direction from mark as star is from meridian ~~A curve given by Hotchkiss, Bean, and Wheelwright gives the offset for each foot of base line for the latitude of northern Wisconsin.~~ The following table is taken from Spalding, G. R., Training manual in topography, map reading, and reconnaissance, U. S. Army, 1917, p. 82. It is good until 1930. ~~Somewhat similar tables may be found in many text books on surveying.~~

Hours after upper culmination	Angle	Angular error, Minutes	~~Tan or~~ offset in feet per foot of base line
0 hrs. 0 min.		0	0.00000
1		18 West	0.00524
2		35 "	0.01018
3		49 "	0.01425
4		61 "	0.01775
5hrs. 59 Min. (W. elongation)		70 "	0.02036
8		61 "	0.01775
9		49 "	0.01425
10		35 "	0.01018
11 hrs. 58 min.		18 "	0.00524
~~11~~ (Lower culmination)		0 "	0.00000

Hours after lower culmination the same values but East. Correction for latitude.

0-18	multiply by 1.0
19-30	1.1
31-37	1.2
38-42	1.3
43-46	1.4
47-50	1.5
51-53	1.6
56-56	1.7
58-59	1.8
60-61	1.9

Note: Zeta of great dipper is to left of pole at east elongation and to right at west elongation. Delta cassiopea is opposite.

The above tables will give results to a quarter of a degree which is about as closely as a compass can be read. The base line should be prolonged to about 300 feet by day light and compasses read on it.

~~Use of the compass.~~ The chief difficulty with the use of a compass in the hand is the swing of the needle. but If the needle does not swing freely the instrument is defective. Wait until the swing is regular ~~and less than 5 degrees~~ and then take the middle point. The stop which holds the needle when the instrument is being carried may be used to check the needle and hasten its settling. A similar result may be gained by tilting the instrument so that the needle rubs against the cover. Care must be taken that the instrument is level when the reading is taken. New model Bruntan compasses have two levels set at right angles which are used for this purpose. cautions Never try to use a compass within 10 feet of a wire fence, pipe line, reenforced concrete bridge or culvert, or railroad track, within 15 feet of a well with steel casing, or 20 feet of an automobile. Keep hammers etc away from a compass when using it Street car lines run by direct current are very troublesome. Always read the north end of the needle. It is marked by either some different shape or color. The south end (in our hemisphere) has a counterbalance made of fine copper wire. Before recording any compass direction determine north approximately by looking at the sun or at land marks; then ~~stop,~~ ask yourself is this reading correct? It is very easy to record the wrong quadrent, easier, in fact, than the wrong degree. Second, check the direction in which you read the dial. It is very easy to read in the wrong direction since the graduations run in different directions in different parts of the dial.

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INSTRUMENTS AND METHODS FOR DETERMINATION OF DIRECTIONS AND DISTANCES

l.c. THE PLANE TABLE.

General Instruments for determination of directions and distances comprise (a) plane table, (b) sketching case, (c) compass and note books.

Construction ~~General.~~ The plane table consists of a board mounted on a tripod so ~~so supported~~ that it can be held horizontally and turned until ~~so that directions on~~ the map placed on it agrees with directions on the ground. Large tables have a leveling device on top of the tripod. Some tables have a built in compass ~~on them~~. The operations of traversing, locating objects by means of bearings, or locating a point not previously measured to be means of bearings of points on the map are all performed with rapidity by means of the plane table. All problems are solved graphically with the plane table, and as the map is constructed in the field, the chances of errors from mistakes in notes and from omissions is minimized. Where an extraordinarily high degree of accuracy is not demanded, the plane table is the most useful of all instruments for mapping. There are no adjustments

Use - Traversing. The table is set up as nearly level as possible. If such be not done, the directions to points not in the horizontal will not be correctly indicated. Once the table is set up at a "station" ~~point~~ the bearings of points sighted can be obtained by drawing lines along the edge of the instrument called an "alidade". The alidade may consist simply of a strip of wood, may have open sights, or a telescopic sight. The line of sight must be parallel to the edge of the ruler but need not be vertically above that edge as such a refinement is beyond the capabilities of the instrument. After the direction of the next station has been drawn on the map, the distance to that station is measured and the table set up at that point. Now the table must be turned on the vertical axis so that lines on it are parallel to their position when it stood at the first station. This may be done either (a) with the use of a compass or (b) by laying the alidade along the line drawn to the station now occupied and then turning the table until the first sight is seen ~~sighted~~ in the reverse direction.along the line from that in which the sight was first taken. Another method is to at once scale off the distance measured on the line thus giving the location of the new point. ~~Then~~ lay the alidade from that point to some object on the map which is visible and has been previously located, and then turn the table until the line of sight strikes the mark selected. This process is called "orienting" the table. It is best to always use two methods of orienting, if possible, as failure to agree shows either local magnetic attraction or an error in the map. ~~A~~

A traverse may also be run by the "turning point " method. Then a sight is taken to a point ahead of the table; this is called a foresight. The point is then located on this line by measurment but the table is not set up over it. Instead the table is taken farther on to a ~~point~~ place from which the point can be seen. It is set up there (oriented by compass) and the alidade laid through the intermediate point which is called a turning point. The alidade is then turned until the turning point is seen and a line is drawn. Distance is obtained by measurment and then the location of the second table location or station is obtained. This method is workable only where there is no local attraction; it is out of the question in towns and cities. In work with the open sight alidade it is also open to the objection that the turning point may be mistaken when seen from another point of view.

to agree shows either local magnetic attraction o~~f~~r an error in the map. A traverse may also be run by the "turning point" ~~"every other station"~~ method, that is each location ~~as described with~~ is made by a backsight to and measuring distane from the point located by a foresigh and measurement of distane from last location ~~the compass~~. The accuracy of the work is then dependant wholly upon the absence of local magnetic attraction. This method is used almost wholly in oil work and on the U. S. G. S. but should never be used in towns or in regions of magnetic disturbance unless it is always possible to check orientation by sights to other points (preferably three).

Use - Intersection. Points not located by measurement of distance can be located on the plane table by the intersection of two or more lines drawn to them from different locations of the table. All the lines should intersect at the same point. If they do not, there is an error either in orientation or in measuring some distance~~s~~. Such intersections serve a valuable purpose as a check on the accuracy of the map whatever method is used. Being discovered in the field, such errors can be corrected. Never attempt to locate a point accurately unless the angle where the lines intersect is ~~not less than~~ over 30°. In drawing the lines to points to be located by intersections use a very sharp chisel-pointed hard pencil. Draw the lines ~~to the~~ near estimated position of the object unless ~~If~~ these lines are to be used for orientation by backsights in which case draw them the full length of the alidade. Lines that will not be used for backsights should be drawn very lightly and removed as soon as no longer needed. In many cases lines can be omitted within areas on which work is being done and extended to points of intersection when needed. Always mark each line neatly ~~drawn~~ with name of object sighted. After object is located erase ~~remove~~ this and letter in name of object in proper place. Stations ~~located by traversing~~ are marked with a dot or pin prick within a small triangle. Points located by intersection or otherwise by a dot within a ~~circle, or better a~~ square. In some cases it may be necessary to keep a note book record of points sighted.

~~Use~~ Resection. ~~Locations may be secured by sighting a station and then occupying it without measuring its distance.~~ Orientation is then made by a backsight. A previously located point is ~~then~~ next sighted and a line drawn from it intersecting the first line which ~~is~~ was used ~~only~~ so far only for purposes of orientation. The point of intersection of the two lines is the point now occupied. This method is called "resection." It is very useful in all plane table work especially in crossing areas where distances cannot be measured.

Use- Three point problem. The location of a station not previously sighted can be made by resection from three located points without the use of the compass for orientation. Out of a large number of methods of solution the following are the most practicable in the field. The great advantage of three point locations is that ~~the topographer~~ one can set up and obtain his location provided the country is fairly open, at any point which pleases him regardless of whether or not it has been previously sighted. Locations are independent of compass errors. ~~the following methods are adapted from Wainwright, D. B., A plane table manual, U.S. Coast and Geodetic Survey, Report for 1905, pp. 296-342, 1916.~~

no II Definitions. The three located map points are designated as fixed points. The triangle connecting them is called the "great triangle". The circle passed thru them is called the "great circle". Directions right and left are measured as the surveyor faces the signals.

not (1) Location by estimation. ~~The table is set up as nearly oriented as is possible and resections made from each of the three signals.~~ (Lehmanns method) Rule 1.- The point sought is always distant from each of the three lines drawn from the three fixed points in proportion to the distances of the corresponding actual points from the station occupied, and it will always be found on the corresponding side of each of the lines drawn from the fixed points. Rule 2.- When the point sought is without the great circle it is always on the same side of the line drawn from the most distant point as is the intersection of the other two lines. Rule 3.—When the point sought falls within either of the three segments of the great circle formed by the sides of the great triangle the line drawn from the middle point lies between the point sought and the intersection of the other two [p 17] lines. Rule 4.—When the point sought it within the great triangle the location is within the triangle of error formed by the intersections of the three lines. Rule 5.—When the point sought is on the great circle no location can be obtained since the problem is indeterminate.

no II <u>Application of rules:</u> (a) The table is oriented as near as can be done. (b) the three lines drawn forming ~~the~~ a triangle of error, (c) the point sought located by estimation, (using above rules) (c) table reoriented on one of the points. and (d) location ~~and~~ checked by new lines until all lines intersect at a point. Another solution ~~used in case~~ is to ~~shift~~ turn the table slighty and draw another set of ~~lines~~ thus giving two triangles of error ~~are formed is to~~ Then pass ~~straight lines through the corresponding angles of each of the two triangles. The point of intersection of these three lines is the point sought.~~

no II (2) <u>Bessel's method.</u> This method is more accurate than that previously described but the construction lines often fall off the sheet. ~~Let the three of the stations.~~ Of the three map points choose two so located that the point sought does not lie too near the line which joins them. This can easily be seen by looking at the points on the ground. Lay the alidade between the two map points and swing the table so that <u>each</u> in turn is directed toward the ground point that it represents. This means that the alidade must be reversed between the two pointings. When table is set in this way sight the <u>other</u> one of the three ground points and draw a line ~~toward it~~, paying <u>no</u> <u>attention</u> <u>to</u> <u>its</u> <u>map</u> <u>location</u>, through the one of the two map points that is NOT directed toward its ground location. This gives (then) two construction lines which intersect. Lay the alidade along this line joining this intersection and the map location of the third point for the point sought lies somewhere on this line and you can orient the table. ~~How can location of the point~~ ... the set rules

~~c is directed to C. Then with table clamped a line is drawn from a toward B, termed line ae. The two construction lines intersect at e. The line joining e and b is the true direction on the table of b from the point sought. Set the alidade on be and orient upon B.~~ Now locate point sought by resections from the other two fixed points.

USC <u>Two point problem.</u> Location from only two points of known location may be made in several ways. (a) If the point sought is used only for sketching and not as a base for other determinations resection from the two visible points

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with the table oriented by compass is sufficient. (b) If the table can be set up in line with two fixed points it can be oriented on them and the location fixed by resection from another fixed point. (c) Other methods involve the use of a base line laid off but not necessarily measured, from the point sought. ~~From~~ Make a construction location of the point sought in some unoccupied corner of the map and from this with table oriented by guess sight the two ground points paying no attention to their map locations. Next sight the point chosen for the other end of the base (having previously made sure that the two points can be seen from there). Go to that location and lay off the base line on the sheet by estimation. Orient table by backsight along this base line to ~~on~~ point sought. Then sight the two points from which locations are to be secured. The construction locations thus determined by intersections ~~for~~ on the two points will be in a line that is parallel to their actual position on the ground. Go to point sought and lay the alidade on this line and sight a distant object. Then lay it on the map positions of the two points and turn the table until the same distant point can be sighted. The table is now oriented and the location of the point sought may be made by resection. Another possible method is to measure and scale off the base. The intersections then give the distances to the two points from the point sought.

the two ends of this base the fixed points are located by intersections. The angle between the line joining the two points as located in this way and the line between the correct location on the sheet represents the angle through which the table must be turned to orient it. Or the distance to each of the points may be obtained if the base line is measured. This may be used to obtain location by intersecting arcs. The limitation on these solutions is the possibility of obtaining a base of sufficient length from which the two signals can be seen.

Use - summary ~~Plane table survey.~~ (1) In open country of ~~fair~~ some relief a plane table survey may be started by measuring a base line with steel tape or equivalent and then locating points by intersections. If possible more than two stations should be occupied ~~along~~ on the base line so as to get a check on the intersections. Lines should also be drawn to points which may be occupied but cannot be located from the base line on account of being invisible from one end or having two small intersection angles. These points may be located ~~either~~ (a) by intersection from points previously located ~~or~~ (b) by resection or (c) the lines may be used only for orientation when points are occupied. By occupying successively points located from the original stations the system of triangulation may be extended over the whole sheet to be mapped. Great care must be used in this work since the accuracy of the entire map depends upon it. Locations made by the three point method may be used for triangulation but never any station in whose location the compass was depended upon. ~~Stations on traverse lines, or used simply to fill in local details, may be located by compass orientation.~~ (2) In case the country is of low relief, without conspicuous landmarks to use as signals, or is forested, traversing must be used. A traverse should be run around the outside of the area to be mapped, preferably following roads or trails. The traverse must come back to the point of beginning. In practice the map location of this point will never exactly correspond to its original one. This error is called the "error of Closure". Its magnitude depends upon the care with which distances were measured and the table kept from turning after set up. Errors due to local magnetic attraction will destroy the accuracy if the ~~needle~~ turning point method has been used. Study the error in closure and see if you can locate any specific error. If not, and it is not too large, join the two plotted positions of the point of beginning. Pass parallel lines through all stations. Relocate them proportionately to their distance from the point of beginning. This is called adjusting the closure. Account should be taken of relative difficulty in obtaining directions and distances in different parts of the map as well as of distance from the point of beginning. The plane table is not used to advantage in unsettled heavily forested or in very flat country. Other methods are more profitable in such situations.

~~Errors~~ Cautions. The principal sources of error in plane table surveying ~~is~~ are (a) failure to orient the table correctly ~~or~~ and (b) movement after orientation. Whenever the table is oriented a sight should be taken at once to some signal. Before leaving, this direction should be checked to demonstrate that no movement has taken place. Other faults are ~~due to~~ shrinkage and expansion of paper due to changes in weather. This is obviated by mounting ~~two sheets of~~ good paper on muslin ~~opposite sides of a piece of cloth, taking care to cross the grain of the paper. The annoying thing is that paper does not change in size equally in both directions.~~ In a wet climate white celluloid may be used. ~~Special white celluloid is generally employed, but heavy transparent celluloid can be roughened with sand paper. Lines are more readily seen if a sheet of paper is inserted under this kind.~~ The objection to celluloid is its tendancy to buckle and its large ~~xxfxx~~ coefficient of expansion. ~~Another solution which is not known to have been tried, would be the mounting of paper with rubber xxxxxx cement either on cloth or directly on another sheet with its grain at 90°.~~ Paper could also be mounted on a thin sheet of copper or zinc, ~~... with celluloid dissolved in a stove.~~ Another source of error is faulure to have the table horizontal when sighting objects much above of below its level. Care must be taken with ragard to locations depending upon intersecting lines. The 30° rule should hold in all cases. Failure to properly identify distant objects when seen from a different direction may be guarded against by notes describing the objects sighted and by lines drawn to them from a short base, too short to locate the signals accurately but still sufficient to guard against big errors. Above all, keep the table from being moved, keep the map from exposure to water if on paper, keep it clean all the time and avoid ommissions due to erasures.

