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*MINERAL LAND AND MINE SURVEYING.*

BY R. S. WEITZELL.

As the business of land surveying to some extent, and the running of lines upon the surface of the ground, is inseparably connected with mine surveying, it is, to that extent a perfectly proper subject for the consideration of this Institute; and because so closely allied, it is quite appropriate to treat them together in the same article.

We propose to give the equipment of field notes, assistants, and tools and implements, and the mode of operations as pursued by us in the survey of mineral lands and mines; all sufficiently detailed to render the whole clear and comprehensive to the profession.

The section of country to which our operations in the above named line have been confined principally, is what is known as the Hocking Valley coal and iron region of Athens, Hocking and Perry counties.

The country is very broken and rough; the summits of the hills and ridges rising from 250 to 300 feet above the level of the valleys, with very precipitous sides; the ratio of perpendicular to horizontal being in places as 7 to 15, with a great deal of about 7 to 30, and but little with as gradual slope as 7 to 100—the valleys of the streams excepted.

The surface being rough and the soil poor, a great deal of the country still remains in timber, and is universally grown up with the densest of underbrush, that great impediment to progress in the field work of land surveys.

Our practice has led to the survey of a piece of coal land, to mean, with us, the running of the boundary lines, a contour around the outcrop of the coal in case the coal crops out on the premises, and the meandering of any considerable streams and ravines, particularly that part of them lying above the level of the coal.

The equipment for running the boundary lines is as follows: of notes, a description of the property, copied from the owners deed; a little offhand pencil sketch of the property, and of that immediately adjoining, or a tracing taken off of some map of it; the original or government field notes, *i.e.*, the bearing trees to corners and lengths of the different lines, and all subsequent field notes that are on record, and generally all the field notes of the lands immediately

adjoining, to assist us in re-establishing any corners that may be lost or unsatisfactory.

Of assistants, whatever number of axemen are necessary, sometimes one, sometimes two, and sometimes three, to clear the line and make and drive the necessary plugs and stakes; then two chainmen; one of whom at least, shall be an experienced person in that capacity, and thoroughly reliable, and the other one the same, if one can be had; next a back flag man who may be a good chunk of a boy if he is thoroughly reliable and trustworthy, with the Casabiancan trait of staying right at his post until called away; and last of the party is self, who handles the transit, keeps the notes and generally supervises and directs the survey. Of tools and implements, an axe piece for the axmen, and some nails, about 4d., for the axman who makes and drives the plugs; a flagpole for the back flag man, and one for the front chainman, a one-hundred foot and a four-hundred foot steel tape line, a regular transit plummet for each of the chainmen, eleven marking pins, a piece of red chalk and last, an engineer's transit reading by vernier to single minutes.

Thus equipped, we proceed to some corner of the premises which we have previously decided, from circumstances, to make our initial point; we establish our corner, if not already in; and if we can see the next corner from this one, or can at some point, from which both corners can be seen, get in the straight line between them, or in this line produced in either direction, it is done, and the straight line between the corners cleared and measured.

But the straight line between the corners can rarely be determined at the start. We then set the transit over the first corner and by springing the needle determine as nearly as we can from this ever inconstant, changing instrument, the direction to the next corner; the needle is then lifted off its pivot and the line continued from backsights, all angles being turned by the vernier.

The axmen clear the line thoroughly, so as to give a clear and unobstructed view for the transitman and a chance for the chainmen to measure reliably, and as rapidly as possible.

As soon as a distance of one hundred feet is cleared, the measuring begins, the tape line being drawn out each time to its full length, from each full station; the front chainman coming back for

the purpose of breaking chain, when this has to be done ; by this method the front end of the tape, each time it is reached, denotes a full station, and errors are less liable to be made.

As the measuring progresses, the first chainman calls out to us the station at which the line crosses any streams or ravines and the summits of all ridges, all of which we sketch in our note book, and make the proper notes and explanations.

When the chainmen arrive at a point where it is necessary to set up the transit, a good solid stake from one to two feet long (called a plug) is driven firmly into the ground, with its top about level with the surface, and a nail driven into it, precisely in the line as determined by the transit, then another stake, (called a witness stake) is driven about a foot to the left of the plug and left sticking eighteen inches to two feet above the ground ; the side of it next to the plug is blazed smoothly, and upon this is marked, with the red chalk, the station to the nail in the plug.

As soon as the nail is driven in the plug, we move forward to it with the transit while the axman is preparing and putting in the witness stake, and the back flagman occupies the place just abandoned by us.

Plugs and witness stakes are put in, and the stations taken to them all as just described, at the crossings of all streams or ravines that we wish to meander, and also at the outcrop of the coal wherever it may be crossed, of all of which we make full and complete notes in our book.

The use of the plummets in the hands of the chainmen will be understood by the profession to enable them to carry level tape ; but besides this, their more general use, we frequently find them very convenient, and in fact almost indispensable in setting points ahead and in taking backsights where the view is so badly obstructed as to render the use of the flag poles unreliable.