Sketching case

General. The sketching case consists of a small board with attached compass. A long strip of paper is held on rolls on both sides and passes over the top of the board. A ~~special protractor~~ and scale ~~is held over the top of the board.~~ Rifle sights on the compass permit of reading bearings somewhat in the manner of a prismatic compass. ~~The~~ Bearings and distanes are laid off on the map with ~~the~~ a special protractor and scale fixed to one edge of the board. Distances are determined by pacing or time of travel. The instrument is primarily designed for military mapping on horseback but is used to some extent by geologists. It is undoubtedly slower than a plane-table but better than the following method

Compass and notebook

~~Compass traversing.~~ Use In making a compass traverse say of a road, distance may be measured in any way, but as the compass is not an instrument of great precision, they will usually be measured by pacing. Method (1) Mark the point of starting. Read the bearing or azimuth ahead to some recognizable landmark such as a tree. Record same. The mark need not be at the point you next intend to stop but may be ~~at a distance~~ beyond that. Keep on the line by walking directly toward the mark ~~and~~ keeping your eyes on it all the time. When you can go no farther or must make a turn, stop and take the bearings of not only the next mark or "station" ahead, but also of the one previously occupied. If there is any local

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disturbance of the compass at any station this proceedure will disclose it. In regions where there is no reason to think there is local magnetic attraction a considerable saving of time may be accomplished by not stopping at every point but at the first station sight a readily recognizable land mark at the next turning; pace to it, turn; go on pacing as long as looking back you can see the mark; stop and read bearings back to the mark and to one ahead. Never follow this proceedure in a town. Objects off of the line of traverse should have their bearings taken from at least two points if it is desired to obtain their location. Along a winding road or stream short cuts can be traversed and the location of the road or stream sketched in. The following ~~forms~~ form may be used for notes.

method (2)

Sta. occ.	Sta. sighted	Bearing (or azimuth)	~~Description~~	Distance

It is best to carry a protractor and actually map the traverse in the field. Cross section paper or paper with ruled parallel lines is very handy since the north direction can be found at any point. For rough reconnaissance the approximate tangents of the angles measured may be platted by the use of cross section paper which saves the use of a protractor. If no cross section paper is available, the angle between the ~~map~~ compass readings must be computed and laid off. This is easier with azimuths than with bearings and is always greatly facilitated by drawing a rough sketch of the relation between the two lines. A rough sketch showing directions and distances should always be made in the field even if no attempt can be made at accuracy. It will prevent many large errors. The bearings to objects not visited should be platted. The intersections give the map locations. If several sights to the same object do not intersect at the same place, an error is at once made apparent. Locations off the line of travel can be used in passing places where the distance cannot be measured. In this case, as with

The location of a point occupied but not measured to, compass bearings are prolonged on the map from the points of known position. Their intersection is the place where they were taken from. While only two bearings are necessary, three or more are valuable as a check on one another.

Station : Time : Bar. : Correction : Elev.

Advantages of compass survey. A compass survey should be made where (1) the weight weight of a plane table or other instruments prevents their use; (2) where the amount of work to be done does not justify carrying other more bulky instruments, (3) in thick brush; or (4) where it is desirable to avoid attracting attention. The compass is slower than the plane table under most conditions.

Table of approximate tangents

Degrees	Offset in distane of 10 units
5	0.9
10	1.8
15	2.7
20	3.6
25	4.7
30	5.8
35	7.0
40	8.4
45	10.0

~~Copy this table in your notebook for future use.~~

For angles over 45 degrees use complimentary angle.

References

INSTRUMENTS FOR DETERMINATION OF VERTICAL ANGLES

General. Geologists need to determine vertical angles (a) in measuring the dip of strata, and (b) in measuring differences of elevation. Instruments commonly used comprise (a) Abney level, and (b) Bruntön Compass.

Abney level.

~~Abney level~~ Construction. The Abney level is like the hand level except that the level vial can be rotated on a horizontal axis. An arc and vernier attached to this acis indicates vertical angles. This vernier on most instruments is graduated so that it can be read in both directions. It is divided to 5'. minutes In case the reading is less than 30' read one end of the ~~xxixx~~ scale from the 0 which is in the middle. In case the fractional degree is over 30' read the other end. in same direction Inspection of the position of the 0 point on the scale of degrees will show at once which end to read.

Adjustment ~~of Abney level~~. Adjust the Abney level in the same way as the hand level. Movement is accomplished by a screw at one side in front ~~screws at each end of the level~~ which moves the wire and mirror as in some hand levels. ~~vialx~~

~~Limitations of Abney level~~ Use. The limit to the usefulness of the Abney level is fixed by its crude line of sight rather than by the sensitiveness of the bubble. Never attempt to get accurate angles at distances of over 1,000 feet; ~~preferably much less than that~~. Clamped at 0, the instrument is a hand level.

Brunton Compass. Use The Brunton compass can be used to measure vertical angles by unfolding the sight vane, folding back at right angles the little peep sight on the end and half closing the cover. Now with the instrument held sideways, sight through the peep sight on the end of the vane and the hole in the cover. Point the line of sight at the object and center the level bubble seen in the mirror by means of the lever on the bottom of the instrument. ~~The angle~~

The vernier is divided to 5 minutes.

Measuring dips. In order to measure dips of strata with either of the above instruments it is impractiable to simply lay them on a bed as shown in illustrations in many text books. It is best to either(a) lay the instrument of a long straight stick that is laid on the beds or as this is generally not available (b) place the eye in the same plane with one of the beds and hold up the instrument so that its edge comes on the edge of the bed in question where at the same level as the observers eye. Then center the bubble. Dips can rarely be measured closer than to the nearest degree.

Measuring elevations. To obtain the difference of elevation where horizontal distance is known multiply by tangent of vertical angle. A method which avoids the carrying of a table of tangents is used by army officers. Construct a scale for the map ~~scale~~ used on which the difference of elevation on a one degree slope in any given horizontal distance is shown. ~~For instance marks can be placed on the scale at such points that each is 10 feet higher than the last if the slope is one degree.~~ Since a one degree slope is equal to one unit ~~feet~~ ~~in~~ vertical in 57.3 units ~~feet~~ horizontal the following formula will give the length of a scale to show any desired ~~say 10 feet~~ difference of elevation on a one degree slope.

Length = Diff. in elevationX scale of map divided by tangent of 1 deg. Recomputed this is:

Length=diff. elev.X scaleX 57.3.

see Map Scales

The scale is stated as a fraction, ~~The units (inches or feet) must be the same on both sides of this equation.~~

~~All units should be computed in inches.~~ ~~Example: Divide a scale to show 10 foot intervals for scale 1: 10,000~~

~~Length = 120X 1/10,000 X 57.3 = 120X57.3/10,000 =~~

To use this scale to measure differneces of elevations for other slopes than one degree obtain the reading for the desired distance with the scale an multiply by the number of degrees actually observed. This rule holds only up to about 15 degrees since it is only an approximation. The error at 15 degrees is about 2 1/4 percent. It is sometimes necessary to find the heigth of a point to which horizontal distance cannot be measured. In this case read two angles to the point from opposite ends of a base measured in such a direction that all observations lie in the same plane. Then use the formula Heigth = base divided by difference of cotangents of the two vertical angles.

Section making in inclined ~~sediments~~ beds. Sections of inclined beds may be measured with the Abney level or the Brunton compass in much the same way as with a hand level is used in measuring horizontal beds. In this case set the instrument to the angle of dip and proceed as with the level. **Thickness of strata at each shot is heigth of observers eye multiplied by cosine of dip.**

A convenient method where the ~~base of th~~ point vertically beneath the object can be reached is to set the Abney level to one of the points given on the scale of slopes which is generally opposite to the scale of angles. Slopes are measured as so many units horizontal ~~x~~ to one vertical. Set to 1 in 1 and the angle is 45 degrees, to 1 in 2 it is about 26½ degrees. With this data it is easy to place oneself at such a distance from the inacessible object that it is sighted when the angle is set at a easily computed slope. The horizontal distance is then measured, the computation made and the heigth of the observers eye above the ground added. This method is a good one by which to measure the heigth of the face of a quarry.

Contour spacing. Scales may be made for any particular map which show the spacing of contours of any particular interval at different degrees of slope. The construction of such scales is greatly facilitated by a method invented by W. J. Mead. Construct a scale for the lowest slope desired, probably $\frac{1}{2}$ degree. At one end erect a perpendicular. Connect all points on the scale with the same point on the perpendicular. The proper spacing for twice the slope of the bottom line is found half way from this point to the base, for three times at one third the distance and so on. Rather than use separate scales for each slope the method employed in the Army can be followed. On one scale spacing for $\frac{1}{2}$, 1, 2, 4, and 8 degrees is shown by simply marking the proper lines in adifferent way. Other combinations can be worked out so that nearly all slopes up to 12 degrees can be shown by use of only four scales.

Distances from vertical angles. Whenever the difference of elevation between two points is known the horizontal distance can be worked out by the same process as used to obtain differences of elevation from vertical angles taken ~~worked~~ backwards. The rule is to divide the vertical distance by the tangent of the vertical angle. If a slope scale is used divide the vertical distance by the number of degrees ~~read~~ and the resulting reading on the slope scale is the map distance of the point. This method is of value when the elevation above a body of water is known and distances to points on its shore are desired.

INSTRUMENTS FOR DETERMINATIONS OF DIRECTIONS, DISTANCES, AND ELEVATIONS COMBINED.

General. Instruments for determination of directions, distances, and elevations combined comprise (a) telescopic alidade with plane table, and (b) engineers transit.

The telescopic alidade: construction, adjustment, and care.

Construction. The telescopic alidade consists of a ~~simple~~ telescope with two principal lenses. The large lens is called the objective, the smaller, ~~usually compound,~~ is called the ocular. A reflecting prism in the ocular or eyepiece enables the observer to look through the instrument which can therefore be set near to its base ~~with greater ease than if none were provided~~. It ~~also~~ makes objects appear right side up but with right and left interchanged. Just in front of the ocular is a ring on which are mounted four wires, three horizontal and one vertical. The telescope is free to revolve both on an axis in a horizontal plane at right angles to its own axis and in the mounting around its axis. The former motion is provided with a clamp and slow motion screw. The latter motion is only used for adjustment and is clamped by a ring just in front of the horizontal axis. On top of the telescope is a post to which a "striding" level can be attached. This level is removed to a post on the base when the instrument is not in use. A small compass may or may not be attached to the base which ~~often~~ has a scale along one side. The arc for reading vertical angles has an adjustable index which carries a level.

Adjustment ~~of~~ eyepiece. The eyepiece (or ocular) must be focused on the wires. Turn the telescope toward the light and move the eyepiece in or out until the wires appear sharp and clear. ~~In different instruments~~ this is done depending on make of instrument, either by sliding or by rotation. The reflecting prism is free to turn to any angle without affecting the focus. This adjustment is made once for all for each user of the instrument. Test its accuracy by turning down the telescope and focusing the objective upon some object by means of the knurled screw. If on slightly moving the eye from side to side the wires appear to move on the image of the object the error is called "parallax". See if this effect is due to faulty focusing of the objective. If not, turn to the sky and readjust the eyepiece.

II Adjustment <u>Collimation or line of sight.</u> The object of this adjustment is to make the line of sight coincide with the axis of the telescope. The line of sight is fixed by the intersection of the center and vertical wires.

(1) Loosen the clamping ring so that the telescope may be revolved on its own axis.

(2) Place the instrument on a firm support like a solid table.

(3) Point the telescope at some distant fixed object of small size and center the line of sight accurately upon it. The telescope need not be horizontal.

(4) Rotate the telescope through 180° being careful to not disturb the support of the instrument.

(5) Rotate the reflecting prism so that you can look through it (this may be done by holding it while the telescope is rotated) and see if the point of intersection of the wires has moved. If it has not the adjustment is correct.

(6) If the adjustment is off, correct the position of the wire intersection ONE HALF the distance, both vertically or horizontally, which they appear to have moved on account of the rotation of the telescope.

Adjustment of the wires is accomplished by means of four screws which hold the ring on which they are mounted. In many instruments the heads of these screws, which are just in front of the eyepiece, are concealed by a ring. Unscrew this ring and obtain a small screw driver with a sharp blade. The holes in the telescope are not threaded, but only those on the ring. The holes on the telescope are considerably larger than the screws. When all four screws are loose, the entire ring with the wires may be rotated through a considerable angle. By tightening one screw and loosening the opposite one the ring may be moved from side to side. Never attempt any considerable movement without loosening all the screws. Never set the screws up too tight. They are brass and can readily be stripped. Set them firmly with a small screw driver.

no II In adjusting the line of collimation with instruments that show an erect image with right and left reversed, loosen the screw away from which the vertical wire must apparently be moved, and tighten the opposite screw. After correcting one half the error test the adjustment again. Continue until no error is apparent.

no II Check this adjustment at least once a week and whenever the instrument has been subjected to any unusual jar.

II Adjustment-striding Level. The object of this adjustment is to make the line of sight parallel to the bubble axis so that it will be horizontal when the bubble is centered. The two collars on which the level rests are supposed to be concentric with the axis of the telescope.

(1) Set up the instrument and center the striding level bubble.

(2) Without disturbing the instrument remove the level and replace turned end for end.

(3) See if the bubble still centers. If not, move HALF WAY back with the slow motion screw.

(4) Remove level and turn the adjusting screw on the bottom of the level with a screw driver until when replaced the bubble centers. Check this adjustment ~~with~~ at every set up.

With a new instrument it would be well to test the parallelism in the same way as with a level. See section on adjustment of ~~hand~~ engineers level.

II Adjustment-index level. Place the striding level on the telescope and check its adjustment. Level the telescope. With knurled screw on left side of instrument set the index so that it reads 30 on the degree scale and 50 on the Beaman arc. Then with capstan-headed screws at ends of level on the ~~arc~~ index set it to read level when the striding level is the same. Be sure screws are tight but do not strip them. ~~No notes are required for this exercise.~~ Check adjustment at every set up.

Adjustment **Stadia constant.** The distance between stadia wires cannot be altered. A test may be made of a new instrument by reading the rod at different distances measured with a steel tape under different light and weather conditions. If any discrepancy is revealed a new stadia constant other than 100 must be employed in all work. If it ever is necessary to install new wires the constant must be then determined.

Replacement of wires. Provide (a) ~~a little~~ some shellac dissolved in alcohol, some beeswax, (b) a pair of dividers or a forked stick, ~~and~~ (c) some spider web, and (d) a small stick or tweezers. Use either web from a cocoon or fresh web of a small spider. Remove the eyepiece. Take out two of the screws holding the ring and loosen the other two, turn ring sideways. Insert a small sharpened stick in one hole to use for a handle before removing the other screws. Now remove the ring. Replace in ~~same~~ ring reverse manner (as removed) placing wires on side toward eyepiece.

no ¶ Press a piece of beeswax on each prong of the dividers or forked stick. Let a small web fall from the end of one of the prongs or pick up a single thread from the cocoon, stretch the thread moderately and attach to the other prong. If old web is used, it should first be dampened by dipping in water for a few seconds. Place the web across the ring, using a ~~magnifier~~ hand lens to insure their being on the marks. Put a small drop of shellac on each end and allow to stand until dry.

¶ Adjustment **~~Plane table~~ Bulls-eye level.** It is rarely necessary to test this adjustment of the bulls eye level. Level the table with the alidade in one position. Reverse the alidade and see if the bubble is still on center, or better, place the instrument on a surface known to be level. Correction must be made by inserting paper under the edges of the level.

Adjustment **Telescope axis and vertical wire.** The vertical wire may be out of perpendicular owing to slipping of the telescope in its clamp. It may be thrown out during the adjustment. Level the table and test either on the corner of a building or a plumb line. No adjustment of the horizontal axis can be made in the field. Any error in this would be the result of damage to the instrument.

Care of the alidade. The alidade is composed of rather soft non-magnetic metals. Never lay it on the ground or on rocks. Replace in the case

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Whenever not in use, and between set ups, making sure the striding level is firmly attached to its post. Never leave the table with the alidade upon it. Never leave go of ~~it~~ alidade until table is level and clamped firmly. Do not set up on pavement or traveled part of a main road. Every two weeks wipe off the instrument with a rag dampened with light oil, like 3 in 1. Remove the springs which play against the bearing studs, wipe clean, stretch a little, replace. Remove the gradienter screw and clean. Keep the plate against which it presses tight. Resurface it if holes form (this is necessary only if a gradienter is used for readings). Never move without ~~raising~~ blocking the compass needle. Do not release the needle unless approximately on the magnetic meridian. Open and dry the compass box if instrument has been used in rain. ~~Do not perform unnecessary adjustments, but use methods which eliminate instrumental errors.~~

Use ~~of the telescopic alidade~~. General. The telescopic alidade is used in the same manner as the open sight instrument except that it can be used to determine distance by stadia readings and is capable of greater accuracy than the other type. It is used by geologists mainly in oil work.

USC- Rods. Many different kinds of rods are used with the telescopic alidade. Geologists generally take longer shots than do engineers and so need rods which can be read at greater distances. The writer prefers a rod divided to single feet only in alternate black and white except that the ~~fixa~~ fifth and the tenth feet are divided into tenths. Such a rod fourteen feet long ~~is then reversible and~~ can be used either way up. Figures on the feet are handy but cannot be seen at long distances so that the writer thinks they can be omitted. If painted on the rod it would be an excellent idea to show them as they appear in a mirror so that they could be read ~~appear~~ correctly in the alidade. An engineers level rod can also be used by holding it upside down for the distance readings so that one wire can be set on the top of the rod and the target moved ~~set~~ to the other wire in response to signals. The U. S. Geol. Survey uses paper strips which can be gummed onto a board with shellac. They are divided into tenths of feet. A good idea would be to obtaine black paper cut to proper lengths which could be gummed onto a plain white rod. If a painted rod is used it should fold up for carrying. One hinged joint ~~division~~ in the middle of a fourteen foot rod is generally sufficient. ~~A hinge is placed at the joint.~~ It is most convenient to place a short length of board on the upper half of the rod. When in use the rodman uses this to pull up the top half while the reading is being taken.

USC- Signals. If some methods are used it is necessary to have a system of signals by which the rodman can communicate results to the man at the instrument. That commonly in use is: Right hand raised vertically= 1, horizontal=2, down =3, left hand vertical=4, horizontal=5, down=6, both hands vertical=7, horizontal=8, down=9, over head=0. Remember that the alidade changes directions ~~of~~ left and right.

Use of Stadia. The rod reading between the two outer wires is multiplied by 100 to give the horizontal distance. Thus (the line of sight being horizontal) 1 foot on the rod represents 100 feet on the ground. A 14 foot rot will thus permit the measurement of distances up to 1400 feet. At greater distances the interval between two of the wires may be read ("half interval"). In this case the rod reading is multiplied by 200. ~~If unusual accuracy is required, read both half intervals and average.~~ The use of the half interval will enable one to read distance up to 2800 feet with a 14 foot rod. It is generally advisable to move the telescope with the slow motion screw until one wire is on an even foot, often the top of the rod. Fractions of a foot can be read on feet which are subdivided. The constant (f + c) can generally be neglected in plane table work since it is less than a foot with a small instrument. It is sometimes necessary to read distances more than 200 times the rod length in order to cross impassible ground or to avoid having to make an additional set up. ~~The following methods have been adapted from Mather, K.F.? The manipulation of the telescopic alidade in geologic mapping: Denison Univ., Bull. Sci. Lab., vol. 29, pp. 97-142, 1919.~~ At times not enough of the rod can be seen to span a half interval.

p 26. Method (1) Rotate the telescope 90 deg. so that the stadia wires are vertical. Signal the rodman to use some mark like a tree for one end of a base line. Line in one of the wires on this mark and motion the rodman to move over until his rod held edgewise is in line with one of the other wires. He will then measure the distance on the ground which was subtended by the wires used. The distance may be either communicated by signals or recorded for later communication. It is then multiplied by either 100 or 200 depending on interval used. The rodman will probably need a field glass to see signals

Method (2) Rotate telescope as in method (1). Signal rodman to hold rod horizontally. Line in one wire on base of rod. Motion rodman to move rod ~~so that its bottom is~~ where top was before. Repeat until ~~rod is cut by another wire~~. Distance will ~~not then have to be communicated by~~ signals. 3 be communicated by

Method (3) ~~If instrument has the~~ Method three depends upon finding the amount that the visible part of the rod fails to span a half interval and adding this to the observed reading to obtain the proper reading, if the rod had been long enough. This amount is measured in terms of drum reading and then the value of this reading at the rod distance ~~the rod is~~ is determined by seeing how many feet are passed over on the rod when the telescope is turned through this amount. (a) place top or middle wire on top of visible part of rod, (b) read and record drum, (c) tighten drum screw until next lower wire is on lowest visible division of rod, (d) read and record drum, (e) tighten screw this number of divisions, the difference of the two readings, (f) read the number of feet and fractions that the wire has moved up from its former position at the bottom of the visible portion of the rod, and (g) add this figure to the length of visible rod thus giving length of half interval if it could have been seen and obtain distance by multiplying by 200.

Method (4) ~~Use method 4 in outline. This~~ Method depends upon the assumption that one complete revolution of the drum swings the telescope over 1 foot on the rod at distance of 100 feet. It ~~also~~ swings the telescope over a full interval rod reading. ~~Assuming that you can see less than one half of the full interval on the rod~~ swing the telescope over the visible distance ~~chosen~~ several times and average the differences in drum readings that are obtained. Note that one entire revolution is called 1.00 Divide distance swung over by drum reading to obtain distance.

Method (5) ~~Check result on former determinations.~~ Method 5 depends upon finding what fraction of the half interval is spanned by the visible portion of the rod. Observed lenth on rod: half inteval reading :: drum reading swinging over visible lenth of rod : drum reading for half inteval swing. The last figure should be 0.50 turn but it is best to check this by actually swinging the telescope through a half inteval. ~~The outline gives rules for the routine of observation but it is best to grasp the idea before attempting to learn set rules.~~

This method is ~~[illegible]~~ better than 3 or 4.

divided by 2-a.

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(6) Ground rod readings. A system of stadia readings used by English makes use of two short rods each with a target on the ends. For distances up to ~~the sum of the~~ about 800 f ~~two rods placed end to end (about 8 feet) the two are~~ are connected ~~connected together.~~ The targets are spaced by signals from the instrument man to span a full or half interval and the result signaled back by the rodman. For very long shots the ~~flags~~ rods are stuck in the ground in accordance to signals and the horizontal ~~difference~~ distance measured with a tape. The stadia wires are kept vertical. The method allows of long shots against the sun. ~~With inclined shots the stadia computer cannot be~~

Differences in elevation. To obtain differences in elevation the rod is always held vertically. The formula

Diff. elevation = 100 X rod reading X ½ sin 2 vertical angle

gives the vertical distance between the instrument and the position where the middle wire cuts the rod. In practice the results are found by the use of stadia tables or special slide rules. The latter are much more rapid but are not quite as accurate. Directions for use accompany them. Note that this formula does not apply with methods 1, 2 and 6 for distance determination. Here multiply by sine of vertical angle.

Correction of distance. The result 100 X rod reading does not give true horizontal distance unless telescope is level but the difference is scarcely appreciable at angle of less than 3 degrees. The formula horizontal distance equals apparent distance X $\cos^2$ vertical angle is used. In practice the values are obtained as with differences in elevation. In platting with small scales they can be neglected up to 10 deg. vertical angle. With methods 1, 2, and 6 multiply by cosine of vertical angle

Field procedure. Differences of elevation can be measured Transpose (by (1) use of vertical angles read on arc, (2) use of telescope as a level, (3) step method, (4) Beaman arc, (5) gradienter drum. ~~Of these (1) is used when angle exceeds that at which any wire will cut the rod with telescope level. It is especially applicable to rather high angles.~~ Methods (3) and (5) are limited to small angles but are both very rapid. ~~Always use telescope level if you can~~

(1) Level sights. Always read ~~levels~~ differences of elevation with the bubble centered if possible.

The readings thus taken are much more accurate than inclined sights and require less computation. If the middle wire does not strike the rod read the wire that does and add or subtract the half interval reading on the rod from the actual reading. ~~Carry lower wire readings as − angles, upper wire readings as + angles.~~ Record wire read, as U, M, or L. (upper, middle, lower).

(2) Vertical angle method. The routine of observation is as follows: 53

(1) Line in the rod so that vertical wire is on it. As the field of view of the telescope is small first sight over the top to get general direction, then get exact line when looking through instrument. At first a help is to place a pin or fine needle in the table to mark the station occupied. This cannot be done when celluloid sheet is used and is not permitted on very small scale maps.

(2) Set top wire on top of rod or other conveinent point and read distance. When sun is behind rod less distance can be read than when illumination is good.

(3) Redord distance.

(4) Set middle wire anywhere on the rod. ~~(First see if any of the wires will strike the rod with bubble centered. If they do not follow this method.)~~ Either Top or 10 foot mark are commonly used

(5) Record reading of center wire.

(6) Signal rodman to go on.

(7) Center index level

(7) Read vertical angle with vernier. Arc is divided to half degrees;

(8) Record ~~this.~~

~~(9) Center bubble.~~

~~(10) Read vernier.~~

~~(11) record reading.~~

(12) ~~Obtain difference of two readings.~~ Subtract 30-00 from reading. Since scale is continuous it will at once be apparent whether the line of sight is inclined up or down. A positive remainder indicates a + angle and vica versa.

(13) Compute difference of elevation with slide rule or table.

(14) If angle is large enough compute horizontal distance.

~~If the sight is very long or of great importance, in which case a slight error of adjustment in the bubble would be serious, repeat the operations from (9) on with level reversed. Average the two readings. For very refined work the entire operation should be repeated with the telescope rotated 180° on its axis, making four readings to be averaged, but which should notvary widely. This eliminates all instrumental errors. Great care should be taken in reading the vernier since an error of a single minute means an error of 0.3 foot at 1000 feet.~~

First be sure where the zero is in the scale of degrees. Estimate from this what the reading will be. Then look for the coinciding lines with a magnifier. Record. Then look again to be sure, first, that you read the correct zero line, second, that you read the correct number of degrees in the right direction on the scale. Number of coinciding line on vernier gives number of minutes to add.

Form of notes-vertical angle system. All motes should be kept in a good fieldnotebook in either hard pencil or with fountain pen. The idea is to (a) put the items across the page from left to right in the order in which the observations are made and (b) keep related items in adjacent columns. The writer prefers the following form

Locations			Angles			Difference		Elevations		
Sta.	Rod	Dist.	Oblique	Diff. + or −	Rod.	Compt. + or −	Net + or −	Sta	~~Rod.~~ T.P.	S.s.

The two columns at the left are for locations of table and rod respectively. Do not confuse them with the elevation columns. Distance column contains 100 times the full interval rod reading, that is the apparent distance. True horizontal distance is not shown. Oblique column is for ~~angle~~ arc reading. Difference column is for angle after 30-00 is subtracted; be sure to give sign. Never use signs for degrees and minutes but put dash between. Rod column is for reading of middle wire for obtaining elevation. Difference columns are for computed difference, that is difference of elevation of the instrument and the point on the rod indicated in the column to left. Net difference is this figure corrected by the rod reading to indicate difference of elevation of instrument and ground where rod is held. Signs must be indicated.

Last three columns are for elevation of instrument (H. I.), ground elevation of rod ~~provided it is to be~~ at turning point used to obtain elevations from later, and ground elevation of rod where no further sights will be taken to that point ~~; the last are called~~ (side shots). In this system of notes it is presumed that the turning point system of traverse is used. Signs of net difference indicate if it is to be added or subtracted from last elevation. Computed differences are obtained with either a stadia computer or a stadia table. Many computers read only to 1000 feet apparent distance. For long shots compute difference for that distance, then difference for excess and add results. ~~Some level sights will undoubtedly be included; in these be especially careful to indicate by letter, U. M. or L. which wire was read.~~

Signs of angles are obtained automatically. Signs of difference of elevation carry the same sign as the angle in the case of foresights (sights to points not yet determined, including side shots) and the opposite in the case of backsights (sights to determine elevation of instrument from a previously determined point.) This can be memorized as the reverse when the observer is ~~lxxx~~looking backward on ~~the~~ his tracks. To obtain net difference of elevation give the rod readings for elevation a + sign for back sights and a - sign for foresights. Remainders are computed algegraicly. Always show signs in notes; it is a great help in checking computations. Some level sights will always be mixed in among angle shots. Always be sure to indicate which wire was read. Carry lower wire shots as - angles, with half interval value in computed difference column, middle wire readings put rod reading in net difference column, upper wire readings as + angles with half interval value in computed difference column.

Computations. In all computation remember that ~~resultst~~ results are no more accurate than the data. If you read elevations on rod to nearest tenth of a foot do not compute closer than to nearest tenth and if you read only to nearest foot compute only to nearest foot. When a computation comes out at a half take the even whole number.