The four-hundred foot tape line is called into requisition whenever it can be used to advantage, and this is quite frequent in the crossing of ravines with steep sides, saving the time and labor of clearing and measuring with the one-hundred foot tape line ; and again it occasionally happens that a triangulation is the easiest and most expeditious method of getting a certain distance, and is, of course, resorted to ; here the long tape answers a splendid purpose as our base measuring apparatus.

It is in connection with the use of the long tape that the pocket level is used to get points of the same height on the opposite sides of the ravines, and also at the two ends of the base line for triangulating.

The pocket level is but rarely used with the one-hundred foot tape, an experienced chainman being able to so nearly level the tape with his eye as to make no appreciable difference in distance.

It is not necessary to give the purpose of and manner of using the marking pins.

Corners to any subdivisions of the property we are surveying, or to adjacent property are located by ordinates to our lines.

And thus we proceed around the property, until we reach the last corner next to the one at which we began, and then, assuming our angles and measurements thus far to be correct, we compute the direction and distance to the place of beginning and start for it; and when we arrive there, we have only to intersect this last line with the first and turn the angles, and we have a check upon both the angles and measurements.

To get the magnetic direction of our lines the needle is sprung on some one of them about eight o'clock A.M. and its bearing carefully taken, and that of the balance of the lines deduced from this one.

In running a crop line we make two operations of it; first, clearing the line and putting in the points, and second, turning the angles and measuring the line.

The assistants are the two chainmen and perhaps one of the axmen, (the balance of the party being dismissed;) all of whom act as axmen during the first operation.

With the pocket level we follow the contour of the hillsides, deciding upon places where to change the direction of the line; the axmen clear the line between these points and drive a good stout stake in at each of them, letting it project about eighteen inches above the ground and then drive a nail in its top; the stake is blazed smoothly on one side and numbered with the red chalk.

These stakes are numbered in regular numerical order, 1, 2, 3, etc., instead of by stations as on the boundary lines, for two reasons: first, as the chaining is not yet done, the station to the stake is unknown; second, by the regular numerical numbering the front chainman can always tell whether or not he has missed any when chaining the line.

In this manner we proceed around the hills, up the hollows and ravines on one side until the coal passes under them, then down on the other, and so on until another point is reached where the crop is crossed by some one of the boundary lines.

In the second operation the only assistants used are the two chainmen, and of tools and implements, the transit, two flag poles, and long tape line.

The mode of procedure is as follows: we set the transit over the plug on the boundary line where it crosses the outcrop; the rear chainman gives us a sight on some other point on the boundary line, and the front chainman goes to crop stake No. 1 and gives us a sight, taking with him one end of the long tape line; as soon as we get our sight on the rear chainman we call out to him "All right," and he at once comes forward to the transit while we are taking our sight on the front chainman, and as soon as this is done and while we are reading and recording the angle, the two chainmen take the distance with the tape line and call it out to us which we at once record; we then move forward with the transit to stake No. 1, the front chainman at the same time going forward with tape line to stake No. 2, the rear chainman remaining at the point of beginning, and identically the same operations are gone through with again; these are repeated at each stake until we get around to where we again connect with some one of the boundary lines.

Meander lines of streams and ravines are run in precisely the same way in every particular.

The method of running crop and meander lines as just described we find to be the most rapid and economical and the least liable to errors; the long tape line is much more advantageous than the one-hundred foot one for this work, in as much as these lines are always very crooked and the sides are so short that the full length of each of them can be taken without breaking chain or using plummet.

Now as to the work underground; if the mine is a large one, *i. e.* has mined over considerable territory, and is one with which we are not familiar, the first thing is to get acquainted with it, which we do by making a reconnoissance of it in company with the mine boss and familiarize ourselves with it sufficiently to get along with our work without any further assistance from him. When we are familiar with the mine, and have been there and done work before,

we only enquire of the mine boss for unsafe places and what parts of the mine have been worked since our last visit, and go at once into the mine and go to work without the preliminary preparation as in the case of a mine new to us.

The equipment for mine surveying is, of assistants, the two chainmen only; of tools and implements, a drill, some round plugs of wood to drive into the drill holes, some horse shoe nails shortened to about an inch with the heads flattened and small holes punched through them, (these we call bank nails) hatchet, a piece of carpenters white chalk, a one-hundred foot steel tape and a fifty foot Chesterman metallic tape, eleven marking pins, some common nails, about 8 d., a piece of lead or cast iron 2 to 3 inches in diameter and  $\frac{3}{4}$  inch thick with the center on one side very plainly and definitely marked by a cross or other means, and with a small strap attached with which to carry it, (this we call a portable plug), a transit reading by vernier to single minutes, the two transit plummet used by the chainmen in the outside work, a mining lamp a piece with an extra one for one of the assistants and a supply of oil and matches.

The mine surveying, like running of a crop line, we divide into two operations; first, selecting the places and putting in our points, and second, turning the angles, measuring the lines, taking the side measurments, etc.