Vertical angles and intersections. In obtaining the elevations of points located by intersection or by the three point method differences of elevation ~~may be~~ are computed by the formula:

Diff. elev. = hor. dist. X tan vert. angle.

~~Scale off the distance in feet shown on the map and use either a slide rule or a table of natural tangents or both.~~ stadia computer. If the distance is ~~considerable, say~~ over a mile, account must be made of curvature of the earth. This will diminish the observed elevation according to the formula:

Curvature = 0.667 ft. X square of dist. in miles.

Refraction has the opposite effect and decreases the curvature correction. Mather gives the formula:

Curvature plus refraction = 0.57135 ft. X sq. of dist. in miles.

Refraction is, ~~xxxxxx~~ however, not constant so that little dependance can be placed upon small vertical angles to very distant points. The Stebinger drum may be used to determine small vertical angles. A complete revolution deflects the telescope about 34' and as 1/500 revolution can be read it is much more delicate than the arc.

Form of notes

			Angles				Elevations ~~Elev.~~				
Sta. oc.	Sta. sitd.	Distance	Oblique	Diff.	Comp. diff.	H.I.	Sta. oc.		H.F.	Sta. si.	
				+ or −	+ or −		gr	inst		gr.	fl.

Note that elevations must include elevation of instrument, elevation of ground below instrument, elevation of flag sighted, and elevation of ground below flag. Column H.I. is for heigth of instrument above ground measured with pocket tape. Column H.F. is for heigth of flag above ground as either measured when at station or obtained from person who set the flag. These figures need only be measured to nearest foot. Do not enter signs for degrees and minutes since they cause confusion but use dash between the two. With less than one degree enter 0 before the dash. With less than 10 minutes enter 0 before the figure. Note that with the K. and E. instrument with divided scale on arc the difference column is not needed but you must be careful to record if the angle is + or −.

add section on computation

Computation of notes on the system given above may be done with (a) table of natural tangents, (b) ordinary slide rule, or (c) stadia computer. The first job is to scale the distances from the map. If these are not very carefully measured the elevations will not check. The first method is the most accurate. The second method requires the use of the scale of sines for angles less than about 6 degrees; this does not itself involve much error but as the scale is coarsely divided is not recommended. If a stadia computer is used set the vertical angle on the "horizontal distance" scale to the horizontal distance on the foot scale and then read difference of elevation in usual manner. This is because the apparent distance is not observed in this method. Elevations need only be computed to nearest foot. After the elevation of the instrument at a station has been determined the readings are all foresights and carry the same ~~xxxxxxx~~ sign as that of the vertical angle. In computing start at the base line stations where ground elevation is known and figure out from that to other stations. Since the flags are sighted the corrections for heigth of flag are -. Corrections for heighth of instrument are added to ground elevations. It will almost always p30 be found that elevations of a given station obtained from different sights will not check. Go over the work and see (a) that you scaled the distances accurately, and then (b) that you preformed the computations correctly. If a difference is still present see if it might be due to reading upper or lower wire instead of middle wire; this causes an error of 17 minutes. An error in reading the scale on the arc or in taking the wrong 0 line on the vernier is generally 30 minutes. See of the error is of either of these two orders of magnitude; it it is the shot can be disregarded. In adjustment preference must be given to figures based on (a) short shots, and (b) low angles. As a general thing the errors in this work should never exceed 5 feet even if elevations are carried for several miles from the base.

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(3) Step method. ~~The step method is an extension of the preceding.~~ In case all three wires fail to touch the rod, with telescope level (say falling above the rod) one may note some fixed object cut by the bottom wire. Then turn down the telescope until the top wire is at the place where the bottom wire was before. If the middle wire now cuts the rod, read the rod and add the full interval rod reading to obtain the reading there would have been if the rod were long enough to have been caught at first.

[illegible] e. The process can be repeated up to six times, beyond which it is not accurate. ~~The method should only be used for side shots and then not for very important ones.~~ It is an excellent check on important sights.
Sign of computed difference is computed as with angles - see Beaman arc.

(4) Beaman arc. The Beaman arc is an adaptation of the step method. An arc is provided with graduations for each step. These increase in length with increase of vertical angle. Readings therefore cannot be interpolated between marks and no vernier can be supplied. The graduations are large and easily read and the computation is very simple~~, since the full interval rod reading is multiplied by the number of divisions from the center point of the scale (marked 50)~~. The routine is as follows:

(1) Line in the station as directed for other method.

(2) Read distance.

(3) Record ~~distance.~~ full interval reading, not apparent distance.

(4) Center bubble on index.

~~(5) With screw on Beaman arc index set zero point to 50.~~

~~(6) Turn telescope until rod is seen.~~

5 (7) With slow motion ~~screw turn~~ telescope until Beaman arc zero is at a division.

6 (8) Read where center wire cuts rod. If it does not, try another division.

7 (9) Record rod reading.

8 (10) Signal rodman on.

9 (11) Read Beaman arc.

10 (12) Record same.

11 (13) ~~Compute difference of elevation by multiplying full interval reading by number of divisions on Beaman arc away from 50, taking account of rod reading in figuring elevation of bottom of rod.~~

(14) Read percentage correction of horizontal distance on upper scale

~~In this system the labor of computing is lightened but the rodman is held on station~~ slightly ~~longer than with vertical angles. There is less liability of error in reading~~ (or computing) ~~but there is no check by reversing the level.~~

Form of Notes

Locations		Arc		1/100				Elevation		
Sta.	Rod.	B.S.	F.S.	~~Rod.~~ dist.	Prod. + or −	Rod. Cor.	Net dif.	~~T.P.~~ Sta.	Sta. T.P.	S.S.
						+ or −	+ or −			

Method of computation: The Beaman arc is so constructed that one division swings the telescope over one full interval or step. Level is indicated by a reading of 50. mentally Subtract 50 from ~~all~~ every readings of the arc and use the algebraic remainder to multiply the full interval rod reading (1/100th apparent distance) to obtain the product. Note that apparent and real distances are not shown in the notes. ~~How may~~ True horizontal distances ~~be~~ are obtained ~~with this system?~~ from scale above divisions read for elevation This gives percentage of correction The sign of the product(or computed difference in elevation)is obtained by following rules:

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If sight is a B. S. (back sight) for determining elevation of the instrument from a previously measured point sign of product is opposite to that of the remainder when 50 is subtracted from the arc reading.

If sight is a F. S. (fore sight) to determine elevation of place where rod is held then sign of product is the same as that of arc remainder.

The column for rod correction gives the readings of the middle wire on the rod after the arc has been set to read a whole number. It corresponds to the column of rod readings in the other style of observations except that with angles the middle wire can be set on any part of the rod whil here the reading must be taken wherever the arc setting makes it come.

To obtain net difference of elevation give the rod corrections a plus (+) sign for B. S. and a minus (-) sign for F. S. and use algebraic remainders. Signs indicate if remainder is to be added or subtracted from last elevation.

Another rule. Also remember that uphill (+ arc reading) net difference is computed difference(or product) less rod correction and downhill (- arc reading) it is computed difference (or product) plus rod correction. ~~Show this by diagrams.~~

Downhill back sights are +, uphill BSs. are -, downhill F. Ss. are -, and uphill F. Ss. are +.

Step method observations are computed in the same way as above.

II Drum method

angles must always be read by turning the telescope in the direction accomplished by tightening the ~~Stebinger~~ drum (slow motion screw) 60

or gradienter against the spring. The number ofrevolutions is read on the horizontal scale above the drum. There are 100 divisions on the drum. whole revolutions are counted on small horizontal arm above drum. Care should be taken that the tension on the spring does not vary too much; see that the arm is approximatly in the middle of its swing before clamping. See that clamp is tight for any slip will vitiate results. The screw is intended to swing the telescope through 1 foot at 100 feet distance. Therefore differences of elevation may be determined by the following method: (1) Center the bubble, (2) read and record drum, (3) turn drum screw or gradienter screw until middle wire cuts the rod, (4) read and record drum, (5) take difference in turns and fraction and multiply this figure by the full interval rod reading. The result is the difference in elevation. As the screw must always be tightened the above applies only when the sight is up hill. When rod is below instrument reverse the operations as follows: (1) set middle wire on top of rod, (2) read and record drum, (3) turn up until bubble centers, (4) read and record, (5) take difference etc. On many instruments the screw does not work just as intended by the maker. Then make a correction table by either one of two methods. ~~Mathers method.~~ (A) Withdraw the screw until its does not take hold. (1) tighten until it does take hold and then (2) set drum to read 0, (3) ~~xxxxxx~~ read vernier on arc, (4) tighten one complete turn, (5) read vernier, (6) go on for 10 turns in same manner and then repeat entire operation 5 times. (7) tabulate and average results stating the angular value of each turn. (8) complete the table by looking up the sines of ~~half~~ twice of each value and multiply each result by ~~200~~ 59. The results are the feet swing for each turn at 100 feet.

~~English's method (English, W.A., Some planetable methods: Am. Assoc. Petroleum Geologists, Bull., vol. 8, pp. 47-54, 1924)~~

(B) Set up the instrument exactly 100 feet from a graduated to 100th of a foot rod. By handling the screw as with other method read the actual swing on the rod to nearest 1/100 foot. Repeat several times and average. This method is much simpler and more rapid and offers less chance for error in computation. In all use of the gradienter care must be taken to see that the plate against which it bears has not worn into a hole. If it has it can be either resurfaced or replaced by a plate of hard bronze. The use of the gradienter is confined to rather small angles but it is much easier to read than is the arc.

6 2

Traversing with telescopic alidade. Methods of running a traverse with the telescopic alidade are in theory just the same as with an open sight instrument. In practice several differences are introduced because of the greater precision with which distances are measured and the desire for accurate elevations. Traverses may be made in two distinct ways; (1) either locating every new table station with a foresight or (2) by taking a foresight to what is called a "turning point" then taking the table beyond, ~~setting~~ orienting up by means of the compass and obtaining both p32 location and elevation from the turning point. The first method closely follows the method of transit traverse used by engineers. The second is almost universally used in oil work and in filling in topography on the U. S. Geol. Survey. It is out of the question (a) in country with local magnetic attraction, (b) where many locations may be made by intersections which would be based only on compass orientations, and (c) where lines longer than the compass needle have to be drawn on the map. It is quicker, however, and has the great advantage that the elevations are not entirely carried by foresights as in the other method. In method (1) the H. I. is determined by simply holding the rod alongside of the instrument. The same point on the rod is then sighted at every shot from that station so that in figuring ground elevations the ~~exact~~ elevation of the instrument itself cuts no figure; everything is automatically reduced to ground level. If the instrument is even slightly out of adjustment, however, the error tends to pile up as all sights are of the same ~~sign~~ kind. for Method(1) is the only possible one in a magnetic area With turning points midway between set ups the error is largely minimized. Wherever other stations can be sighted for checks on location and orientation, the turning point system gives very accurate locations, although it is not permitted by the U. S. Coast and Geodetic Survey. It is a good idea to read each sight to a turning point in two ways; for instance, by angles and by Beaman arc or step method

Platting. Plane table stations are located on the map by a dot or pin prick within a small triangle; turning points by a dot within a small square; side shots by a dot alone. Where elevations are platted on the map, use the dot for the decimal point.

Baldwin solar chart. The Baldwin solar chart is a device used by the U. S. Geol. Survey to orient a plane table in areas of magnetic attraction. Its construction and use are explained in Topographic instructions of the U. S. Geol. Survey, pp. 136-141, 1918. Its theory is much the same as that of the dial compass, but the time corrections are obtained from several auxiliary graphs. An open sight alidade is ~~usually~~ used to cast the shadow.

TRANSIT

General. The transit can be used for much of the work that the plane table is. It offers the advantages of being more accurate especially in windy weather and being easier to carry in brush but this is offset by the liability of mistakes in the course of office work. The construction adjustment and use of the transit is described in all texts on surveying and could soon be picked up by anyone familiar with the telescopic alidade.

~~1924~~

English, W.A.
Some planetable methods:
Am. Assoc. Pet. Geologists. Bull, vol 8,
pp 47-54, 1924

Mather, K. F.
The manipulation of the Telescopic alidade in geologic mapping
Bull of Sci. Lab, of Denison Univ.,
vol 19, pp 97-142, 1919

~~MISCELLANEOUS~~ MAGNETIC INSTRUMENTS

Dial compass. The dial compass, a form of solar compass, is used in regions of magnetic attraction. It serves two purposes, (a) defining directions ~~and~~ from true north and (b) measuring the amount of the declination or local attraction. The principle of this instrument is the reverse of ~~a~~ that of the sun dial. The shadow cast by a thread fixed parallel to the earths axis is cast by the sun on a dial around the edge of the compass graduated in time units. The instrument is leveled and then turned until the dial reading agrees with local solar time as determined by an accurate watch. It must be remembered that local solar time varies through the year p33 on account of the "equation of time." In practice the true meridian is determined; the compass is then set up on this line and a table prepared showing the differences between watch time and time as indicated by the dial. These observations are made at intervals throughout a day. They serve to correct differences in individual instruments. ~~The theory and use of the dial compass are explained in Hotchkiss, W. O., Bean, E. F., and Wheelwright, O. W., Mineral land classification: Wisconsin Geol. and Nat. Hist. Survey, Bull. 44, pp. 86-97, 1915.~~ The instrument if properly used is accurate to about ½ degree. It might profitably be employed to orient a plane table in areas of magnetic attraction.

~~Dip needle. The dip needle is used to trace magnetic formations and~~

Dip needle. The dip needle consists of a magnetized bar so pivoted that is can swing in a vertical plane. It ~~then~~ measures the vertical component of the earths magnetism which is more important in tracing magnetic formations than is the horizontal force measured with the dial compass. Im practice the dip needle is counterbalanced so that it shows not the true direction of dip of the lines of force of the earths field but the departure from normal in that locality. As originally devised the dip needle registered only local attractions of a high order of magnitude but improvements designed by Hotchkiss have rendered it much more sensitive. Among these were: (a) addition of a level vial so that instrument could always be held in a level position, (b) an improved system of blocking the needle, and (c) a different method of counterbalancing which insures maximum sensitivity. Instruments with the last improvement are commonly spoken of a "super-dip needles." It is impossible here to explain the ~~xx~~ theory of the dip needle but references are given below. It is used largely for tracing the strike of more or less magnetic formations wherever such formations are inclined or disturbed; it is of little use in areas of flat strata. As a general thing it does not indicate directly the position of ores.

<u>Other magnetic instruments</u>. Magnetic instruments of other types are either not extensively used in this country or are still in the experimental stage. They consist for the most part in either measuring the strength of the earths field by counting the swings of a needle or by induction.

Reference:

Hotchkiss, W.O., Bean, E.F., and Wheelwright, O.W., Mineral land Classification: Wisconsin Geol. and Nat. Hist. Survey, Bull. 44. pp 86-97, 1915

CONTOUR MAPS

General. Relief may be shown on a map by various methods of shading or by contours. The latter method is almost universally used in this country, although in certain places it fails to show all the features. "Hachures" may be used for steep slopes which are not indicated clearly by the contour lines. Although the general theory of contours is simple the following formal propositions are useful.

(1) A contour line is a line which passes along the surface of the ground through all points which have the same elevation above a certain datum.

(2) Contour lines represent the lines of intersection with the surface of the ground of a plane at a definite elevation above datum.

(3) The vertical distance between successive planes is known as the "contour interval" or "vertical interval" (V. I.).

(4) The less the contour interval the greater the detail of elevations and depressions that can be shown; the size of the ~~xxxxxxx~~ contour interval is also ~~fixed~~ affected by the scale of the map since a small interval might make too closely spaced lines.

(5) The land on one side of a contour line is higher than the elevation of that line; the land on the other side is lower. If you should walk along a contour the ground on your left hand, for instance, is lower and on your right hand is higher than the elevation of the contour.

(6) Contour lines never intersect or cross one another.

(7) An even slope is shown by evenly spaced contours; a sloping plane surface by straight contours; a cliff by coincident contours.

(8) Every contour must either close upon itself within the map or pass off the area mapped at two points or a multiple of two.

(9) When a contour closes upon itself the area enclosed by it is either a hill or an enclosed depression; in the first case the exact height of the top

of the hill is often indicated; in the second case a pond or marsh is often present. In the case of small depressions a special type of contour line called a depression contour is frequently used to avoid confusion with hill tops.

(10) Maximum and minimum ridge and valley contours always go in pairs; that is, no single lower contour line can intervene between two higher ones and no single higher contour line between two lower ones. Violation of this proposition is a very common error of beginners.

(11) In crossing a valley contours bend toward the source of the stream.

(12) It is advisable to make every fifth contour line heavier than the intermediate ones. The elevations of these heavy lines are shown in a break in the line, not to the side. In very flat country it is necessary to number every line unless the exact elevations of intermediate points are sufficient to tell what the elevation of each contour is.

In addition to the formal propositions the relation between contour lines and the origin of the topography should be understood. The key to all topography is the drainage system. The location, direction, and elevation of points along streams must always be determined. The topography developed by stream erosion depends upon the length of time streams have been at work and on the materials they have worked upon. Certain areas, such as the more recent glacial drift, floodplains, sand dunes, areas of recent vulcanism, etc., have not had any stream pattern developed on them; some of these types are still being built up. Everywhere else stream lines are the control lines of the topography. Second in importance to drainage lines are divides between drainage basins or, in the case of very young stream valleys, the limits of the eroded valleys. Remember that normal streams developed in material of uniform resistance increase in grade toward their source while big rivers generally have a grade of only a few inches to the mile. In material of uniform resistance to erosion mature streams develop valleys with intervening ridges of uniform slope, rounded at the top. Where layers of rock of varying hardness occur the resistant formations make steep slopes or cliffs while the weaker ones make gentle slopes. It is therefore of great importance that the topographer understand something of the geology of the country. Of two maps with the same limit of mathematical error, one made by a topographer who understands geology is "alive" and full of meaning, while a map made without this knowledge is "dead" or "wooden" in appearance.

Methods of locating contours. The original method of locating contours, or "curves of equal elevation", was to ~~map~~ trace every contour with a level; this is sometimes done at the present day in country where the relief is low or extreme accuracy is demanded. It is evident, however, that such a procedure would make topographic maps entirely too expensive. The method of interpolation of contour lines between points of known location and elevation was then adopted. Such points should be so placed that they define the borders of plane surfaces; within these plane areas contour lines are equally spaced. Spacing of contours may also be obtained by measurements of the angle of slope of the ground and the use of contour spacing scales for each degree of slope.

Control points. The number of points whose position and elevation are needed to locate contours depends upon (1) the purpose for which the map is to be used, (2) its scale, (3) its contour interval, (4) the nature of the topography, and (5) the forest or brush cover. If the elementary principles outlined above are noted, it will be seen that one must locate and determine the elevation of all summits, saddles, low places, and changes in degree of slope. In the case of erosion topography, this means the location and elevation of points along ridge tops and drainage lines. In country where the slopes are nowhere uniform it is sometimes preferable to traverse typical cross sections of hills and valleys or to divide the country into a series of squares and determine the elevation of each corner. This method is often necessary in country which is heavily forested or has no definite system to its features. In erosion topography it is most economical to traverse the ridge tops and valley bottoms even in dense forest. The selection of the lower limit in size of valleys which must be traversed depends upon (a) the scale of the map and (b) its contour interval. In country like forested terminal moraine the method of small squares is preferable since the features follow no law or system. If great detail is needed the position and elevation of points within the squares can be obtained.

Sketching. The exact position of the contour lines after all control points are located is done by sketching. In this work persons vary greatly in natural ability to see the location of an imaginary horizontal line on the ground and to transfer this line to paper. It is the doing of this work once for all in the field that gives the plane table its great advantage over other methods. It is obvious, however, that in heavily forested country there is no advantage in the use of the plane table. Traverses with compass and aneroid are far more economical unless such acuracy is required that it pays to brush out lines for the use of the stadia. The U. S. Geol. Survey uses a tape and small plane table in brush but it is doubtful if the accuracy obtained is sufficiently greater than that of a paced survey to pay for the increased cost. One should never attempt to sketch contours in timber or brush farther than he can actually see the ground. If the map scale is small and the topographic features devoid of small details which are to be shown, then contours may be interpolated between points where the ground was actually observed. In open country one should never attempt to sketch contours which lie far above or far below the level of observation. The effect of perspective gives rise to serious errors in these cases, so that table locations on the highest summits or in valley bottoms are of little value for sketching. Sketching stations should be chosen at intermediate elevations; their locations may often be made by methods not sufficiently accurate for use in the work of obtaining control points. Never attempt to sketch the reverse side of a hill which you cannot see at all. Above all, do not attempt any sketching of contours except in the immediate vicinity of the table until you have outlined the drainage system and obtained sufficient control points. ~~Always keep in mind the fact that the geology is important in choosing these points. For instance, a certain stratum may determine a line of cliffs.~~ Viewed from below, a ridge generally appears much wider on top than it actually is. Old U. S. G. S. maps are filled with errors due to sketching from too great distances. This often led the topographers to connect portions of different streams because they had not first followed out the drainage pattern. Treat each interstream ridge as a unit bounded by the valleys on either side and work out the topography unit by unit instead of haphazard. Don't assume that there is no break in slope or concealed valley or knoll in a bit of woods just because the tree tops are of uniform height. Do not get all points on ridge tops only by intersections from below. You must climb hills and go into brush if your map is to be any better than a wild sketch. Such a rough sketch is all right for some purposes and may look better than a real map from the point where it was made, but it cannot be correct. The technique of sketching is very hard to describe; it must be learned by practice. Many approximate methods of location, such as measuring distance from vertical angles to points of known elevation, spacing of contours with slope scale on hills whose profile can be seen, etc., are valuable helps. On very steep uniform slopes do not attempt to draw all the contours in the field; draw only the top and bottom contours and possibly every fifth or heavy contour.

Generalization. As it is impossible to represent all of the smaller features of an area on a map some choice must be made as to what to show and what to omit or generalize. In this choice (a) the scale, (b) the contour interval, and (c) the purpose of the map are factors. The U. S. G. S. has steadily increased the amount of detail shown to far beyond what was once thought possible. Features whose presence is of geological importance or which are diagnostic of the origin of the topography should have preference over mere accidents, like big bowlders on a talus slope. Do not choose a scale for the field map so large that much of the detail cannot be shown on the reduced map used for publication, but, on the other hand, do not use so small a scale that measuring, sketching, erasing, and drawing becomes very laborious. The scales used by the U. S. G. S. for field work are far too small for beginners. Above all, do not seek to excuse errors due to insufficient travel over the area, by blaming them to generalization.

Outline of field work. In all mapping of more than a few townships it is necessary to have better "control" over horizontal and vertical locations than can be obtained with the plane table alone. The measurements of location by primary triangulation (trigonometric survey), primary traverse, or primary leveling all belong to the field of the engineer. This kind of work is ~~usually done by government bureaus~~, seldom done by a geologist. In any area of more than about 15 miles square the effect of the curvature of the earth becomes apparent. A map of such an area made by plane table intersections would be on Mercator projection and the scale would differ in different parts. The matter of map projections to keep the scale the same in all parts of the map by changing directions will not be here taken up.

For small areas, sufficient "control" can be obtained by either intersections from a base line with plane table and telescopic alidade or by traversing around the area and along roads with the stadia. The purpose for which the map is made, its size, scale, etc., will determine the number of points within the area whose position and elevation must be determined in this ~~the same~~ way. When this work, called "secondary control", is all done and the horizontal and vertical errors of closure adjusted, the filling in of contours may be begun. In case the area is open and considerable accuracy is required, the remaining points needed to locate contours may be determined by stadia. Table locations for this work may be made by compass orientation using either traverse with turning points or resection from points already determined and both methods where possible. In many cases, particularly where several men are working on the area, it is better to transfer the points and elevations determined by the telescopic alidade to sheets on small traverse tables. These can be used for paced surveys and locations by resection, elevations being secured by vertical angles, hand level, or aneroid. In very dense brush note book compass traverses using the aneroid are more economical than the plane table. In areas of magnetic attraction the dial compass should be used. In some cases, as in very complex topography, two men would be an advantage since one could obtain locations and elevations off the line of traverse leaving the other to keep track of locations alone, thus following ~~parallel-ing~~ the well known methods of geological work in the Lake Superior district. The aneroid readings can be reduced at the end of the day by one of the methods outlined before and ~~the corrected~~ locations and elevations transferred to the final ~~map for use~~ in interpolating contours. Tentative contours and slope measurements should, however, be shown on the field sketch. In areas where squares are preferable to ridge and valley traverses, the size ~~laying~~ out of the squares so as to insure that all the area has been seen depends upon the nature of the topographic features as well as upon the forest and brush conditions. On erosion features in hard rocks, or in ground moraine much larger squares are possible than in a complex terminal moraine or much dissected topography. The squares are best traversed in step like form, that is north one square, east one, north again, so that two sides of each square have been previously traversed affording two checks on previously adjusted work. Unless ~~very small~~ squares less than 1/10 mile on a side are used, every stream and lake shore must be either traversed or located by intersections. The method of squares is slower than traversing of definite features, but that method is applicable only in erosion topography.

<u>Conclusion</u>. Dont't try to sketch what you can't see. Don't be in too much of a hurry to begin drawing contours. You can extend contours up or down a slope whose angle is known but it is better to simply record the angle on the map and fill in coutours later after elevations are all secured. Draw contours at

changes in slope first; the others can often be left until the map is inked in. Don't be afraid to climb hills but don't use extreme summits for sketching. Do try to sketch distant features. Go through woods along ridges and drainage lines if in erosion topography, otherwise in system of squares. Many important geological features are found in woods. In drawing contours every line worth drawing is worth drawing definitely; avoid scratchy, faint lines. An eraser is a necessary part of your equipment but by being careful to draw only what you are sure of, you can minimize errors due to repeated erasures. If you leave a line of traverse for an outlook take the table with you; you may get a much better sketching station and besides something might happen to your map while you are away. Avoid unnecessary intersection and other lines; keep careful record of these lines where they are numerous. Keep them around the edges of the sheet so that they can be extended into area being worked on when needed. Keep the map clean. Sometimes a sheet of wrapping paper with a hole over the place being worked on is a very good way, but in high winds it is apt to give trouble. It is best to ink in the map from day to day instead of at the end of a job. If the map is to be photographed use only black ink. Be sure you use the right kind of paper. ~~Inferior grades and improperly prepared papers shrink and swell very badly. In erasing on celluloid use gasoline; never alcohol.~~ If you are mapping geology show outcrops and boundaries by usual symbols. If you are preparing a map for a geologist exact elevations marked on the map near outcrops are often of great value. Exact elevations of bodies of water, hill tops, road intersections, land corners, sags, and saddles in divides are all important to a geologist. Exact location and elevation of springs may also be valuable.

Geographic nomenclature. The names of all geographic features should be shown on a finished map. Great care should be taken to find the names actually used by the inhabitants of the region; you are not called upon to criticise their choice. Never make up names of your own unless you are certain that no name has ever been previously applied to the feature. Avoid duplications of names elsewhere and under no circumstances name a feature after a living person (unless possibly someone of great eminence). Avoid long and clumsy names and such terms as "Little", "North Branch," etc., in naming forks of rivers.

Finishing the map. Plane table maps should be inked in as soon as possible after the completion of the field work, if possible in the evenings and on rainy days. Waterproof inks should be used. If the map is to be photographed it is best to use only black but if it is to be traced or engraved, then the three colors used on U. S. G. S. maps may be employed with geologic data in a fourth color. Blue is difficult to photograph.

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Reproduction of map. Maps may be reproduced by photography in several ways. The photostat gives white lines on a dark background. Glass plates can be used for prints which show dark lines on a white ground. Zinc cuts are made for printing on paper. In case the size of the photographed map is to be very much smaller than that of the original great care must be taken to avoid narrow spaces and sharp angles between lines which might blur in printing. Cut out parts of lines where necessary. This is especially the case in zinc cuts. Maps can also be re produced by tracing. Information is readily transfered from one map to another of the same scale by tracing on tracing paper in pencil. Then lay the tracing on the other map with a sheet of carbon paper beneath and then trace with hard sharp pencil of steel point. Tracings used for blue or white prints must be made wholly in black. It is best to use only the dull side of tracing cloth

Copy for zinc cuts: must be all in black. To make cuts from colored maps have them first photographed with proper color filter on a panchromatic plate.

at end of ¶

especially if the map is to be photographed. Erasures may be made with razor blade or ordinary eraser. Remember that both tracings and blue prints shrink irregularly and therefore graphical scales must be shown. Engraved maps for publication are made by photographing onto metal or stone plates. The lines are then cut in with a steel tool. Separate plates have to be made for each color.

General hints on drafting maps. Systematize your work -- for instance do all roads, then all water features, then all contours, etc. Never draw freehand any line, however short, which is intended to be a straight line. Use proper instruments and measurements to construct right angles, parallel lines, or circles, however small. Contour, swivel, or Paysant pens can be used for some curved lines; they insure evenness of width. Use guide lines for all lettering. Do erasing slowly; never try to hurry. Wherever possible place all lettering parallel to bottom of map. Where lettering cannot be horizontal incline it so that it can be read from the east side of the map. Balance the size of letters to importance of places named. Follow a U. S. G. S. map for styles but avoid fancy lettering. Plan your lettering so that it will not obscure important details on the map. Place your title in lower left hand corner if possible. The words "map of" are often unnecessary. Give name of organization you are working for, date, name of chief of party, names of instrument men, graphic and at least one other form of scale, magnetic and true meridians. Fancy borders are generally not needed. Remember that all of your work including field notes is the property of your employer. All your work must be in such form that anyone else can "take over" at any time. No one is infallable; check all your work and if possible, have someone else also check it.