In the first operation we drive one of the bank nails overhead into the first timber at the mouth of the mine for our first point, and make this the initial point of our mine work; then, leaving one of the assistants here, we go forward into the entry to the farthest point from which the first point can be seen, unless there be reasons, such as cross entries, for wanting a point sooner, and here we mark on the roof with the carpenters chalk the place for the second point.

The assistants now come forward with the drill, plugs, bank nails and hatchet, drill a hole in the roof from 2 to 3 inches deep if it be of firm sandstone, and 5 to 6 inches deep if it be of slate or coal, drive in a plug and into it one of the bank nails; while this is being done by the assistants we go forward into the entry and select the place for the third plug and mark it as we did the second, and the assistants as soon as they have the second point up proceed to the third and put it up in the same manner as they

did the second; and this operation is repeated over and over until all the entries in the mine have been pointed.

A chalk mark put upon the pillar opposite each of these points enables us to find them easily when we want to use them.

The points are put about the center of the entry laterly because of the greater convenience in putting them up and also greater convenience and safety in handling the transit.

As a rule points are put at the intersection of cross entries, but none in the rooms.

We now return to the second point in the main or first entry with the transit and portable plug, accompanied by the front chainman with his plummet, which he suspends in the nail, letting the point down close to the ground, and we place the portable plug with its center directly under the point of the plummet. The plummet is then removed and taken by the front chainman to the third point and suspended while we are setting up the transit; in the meantime the rear chainman has gone to point number one and suspended his plummet, on which we take a sight as soon as ready; this plummet being at the mouth of the mine can be very distinctly seen against the background of daylight. We reverse the telescope and deflect to the plummet at point number three which we are able to see very distinctly by the assistant holding something white, as a piece of paper, white envelope, or open memorandum book behind and near to the plummet and holding his lamp a little in front and to one side of it.

As soon as we have the angle turned the front man returns to the rear one and they proceed to measure the distance, the rear man having by means of his plummet ascertained a point perpendicularly underneath the first nail and stuck a pin there for a starting point.

The front man puts his lamp upon the ground at the end of the tape line next to the transit and moves it sidewise in obedience to our instructions until the flame is in line, and then stretches up the tape line taut and straight between the pin at the rear end and the lamp flame at the front end, and sticks his pin at the end of the tape.

With the tape left lying in line as just described, the two assistants with the metallic tape take the distances from it to the pillars on either side of the entry, which we record as they are taken;



these widths are always taken at each regular or full station, and at each point, and also at such other places as there are perceptible change in the width of the entry.

The stations to all breakthroughs, sumps, doors, air-shafts, and to one jaw of each room are taken and recorded before removing the tape line.

In this manner is the chaining kept up until the third point is reached, the stations to the second and third points being carefully taken and recorded.

We then move the transit and portable plug to the third point and repeat the operations of the second point, and then the chaining goes on to the fourth point, and so on, until all the entries are taken up.

To complete our mine work there still remains to survey the rooms.

In this, for the sake of system, and to keep our notes in good shape we begin at the same end of the entry that we began at when taking up the entry.

We set the transit at the second point in the entry and take a sight on the first one in the entry. The assistants now drive the common nails in the ground or ties, as they may happen to come about opposite the mouths of the rooms, we, with the transit, directing them into the precise line between the points; before removing the transit, the same is done between the second and third points.

The place of each nail is marked in some conspicuous manner so it can be readily found.

The transit is now set up over the nail opposite the first room, while one of the assistants sets the extra lamp on the ground with its flame directly underneath the second point, and this answers for our fore and back sight while taking up all the rooms to the third point.

When all is ready we take a foresight on the lamp flame at the second point, and turn an angle into the first room, going about the center when practicable, and measure it up in precisely the same manner as an entry, taking widths as frequent as is necessary to get the size and shape of the room, noting all breakthroughs into adjacent rooms. When a room is so crooked that one sight cannot be gotten through its entire length, a nail is driven into the

ground or a tie at such place as is most convenient or practical and an angle made just as in an entry; and in this manner are all the rooms measured up completing our mine work.

The same precision is not practiced in taking up rooms, as in entries, for the reason that room lines seldom become base lines for anything else, and a little discrepancy does not affect anything but the room in which it is made, while the entry lines are bases for further work, ALL of which is effected by an error in the entry.

In order to complete our whole survey there still remains one thing to be done, viz.: to connect the outside with the inside work; this is always done in the most direct and accurate manner, and where practicable by intersecting the first course of the mine with some one of the boundary lines.

To check, or test the correctness of our work, we always enclose a polygon when it is possible; this enables us to test the angles without the use of the needle; the latitudes and departures of the boundary lines are always computed, as a check upon our measurements of those lines; the crop and meander lines are seldom or never traversed, for, with so many sides this would be more laborious than re-measuring the entire lines.

In the mine the angles are checked in the same manner as in the outside work, by enclosing a polygon where possible, but if this can't be done, there only remains the needle and eternal vigilance, and the latter is really the most reliable; the distances between points in the entries are rapidly tested with the long tape line.

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