General. The subject of photographic surveying is introduced not so much because of its importance to geologists as because it is a good method to learn topographic mapping indoors. Photographic surveying has the advantage that it requires less time in the field than do other methods. In regions where much ardous climbing has to be done and weather is uncertain it has had a large application.

Theory. The office work with photographic surveying is essentially the same as the field work with the plane table. Given the locations from which the pictures were taken, the loc. ~~bearings~~ of objects shown is easily found when ~~in~~ two or more views from different stations show the same object the ~~are obtained by~~ intersections are obtained when these angles are laid out on paper. Elevations can ~~also~~ be determined by obtaining the vertical angles after distance has been found. ~~Solutions can be made graphically.~~ If a photograph were made transparent and held in front of the eye of an observer who was at the same place that the camera had been ~~was~~ it would have to be just as far in front of the eye as it was back of the center of the lens in order to just register with the real view. This distance is called the focal length As the photograph with an ordinary camera is a plane it is evident that the distance from the center of the photograph, assuming the camera to have been held horizontal, to any object is proportional to the tangent of the angle between the line to that object and the optic axis of the camera. All points on the same level as the camera are shown in a horizontal line and all objects at the same horizontal angle ~~in a~~ ~~direction~~ from the optic axis ~~are shown~~ lie in a veritical line. It is therefore possible to draw straight lines on the view through all points haveing equal angles above or below the level of the camera and having the same horizontal angles to left or to right of the optic axis. The location of the intersection of the optic axis and the picture is not always the center of the picture since some cameras have a "rising front" and the upper part of a photograph is sometimes trimmed off. The U. S. Geol. Survey has used the panoramic Kodak to a considerable extent. In this instrument the film is curved in a semi circle and the lens revolves so that a total angle of about 126 degrres is included as compared with

35 to 45 degrees in most ordinary cameras. As a consequence of this construction horizontal distances from the center of the view are proportional directly to the angles. Vertical ~~directions~~ angles are shown in same way as ~~with~~ in ordinary pictures. This difference accounts for the peculiar curved effect noticed in photographs taken with ~~this type of~~ the panoramic instrument. ~~This peculiar perspective has to~~ and must be taken into account when drawing contours~~, from these pictures~~. ~~Inxorderxtoxstartxworkxwithxaxcameraxsurveyxitxisxessentialxtoxxx~~

Computations. In order to carry out a camera survey it is necessary to determine accurately the positions and elevations of some of the points later to be shown in photographs or from which photographs will be taken. This is usually done with either the plane table or ~~with~~ the transit. In working with ordinary pictures thise points are identified and used as reference pints. Plat them on a map and then determine the horizontal direction of the optic axis at every camera station. At a distance from each equal to the focal length of the camera or distance from center of lens to picture, plat perpendiculars. On these lay off the actual picture distances to right and left of the vertical plane through the optic axis, of objects shown in the p icture. These objects lie ~~in~~ on the map somewhere in ~~on~~ the lines which join these points with the camera station point. If this is repeated with different views of the same objects locations are obtained by intersections. Use of threads obviates drawing many lines on the paper . Similar proceedure is followed ~~for~~ with vertical distances above or below the camera. Note that distance from the picture to the center of the lens is not everywhere the same ~~in all parts~~. Allowance for this is made in computation. Draw a horizontal line for the optic axis; at proper distances on this from a point which represents the center of the lens erect perpendiculars. Obtain these distances for each point of which the elevation is desired by scaling them from the construction ~~for~~ location. At distance from camera location ~~corresponding~~ equal to map distance of point as found by intersections, erect other perpendiculars. Now scale off on first perpendicular the picture distance of the point above or below a horizontal line through the optic axis. The line between point thus determined and the location of the camera is then drawn. On second perpendicular then scaled difference of elevation is with same scale as that of the map. If constructions are made on cross section paper and a thread instead of a line is used the sheet is kept cleaner. In the case of the panoramic Kodak the number of degrees per inch of horizontal distance is easily determined. Lines of equal bearing can be drawn on the ~~map~~ photograph and then directions can be laid off with a protractor. Other constructions are the same. A further extension of this method is that where the elevation of a point in the picture elsewhere than on the level of the camera is known then its distance can be estimated by working the difference of elevation backward.

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THE UNITED STATES SYSTEM OF PUBLIC LAND SURVEYS

Introduction. The public lands of the United States extended west from the east line of Ohio, north of the Ohio River, and west of the Mississippi River with the exception that Mississippi, Alabama, Louisiana, and Florida were also inluced; large parts of Texas and California as well as smaller areas in other states were privately owned at the time these regions were aquired and were therefore excluded from the survey. According to law the public lands were to be divided into tracts six miles square, known as "Townships", with north-south and east-west boundaries. These were to be subdivided into 36 sections each a mile square. The system of surveys is important to geologists because (a) it affords a means of describing points where notes were made in a manner such that anyone could find them, (b) in examining private lands their boundaries must be found, (c) land divisions must be found in order to show them on new maps, and (d) land divisions are an immense help in finding ones location on a map.

Base lines and meridians. Surveys were started from many initial points, sometimes several in the same state. A true east-west line was run through the initial point and called the "Base Line". A true north-south line was run through the same point and called the "Principal Meridian." Every six miles on the base line township corners were established. "Range Lines" were run true north from each of these for from 24 to 60 miles. Points six miles distant from one another on these were joined by east-west lines called "Township Lines", thus forming townships. On account of the curvature of the earth townships thus surveyed became narrower and narrower the farther north they were of the base line. This reduction below the legal size was compensated for by running new "Standard Parallels" either every 24 or every 60 miles on which new full-sized townships were started to the north. Such lines were also called "Correction Lines". Ends of the lines south of the correction lines were called "Closing corners" while corners for the full townships to the north were called "Standard Corners."

Numbering of townships. East-west rows of townships are called "tiers." Townships in the first tier north of a base line are each called "Township 1 North". The next tier is T. 2 N. and so on. North-south rows are called "ranges" and townships in the first row east of a principal meridian are called R. 1 E., in the next row(or range)R. 2 E., and so on. In some cases townships are numbered south of baselines and west from meridians. In Wisconsin there is only one base line, the south line of the state, and only one principal meridian, the fourth. All townships are therefore N. but there are both E. and W. ranges. The complete description of a township would reads: Township ~~--~~ 48 North, Range ~~--~~ 6 E ~~(or W.)~~, ~~--~~ 5th Principal Meridian, or usually abbreviated T. ~~--~~ 48 N, R. ~~--~~ 6 E, ~~--~~ 5th P. M. or more briefly 48-6E.

See Fig. 1.

Sections. Townships were divided into 36 sections numbered as in Fig. 2. A few of the older surveys used a different system. Section lines are supposed to be parallel to the south and east boundaries of the township and work was supposed to proceed from the southeast corner toward the northwest. The sections were intended to be exactly 5280 feet (80 chains) from north to south with the exception of the north row of each township in which all of the error in subdivision was concentrated. East and west the maximum discrepancy in a section was supposed not to be over 33 feet (50 links), except that all discrepancies, as well as the effect of convergance of the range lines, were concentrated into the westermost row of sections in each township. As a matter of practice few section lines are straight lines for more than one mile and few are exactly north-south or east-west. In some of the older surveys, as in southern Wisconsin, no attempt was made to join section lines to the corners laid out on the north township line and as a result every township line shows slight offsets between the corners for the township to the south and those for the township to the north although the township lines themselves run straight through. None of either the west or the north sections of a township are ~~really~~ squares. A given section ~~is~~ would be described as Section 21, Township 47 North, Range 19 East, 4th P.M. or more commonly Sec. 21, T. 47 N., R. 19 E., 4th P. M., or still more briefly 21, 47-19 E. In the last method the designation Section and North have been omitted where no ambiguity is caused thereby.

Subdivision of sections. The government surveyors placed "quarter posts" at half mile intervals on the section ~~lines~~ and township lines; lines connecting these divided the normal sections into quarters of 160 acres. The points of intersection of the two "quarter lines" in the centers of the sections were not marked but were left to later surveyors. A quarter section ~~is~~ would be described as the northwest quarter of section 5, usually abbreviated to NW¼, Sec. 5 or simply NW 5. In the north and west rows of sections the quarter posts were set a half mile from the south and east boundaries respectively thus throwing all deficiency or excess into the marginal quarter sections on the north and west sides of townships. Elsewhere in the townships the quarter posts on the east-west lines were set exactly midway betwenn the adjacent section corners (~~Note error on Devils Lake map in this respect.~~) Later, settlers wished smaller farms than 160 acres and the quarter sections were divided into quarter-quarters or "40's". These are described as, for instance, the northwest quarter of the southeast quarter of section 5, or more commonly as the NWSE 5. On the north and west sides of townships all of the deficiency or excess was thrown into the marginal rows of 40's, the others in these sections being full size. The fractional areas on the north and west sides of these sections were called "lots" by the Land Office and numbered in each section in general from east to west and from north to south. Geologists generally do not recognize lots in recording locations but treat all sections as though they had been completely subdivided into 40's. See Fig. 3

Meandering. The borders of bodies of water were supposed to have been "meandered" by lines run at angles along their irregularities but apparently when this was done at all it was very crudely executed and few "meander posts" can now be found. The odd-sized tracts were called lots and numbered as shown on the original plats which should always be consulted. For description purposes pay no attention to these lots. Adjacent to bodies of water which interrupted the usual routine of surveying there are many descrepancies in the land survey.

Cornors. In spite of elaborate rules and regulations for the marking of corners with stones, pits, mounds of earth, etc. few seem to have been thus permanently established. Generally a square wood stake was set; such stakes were marked in various ways but few original corner stakes can now be found. Corners were also "witnessed" by taking the bearing and distance to several trees which were blazed and marked "B. T." generally with the number of the section, township, and range also indicated. Most such trees have long since gone but later surveyors have sometimes made new ones. Where corners fell in lakes, ~~swamps~~ streams, etc. "witness corners" were also established on the lines as far as they could be run. Many later surveyors have set iron stakes, dressed stones, or piles of stones often around stakes. Most lines were blazed and later surveyors have reblazed them. Such blazes are generally found at the same heigth on both sides of trees on or near to the lines and can thus be distinguished from natural scars. Care should be taken not to be deceived by corners set by unauthorized and incompetent surveyors; government and county surveyors alone are authorized to reestablish lost corners. Correct corner descriptions can generally be obtained from county surveyors. Original plats are on file at government land offices, and in many states at the capitol. County surveyors also have copies and some "plat books" are also reliable. Roads are commonly laid out along section, quarter, and 40 lines and county maps are therfore a guide to locating land lines and corners. Farm boundaries are generally fenced in a more permanent manner than are lines within the property since the latter are more often changed. "Line fences" are also a guide to finding land lines; farm lines are shown on many county maps. ~~See Devils Lake location map.~~

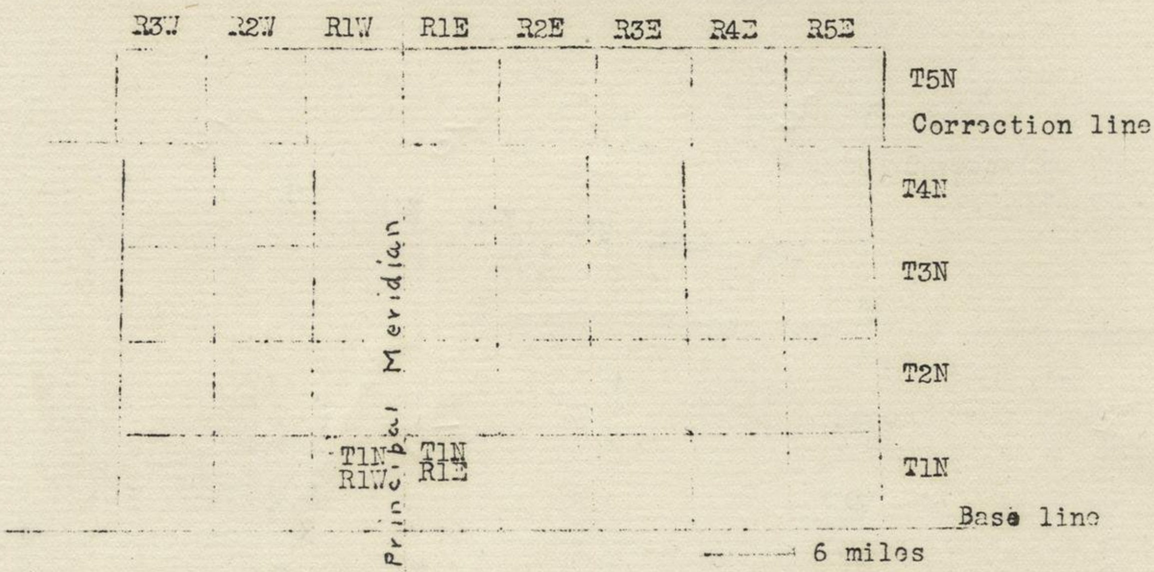

Fig. 1 Townships, base line, Principal meridian. Note that township and range numbers are given opposite middle of each tier and range.

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

1 mile

Fig. 2 Numbering of sections in a township

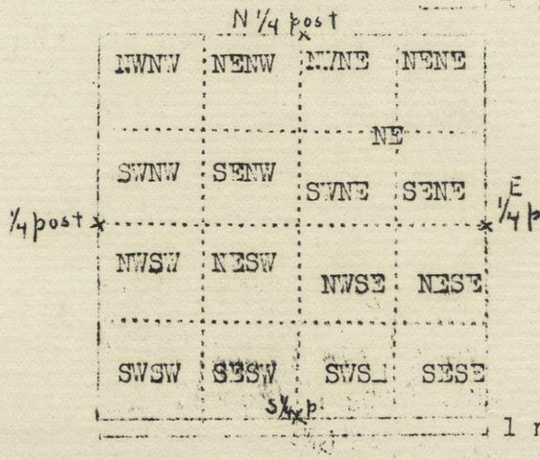

Fig. 3 Subdivision of a section

GEOLOGY 11

Conventional signs

CLUTURE (black)

Building School house Church Camp Public road in good condition

Road in poor condition or private Trail not open to wheeled vechicles

Railroad, single track Railroad, double track RR, narrow gauge or electric

Tunnel State line County line Civil township line

U. S. township line Section line, where subdivision lines are shown

Section line where subdivision lines are not shown Subdivision lines

City limits Reservation or state park line Land corners found

Triangulation station Boundary monument Well, non-flowing

Well, flowing, in rock Well, flowing, in drift Exploration drill hole

Oil wells-drilling Oil well Gas well Gas and oil well Dry hole

Dam Cemetery Bench mark B.M. Lighthouse Quarry Dump Shaft

Pit in drift Road cut Fence, barbed wire

RELIEF (if colors are used, brown)

Elevation of definite point 793 Cliff Slope, gentle Slope, steep

Undulating, gently Undulating, roughly Sags and knobs, gentle

Sags and knobs, pronounced Flat Plain, pitted Sand or wash

Sand dunes Contours, numbered 900 Make every fifth contour heavy and number it as shown

WATER (if colors are used, blue)

Stream, permanent Stream, intermittent Ditch Spring

Marsh, fresh Marsh, salt Tidal flat Lake, intermittent

Glacier or make blue contours on the ice Lakes may be left open

GEOLOGICAL

Outcrop of sedimentary rock, horizontal or unknown dip dip known
Outcrop of igneous rock Outcrop of gneiss or schist Bowlders or talus
Drift exposure (not in a pit) Gravel pit G Clay pit Cl
D=drift S=sand T=till cg= conglomerate dl=dolomite ls=limestone
sl=slate ct=chert qz=quartzite sh=shale ss=sandstone Bt=basalt
Dr=diorite Gn=gneiss St=schist Db=diabase Ga=gabbro Gr=granite
Po=porphyry Tr=trap

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GEOLOGY 11.

Map Scales. The scale of a map represents the relation which exists between the size of distances on the map and the original distances. Scales have nothing directly to do with comparative AREAS, only with DISTANCES. The scale of a map may be stated in ~~three ways:~~ (1) As a statement in words (Example 6 inches equals 1 mile) (2) By means of a line drawn on the map to represent a given ground distance. This is called a graphic scale. (3) By a fraction or proportion (the same thing) which gives the relation between distances on the map and the distances on the ground which they represent.

The first method is convenient since it conveys an idea of the scale as compared to other maps. The second should be given on all maps since it affords the surest method of measuring distances on the map, even after the paper on which it is drawn has changed in size. This is especially true of blue-prints which are wet and shrunken in the process of making. The last is called "fractional scale" and has a number of advantages. Fractions or ratios are the same in every country, so that when the scale of a map is given as a fraction, or ratio, as for instance 1:100,000, it means the same to persons of all countries. Furthermore, if it is desired to compute the distance on the map than is equivalent to any givendistance on the ground it is readily done. On the other hand, if it said on a foreign map that 1 centemeter equals 1 kilometer, one would have to go to some reference book to find the scale in terms of our units.

Methods of Measuring Distances.

Chaining. The process of measuring distances with a tape, wire, or chain is generally called "chaining" although the old fashioned surveyors chain is nearly obsolete.

Instruments. The surveyors chain, 66 feet long, is composed of 100 links. The links wear rapidly in use and are apt to catch in brush but the

PHOTOGRAPHIC INSTRUMENTS

expand this

Introduction. Geologists make use of photography mainly to (a) illustrate and supplement their field notes and (b) illustrate printed or typewritten reports. They are interested ~~mainly~~ chiefly in views of stationary objects and in clear pictures rather than in artistic effects. The following outline is aimed to supplement existing directions by emphasising the peculiar needs of the geologist.

Acknowledgements

Acknowledgements

Choice of equipment. From what has been stated above it is evident that a geologist is not interested in either cameras which are intended primarily to shorten the time of exposure for instance with a focal-plane shutter so that moving objects can be photographed, or in large bulky instruments. What is needed is: (a) a reasonable size of picture, preferably not less than $2\frac{1}{2}$ inches in smaller dimension, (b) a reasonable focal length so as to secure good perspective, preferably not less than 5 inches, ~~and~~ (c) a lens which makes sharp, clear-cut images, that is an anastigmatic lens, and (d) a light ~~outfit~~ compact outfit easily ~~carried for~~ carried in the field. It is ~~also~~ highly desirable that the camera use either (a) roll film or (b) cut film rather then a film pack ~~for the last do not always hold~~ which often allows the film ~~evenly but allow it~~ to buckle.

?X

There is no ~~no~~ advantage whatever in using plates, while their weight, fragilty, and liability to blurring or "halation" render them very undesirable for use in the field. Most comparisons ~~of~~ between work with plates and with films ~~were~~ are based upon comparisons of amature snapshots with time exposures made by professionals; where similar methods are used differences disappear. ~~Different~~ Various kinds of films are discussed later. Although there is comparatively little advantage in high-speed lenses themselves cameras fitted with such lenses generally have so much better shutters and other attachments that their use ~~of such an instrument~~ is necessary. In addition to the camera there are needed (a) a tripod which is rigid in considerable winds, (b) not less than two color filters, (c) some form of lens hood, (d) an exposure meter, and (e) a tin box in which to keep the camera when not in use. For use in hilly country it is very desirable to choose a camera with a rising front and if possible one where the ~~lens~~ lens can be changed so that ~~it can be used~~ both ~~for~~ near and ~~for~~ telephoto views can be taken.

Stops. In order to get good results with a camera it is essential to understand that the amount of light which passes through the lens is regulated by changing the size of the aperture. The several standard apertures or stops are in the better grades of cameras designated by a figure preceded by the letter f. Since the number is the denomenator of the fraction which the diameter of the opening is of the focal length, the larger the number the smaller the aperture. The figures in common use are, with the exception of the largest opening, so calcualted that each sucessive higher number gives exactly half as much light as the next smaller number. There is no appreciable difference in the exposure required by lenses of different makes when the same stop is used. Since a geologist always desires a sharp, ~~and~~ clear view in which objects not in the same plane are all equally definite it is necessary to use as small an aperture as possible. A further advantage of a small stop is that all ~~even cheap~~ lenses give much better results when so used than when opened up to the widest possible extent. With a small stop exact focusing on the principal subject is not necessary, for the distance within which all objects will be sharp is much increased. This distance is called depth of focus. Maximum depth of focus is generally obtained by setting the focus to 25 feet and using the smallest opening. The range finder which is supplied on the larger Special Kodaks and ground glass focusing screens are ~~is~~ alike unnecessary for most geological work. The accompanying diagrams (figs. 1&2) show some of the relations between depth of focus, aperture, and focal length. It is evident that increase in the last ~~latter~~ is at the sacrifice of the first ~~former~~, although this is minimized by using the smallest stop ~~aperture~~ and is offset by the vastly better perspective given by a long focus lens. Lenses must always be kept clean with a soft piece of linen.

Exposures. Recording of a photograph depends upon the relative number of particles of silver compound affected by faint and by intense lights. The stronger the light the darker the resulting negative. Making of a print, or positive, reverses the above conditions so that the strong lights are white and the deep shadows are black. Hereinafter, when photographic reproduction is discussed the positive is referred to and not the negative. In order to regulate the ~~condition~~ quality of the picture ~~with~~ in different intensities of light the duration of the exposure must be changed to meet the~~se varying~~ light conditions and this is what causes the greatest difficulty in photography. Correct exposure requires ~~ki~~ long enough action of the light to secure differentiation between varying degrees of shadow. Most modern photographic films have sufficient ~~latitude~~ latitude of exposure within which the differences in the results are not very marked, to permit of both (a) merely a rough determination of the necessary exposure and (b) photography where the light varies greatly in different parts of the picture. In spite of this fact, to secure best results it is desirable to take photographs of many kinds of subjects in shade rather than in a mixture of shade and sunlight. ~~Especial care must be taken that the sun does not shine directly into the lens and it is also desirable~~ to avoid views in which bright sky and objects in shadow ~~are seen close together.~~

Classification of subjects. With reference to exposures, subjects ~~must~~ may be divided into the following groups: (a) normal scenes in which the ~~prix~~ principal objects are distant over 24 times the focal length of the lens and are less than 500 feet from the camera, (b) close-ups with objects less that the smaller distance noted above, which is usually about 12 feet, and (c) distant views in which the principal objects are more than 500 feet from the instrument ~~and a large part of the area is of sky~~.

Exposure meters. The approximate exposures for the above classes of subjects in clear sunlight, and in lights not far different from that, can soon be learned, but when photographs in deep shade, close-ups of rocks, and extremely distant landscapes are taken, ~~then~~ an exposure meter is absolutely necessary. The only type of such an instrment which is of any value is one of the <u>actinometer</u> type. So far as the writer can determine there are only three makes of these, all German; these are handled by dealers in photographic supplies and sell at ~~from~~ $1.75 to $10.00. These meters are based on the measurement of the strength of the light by means of a movable glass wedge. The meter is held to the eye and adjusted until the detail which it is desired to show is just obliterated. Care must be taken to read rapidly before the eye becomes accustomed to faint light for otherwise too short an exposure will be measured. Some instruments read exposures for normal subjects directly and others require the use of a table with a correction factor for different makes of film. The exposure for normal scenes in full sunlight in the summer months with f 45 is 1 second with most films. Close-ups in the same light require from two to three times normal exposure because as the lens is drawn out the amount of light taken into the camera is reduced. Moreover, it is necessary to show nearby objects in much greater detail than distant ones. On the other hand, very distant subjects ~~objects~~ cannot be exposed long enough for complete detail without risk of <u>fogging</u> the picture by excess light from (a) the sky, which forms a large part of such distant view, (b) stray light, which enters the lens and not being needed for the picture is scattered from the inside of the bellows, and (c) dispersed rays from the dust and water particles in the air. Unless some extra device is used to minimize these troubles attempts to photograph very distant landscapes will be failures although the exposure would have been correct for nearer objects. Such methods comprise (a) filters, and (b) hoods, and are discussed below. With no such aids the best that can be done is to keep the exposures as short as possible, about 1/5 second under conditions and with materials mentioned above. The directions given with some exposure meters are incorrect on this point and must be disregarded. Reduction of exposures applies no matter how clear the atmosphere appears to be, but must be ~~increased~~ magnified when mist, smoke ~~ar~~ are present ~~with fag~~ or dust to such an extent that it is sometimes impossible to get satisfactory pictures ~~under such conditions~~ if the bare lens is used. Some landscapes with extraordinary contrasts, such as snow and rocks or snow and trees, take much less exposure than do normal views at the same distances. In Alaska views of glaciers from the sea can scarcely be underexposed, 1/100 second with f 45 being too long.

As the light diminishes in intensity, the necessary exposure increases rapidly (see fig. 3) ~~and~~ It is generally best to err on the side of too long rather than too short exposures because just as much detail as possible should always be shown.

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In taking exposures from some tables it is necessary to realize that not all the figures there given are speeds built into ~~kax~~ ordinary shutters and to take the next longer exposure. In general, the neceassary exposures will be from 1/2 second to over a minute so that the necessity for a rigid tripod is apparent. It is best to use time rather than bulb exposures and to use a watch rather than to attempt to count seconds. In fact, a shutter for the use of a geologist need only have "time" and one instantaneous speed. Moving water and slowly moving cattle over 100 feet away do not necessitate instantaneous exposures which, no matter how much you paid for the lens, involve the sacrifice of depth of focus and of extreme detail. If it is very windy it is necessary to avoid moving trees and plants which are closer than 100 to 200 feet if a time exposure is taken. Where exposures exceed several seconds rapidly-moving persons or animals will not register at all and may cross the view without imparing its sucess in the slightest.

<u>Checking the exposure</u>. Directions with exposure meters are not always correct and if speeds built into the shutter are used, it must be realized that they may not ~~always be~~ give anything like the ~~times~~ exposures which were intended. It is therefore best to expend a roll of film in experimental work with exposures on the same object varying in length by several hundred percent. A careful record of these exposures should be kept and the negatives examined with this in ~~hnd~~ hand. This procedure will fix individual correction ~~facxxx~~ factors for the particular person, season, and region in question. It must be recalled that the use of exposure meters involves a very considerable <u>personal equation</u> and the geologist must practice ~~with~~ making readings until uniformity of results is attained. Underexposed negatives are thin and lack detail; overexposed ones are very dense and black to gray so that detail is obscured. In rare instances overexposure may go so far as to make very bright objects reverse and show light where they should be dark in the negative. Examination of prints tells little as to exposure since errors may ~~be~~ have been made in the length of their own exposure.

<u>Leveling</u>. It is absolutely essential that the camera be level, for otherwise the pictures are badly distorted. In fairly level country all that is generally needed is to sight across the top of the camera both ways to the horizon. In rough country, and when the best results are desired, the use of a level is necessary. Some cameras have attached levels but if none is furnished either a special level must be carried or a Brunton compass level ~~must be~~ be used.

<u>Panoramas</u>. It is often desired to take several pictures from the same location the prints of which are to be fastened together to make a panorama. For economy of films it is desirable that as little overlap be made as possible. Here the use of a ground glass focusing screen is vastly to be preferred to a <u>finder</u>. Many finders do not tell anything like the truth as to the included view. To check a finder remove the back of the

camera when it is empty and place either a sheet of ground glass or a sheet of tracing cloth or tracing paper over the rollers which carry the ~~film~~. film. ~~Now~~ With the camera placed on a tripod compare the view seen in the finder with the actual view which will be recorded on the film. The view in a finder can often be examined with a pocket lens so that more detail can be observed than with the naked eye. Care (a) to always hold the eye directly over the center of the finder and (b) to watch the same object in turning the camera will usually prevent excessive overlap or failure to overlap. Finders reverse left and right. In mounting the prints make the line of junction midway between the two edges but trim only one of the prints to this line so that in case of faulty cutting or pasting no gap will be left. Special cameras like the Panoramic Kodak, are made especially for panorams but their use as regular equipment cannot be recommended; the pictures which they produce show a curved distortion which is just as objectionable as the angles between straight lines in adjoining views taken with the ordinary camera.

The rising front. In order to take pictures of objects much above or below the level of the camera a device called a rising front is often supplied; such an attachment is very desirable, if not indeed absolutely necessary, for work in rough country. Even on the plains, undesirable foregrounds may be eliminated with this device. In the folding of the camera after use it must be remembered to put the rising front back to normal position.

Hoods. The light admitted by a lens is in the form of a cone ~~while the film~~ only ~~covers~~ a ~~comparatively~~ small protion of whose ~~the~~ base ~~of this figure.~~ is covered by the film. The actual light which is used is in the form of a pyramid inside the cone. The excess light is supposed to be absorbed by the black sides of the bellows but in practice this is not completely done and much of it is dispersed to cause fogging of the picture. Dispersion is worst when the camera points toward the sun; the same phenomenon may be seen in field glasses looking in the same direction. Even if the sun is not visible in the picture any sunlight which falls on the lens is dispersed and causes bad fogging.

Much can be accomplised by shielding the lens from the suns rays with the body of the operator, a hat, book, or other opaque object, but if the best results are desired a <u>lens hood</u> must be employed. These are usually made in the form of a truncated cone fitted around the outside of the lens mount. The angle of the cone can be calculated graphically from the diagonal of the picture and the focal length. It is best to make the cone longer on the top than on the bottom and to make it take apart with snaps so that it can be carried flat. It should be lined with black velvet to reduce reflection of light on the inside. A much better device has been constructed by the writer; this consists of a box lined with velvet and of such dimensions that the light which reaches the lens is formed into the necessary pyramid. The dimensions of the box can easily be calculated from the focal lenth and the dimensions of the picture. Mounting on the lens can be accompished by using a filter to hold the box on the lens or by supplying a special split tube to slip over the lens mount. The box might be made to fold but as it is a convenient place to carry filters and other attachments it may be made of metal and ~~covered with~~ carried in a bag. The use of a lens hood is of most value (a) with telephoto cameras, and (b) when views are taken toward the sun, but it is probably of some value in nearly all cases and its wider use is strongly recommended by ~~some authorities~~ many experts.

<u>Light and color</u>. In order to understand the use of filters it is first necessary to review the nature of light and color. Light is now interpreted as a wave motion in the so-called <u>ether</u>. Sunlight which is passed through a prisim is divided into different wave lengths some of which are not visible to the eye. The very short invisible rays are called <u>ultra-violet</u>, then comes the visible part of the spectrum ranging from violet through blue, green, yellow, and red to long invisible "<u>infra-red</u>" rays. The color of objects illuminated by daylight is due to absorption of certain portions of the spectrum, ~~as follows:~~

Reflected Color	Absorbed or complementary color
Red............	Blue and green
Yellow.........	Blue
Green..........	Blue and red
Blue-green......	Red
Blue...........	Green and red
Purple.........	Green
White..........	None
Black..........	All

Sensitivity of films. The natural sensitivity of ~~films~~ silver compounds and of the eye to colors is widely different. Inasmuch as no commercial process of photography in natural colors has yet been perfected the best that can be done is ~~to attempt~~ to reproduce the different colors in varying shades of gray ~~so arranged that their~~ whose intensity is proportionate to their apparent brilliance. ~~of the different colors.~~ For instance, reds should not be as dark as black but should be ~~rendered~~ darker than yellows, and blue should be darker than yellow. Unfortunately the chemical activity of the light increases with decrease of wave length, that is the blue, violet, and invisible ultra-violet rays are much more powerful in their effect on the film than are the longer rays, although some of the latter appear more brilliant to the eye. ~~and in fact the ultra violet rays are entirely invisible.~~

Kinds of films. Films may be divided according to their sensitivity, into three kinds: (a) ordinary or blue violet light films, (b) orthochromatic or violet-blue-green-yellow light films and (c) panchromatic films sensitive to light of the entire visible spectrum. The differences are due to treatment of the silver emulsion with different kinds of dyes. ~~Different makes of film also differ in the size of the particles of silver compound~~ and hence in the amount of detail that can be recorded. ~~In spite of all treatment, however, all kinds of films are disproportionally affected by blue and violet light.~~ Only the first two kinds of film are sold in rolls and film packs. In choosing a film it is necessary to enquire carefully as to the class in which it ~~is placed~~ belongs and in some instances, tests show that the makers claims are ~~untrue~~ misleading. ~~Testing will soon convince one as to on this point.~~ Panchromatic film is sold only as cut-film which must be used in plate-holders.

<u>Color rendering of films</u>. All kinds of films, no matter how much corrected for color, are chiefly affected by blue and violet light and there-fore these colors are rendered too light on the prints. With ordinary film no difference can be detected between white and blue, while ~~and~~ yellow, orange, and red all render the same as black. In some cases, yellow, orange, or brown will render darker than red. In all cases it is impossible to get much detail in any of the colors ~~as mentioned above~~ whose wave lengths are longer than the film is sensitive to. Orthochromatic films render green and yellow much better than do ordinary films but do not differentiate between orange, red, and black; they also show blue too light. Panchromatic films are much better, but the necessity of loading and unloading, plate holders either by the light of a faint green lamp or, if this cannot be secured, in absolute darkness, coupled with the greater difficulty ~~s~~ of development render their use in the field rather too difficult for general application. Films with a very fine grain of silver compound are very desirable because of the much improved definition and increased amount of detail which is rendered. The best films are of foreign manufacture but cost no more than do inferior American films. It is reported that there are no American orthochromatic films of dependable quality.

<u>Filters</u>. The supersensitivity of all films to blue and ~~xxx~~ violet light is overcome by the use of a medium called a <u>filter</u> through which the light passes and which absorbs all the ultra-violet and some ~~or all~~ of the blue and ~~xxx~~ violet rays. A large part of the very active ultra-violet is absorbed by the glass of the lens in any event. Filters are of ~~to~~ two general types: (a) <u>orthochromatic</u> (isochromatic), or intended ~~simply~~ to correct the rendering of color values, and (b) <u>contrast</u>, or intended to increase color differences and to show detail in colored objects. Filters are generally made of stained gelatin placed between two sheets of glass which are enclosed in a metal cell to slip over the lens. Filters for ~~For~~ very long focus lenses ~~cameras it is essential to use~~ require the very best quality of glass ~~mounting~~ which is very expensive. Filters accomplish little with ordinary films. Orthochromatic films of the best quality give good results ~~will photograph well~~ with orthochromatic filters

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wh~~ii~~ch exclude a large part of or all of the blue and ~~ult~~violet light. Panchromatic films can be used with ~~all~~ both kinds of filters; when a fully correcting orthochromatic filter is used then color tones are rendered as nearly correctly as possible. ~~Unless the subjects contain much dark red the use of panchromatic film is not recommended, for good orthochromatic film will give satisfactory results.~~ The use of an orthochromatic filter improves all pictures on both orthochromatic and panchromatic films and it should be employed whenever one is not forced by circumstances to use a very short exposure. ~~provided real orthochromatic film is obtained.~~ Filters must be kept just as clean as the lens.

<u>Color contrasts</u>. If a colored subject is photographed with a filter of its own color it appears light and markings on it ~~will be~~ are well defined. Yellow rocks should be photographed with a yellow filter if ~~bedding planes~~ grain and lamination are to be shown. A green filter serves to differentiate sharply between greens and reds even with orthochromatic film. Red and orange filters can~~not~~ be used ~~except~~ only with panchromatic film. It must be remembered that such contrasts are at the expense of truthful tone rendering. If a colored object is photographed through a filter of a color which it absorbs, it photographs dark and no detail can be shown. The effect of different filters can generally be obtained by simply looking through them at the object, remembering the limitations of the film. The proper use of filters to secure detail in close-ups of rocks is a study worthy of serious consideration by every geologist once the true reason for the complete failure of most such pictures is appreciated. Although there can be no question but that ~~the use of~~ ~~where much red is shown~~ panchromatic film is most desirable for such work. ~~Close-ups with ordinary film are almost always a pure waste of time and effort. but~~ orthochromatic films are satisfactory where there is no red in the view and are much less troublesome to use.

<u>Penetration of haze</u>. Even when the air appears very clear, as after a rain, there is more or less dust, water vapor, and smoke in it. When these substances become ~~more~~ abundant ~~it is said that the~~ visibility is ~~low.~~ impaired. Geologists cannot always afford to wait for ~~the best~~ clear weather to take photographs and in some climates such a wait would be forever. ~~If a photograph is attempted when the air is thick the result is overexposure~~

~~if the usual exposure for distant views is used with a bare lens~~ and ~~or if the~~ ~~exposure is~~ ~~out~~ much reduced ~~a total blank results. This is because the particles in the air disperse the light and form a secondary source of excess light~~ resulting in fogging. Dispersion due to haze etc increases with decrease of wave length so that the remedy is a filter which will take a photograph by the longest wave length that the film is sensitive to ~~and~~ completely excluding all shorter wave lengths. Such filters are limited to deep yellow with orthochromatic films but orange or red filters can be used with panchromatic films. These are contrast filters and nearby objects are then rendered with exaggerated effects known as <u>over-correction</u>. A further difficulty is that since shadows are lighted by dispersed and reflected ~~light~~ light which is mainly blue the use of such filters destroys shadow detail to an enormous extent. The use of contrast filters should therefore be confined to the photography of very distant ~~objects~~ landscapes under conditions which absolutely necessitate their use. When the air is clear an orthochromatic filter is better. Even the best filter will not remove all the haze if it is very bad; with the best films commonly obtainable filters push back the veil for many miles but do not remove it completely. The remarkable photographs of Mars and some airplane photographs were taken with special plates which are sensitized to infra-red rays and these cannot be kept long enough to use in the field. ~~to any considerable extent~~. Ordinary ~~"~~ray filters~~"~~ or ~~"~~sky filters~~"~~ should never be used for these purposely let in enough blue and violet light to fog the distance and give the "atmosphere" effect so desired by artists and so ~~much undesired~~ detested by geologists and physiographers. The effect of a filter in removing haze can generally be estimated by looking through it; a deep filter is a great help with field glasses in hazy weather.

best method = fail

Exposure with filters. It is evident that the use of a filter necessarily involves an increase of exposure. This increase should be obtained without sacrificing the desirable small stop unless it is absolutely necessary to take an instantaneous exposure. The multiplying factor ~~of~~ applied to ordinary exposures is called the filter factor; it is variously computed by different manufacturers and should be tested by actual use. It should be applied to the exposure determined with the meter for normal views, not to the reduced exposure recommended for distant views with the bare lens. ~~Increase of exposure for close-ups is not affected in this manner.~~ Orthochromatic filter factors with ~~and orthochromatic filters~~ orthochromatic film range from 2, to 12; strong yellow filters used for distant views on hazy days ~~take~~ require a factor of 20 to 30. With panchromatic films factors are much less since the increased sensitivity to long wave lengths permits shorter exposures. In general, close-ups require larger factors than do distant landscapes because of the increased detail which must be rendered. Not all filters with the same name have the same factor, hence the need for experiment. Statements to the effect that filter factors can be determined with the aid of the exposure meter are incorrect.

Choice of subjects. The proper choice of subjects can only be learned by experience. Some geologists seem to think that only unusual features need be photographed and then when illustrations of typical common features ~~is~~ are needed none is forthcoming. It is also well to remember that the necessary limitations of photography in the rendering of colors may make some subjects undesirable, particularly if ordinary or orthochrmatic film is used. It is essential to realize that the camera shows everything in the field of view both above and below the horizon; it cannot skip the foreground or omit the unessentials. Many a view which is instructive to the eye is in the photograph mainly a fence, ~~or~~ a field, or a brush patch. In level country the rising front will sometimes enable one to cut out ~~such~~ undesirable foregrounds but it is better to take the picture from some ~~slightly~~ elevated position such as a dump, a railway crossing, or even a large stump. In taking a view along a road or railway the camera should be set at the side and not in the middle. The best results in landscapes are when the shadows fall across the view and not directly toward or away from the camera. Although distant landscapes are in all cases best in clear weather, close-ups are often better in moderately cloudy weather or when the subject is in shadow. /p16 Avoid subjects where more than five times the exposure is required in one part of the view than in the other part. ~~or where bright sky or too close to shadows~~ stet ~~Many views are ruined by the presence of too much vegetation which is neglected by the eye but with the photograph serves only to confuse.~~ Some types of topography, such as terminal moraines, are very hard to photograph. In some instances it is best to take photographs when the shadows are long rather than near midday. Undrained hollows are best shown just after a rain when they are damp or filled with water.

Scale. A very common fault is to fail to show the scale of a photograph. Something of recognizable size must be included in every view of nearby objects; this may be a hammer, notebook, camera case, etc., never a coin for that is illegal and may make diffuculty in getting prints from some photographers. If the distance is moderate, a person should be shown in the picture; a self-timer is often helpful for this purpose when the geologist is working alone. Since most self-timers work only with the speeds built into the shutter their use often necessitates the use of a larger stop than normally in order to get sufficient exposure. Self-timers which work by clockwork are dependable but those which operate by leakage of air are very freakish in operation and are more nuisance than they are worth. This accessory is also very convenient for camp scenes in which it is deisired to show the entire party.

Tobler

Flashlights. It is sometimes necessary to take flashlights in order to get views underground. Ordinary directions are of little value for this purpose for the flash will in general have to be much more powerful than is recommended for rooms with dark hangings. It must also be recalled that the intensity of the light decreases with the square of the distance.

Unless the contrasts ~~of~~ between light and dark objects are very clear underground views are likely to be disappointing until the photographer has had a great deal of experience. The same remark applies to flashlight camp scenes.

~~Miscellaneous~~ Groups. It is often necessary to take pictures of groups of persons. These should never be taken in full sunlight since someone is sure to make a disagreeable face on account of the glare. They should be taken either in shadow or on a moderately cloudy day; the north side of a building is a very good place. Hats should be removed and the group inspected from just in front of the lens to avoid reflections from glasses. It is almost always necessary to use a large stop with a group for someone is almost sure to move if the exposure exceeds a second.

Filter for freckles

Developing. Except in the tropics field development does not pay for. It is too hard to control temperatures or get an adequate supply of clean wash-water. Special directions are furnished for development under high temperatures such as are there encountered. Films must be carefully protected from both (a) moisture and (b) excessive high temperature both before and after exposure. They should be kept in tins or other metallic containers, sealed with tape. In this connection it should be noted that Autographic films suffer much more readily from both these enemies than do other films and should never be used in the field. if conditions are bad Films are mailed at owner's risk and must therefore be carefully protected for shipment. It is best to send them by first class ~~mail~~ registered mail. Films should never be taken to drugstores or to small-town photographers who do not specialize in such work. Many of these do very poor work and use poor material; few of them have ever seen anything in films ~~but~~ except ~~mediocre~~ poor amateur snapshots and expect nothing better. Spotting, scratching, touching of films in developing tanks, and use of old and dirty developer ~~and~~ or fixing bath are common sins of these sloppy "finishers." It is not easy to find a good photographer who will give proper attention to development of films. In judging results it must be remembered that longitudinal streaks on roll films are almost always due to touching in the ~~dak~~ developing tank. A stuck shutter makes a light spot in the centers of pictures. A light leak in the camera makes a light line which is generally in exactly the same place on ~~the~~ every picture. Poorly rolled film may make irregular spots along the edges, ~~of film~~. Films must always be handled by the edges to avoid fingerprints. They should be filed in albums made for the purpose.

Prints. Prints should always be on glossy paper of the kind which shows contrast and detail to the greatest degree. Such paper has been treated before sensitizing so that it is much smoother than the soft finish which was once demanded by nearly everyone. Prints should be mounted soon after they are made for if kept ~~too~~ long they seem to curl more and more. Paste should never be used. Mounting tissure is sometimes good for avoiding curling but the high temperature required to soften it often burns the picture. Rubber tire cement avoids curling but sometimes causes staining. DuPonts nitrocellulose "household" cement is recommended by some authorities.

Summary. Good results in photography result from experience gained from the examination of negatives in connection with a record of light conditions and exposures. The proper composition of views so as to show just what is desired, the choice of filter, the determination of exposure, the setting of the shutter and stop, ~~and the~~ focusing, timing of the exposure and changing the film are all ~~processes~~ steps which demand methodical care and ~~attention to details of~~ a set routine. There is no excuse for "double exposures", or faulty focusing. The mottos of the field photographer must be "Always be careful." and "Practice makes perfect."

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