1921

Mine surveying in the Missouri coal fields

Edgar C. M. Burkhart

Mine Surveying in the Missouri Coal Fields

A Thesis

for the

Degree of Civil Engineer

by

Edgar C. M. Burkhart

B.S. in C.E. 1918

Mar. 23, 1921.

Approved

Elmo G. Harris
....
Professor of Civil Engineering.

TABLE OF CONTENTS.

TABLE OF CONTENTS.

LIST OF ILLUSTRATIONS.

I- INTRODUCTION.

The coal production for Missouri for 1920 will be nearly 5,000,000 tons according to the Western Coal Journal under date of Jan. 20th, 1921, and who quote as their authority State Mine Inspector George Hill. It was further stated that the leading producers of the state were Macon and Adair county.

The mines surveyed and included in this thesis are certain mines in the foremost and second largest producing counties in the state, namely Macon and Adair county. This thesis also includes surveying at one mine in Randolph County.

The estimated total bituminous coal production for the United States in 1920 is 556,563,000 tons, or an average of 1,805,000 tons per working day. From the above figures it can be readily seen that Missouri produced .898 of one percent of the total bituminous coal mined in 1920. This is a very small part of the total bituminous coal production when we consider that all bituminous mines in an average working day produce nearly one-half of Missouri's annual output.

The mines included in this thesis produced in 1920 approximately 650,000 tons, or about one-seventh of the total output of the state.

The Missouri mines ship for the most part to the west. Kansas City, St. Joseph and Omaha, Neb. probably get most of Missouri's coal. These markets with their freight differential over the Illinois fields allow the Missouri Operators to compete successfully with the cheaper mined coal of her neighboring state on the east.

The mines included in this thesis operate mainly in the Bevier bed. This seam contains an average of 41 inches of coal in Adair County and is somewhat thicker in Macon and Randolph County. All mines in the Bevier bed are operated on the room and pillar system of mining with about 50 to 60 percent extraction in Adair County and a somewhat greater extraction in Macon County. A few mines included in this thesis operate in the Mulky bed. This seam is from 20 to 24 inches thick and is operated on the longwall system with a face track and skip roadways off of the main entry.

FIG. I, page 7, shows the location of the mines included in this thesis in Macon, Adair and Randolph County.

FIG. II, page 8, gives the various mines surveyed, location, seam mined, system of mining and the total 1920 production in net tons.

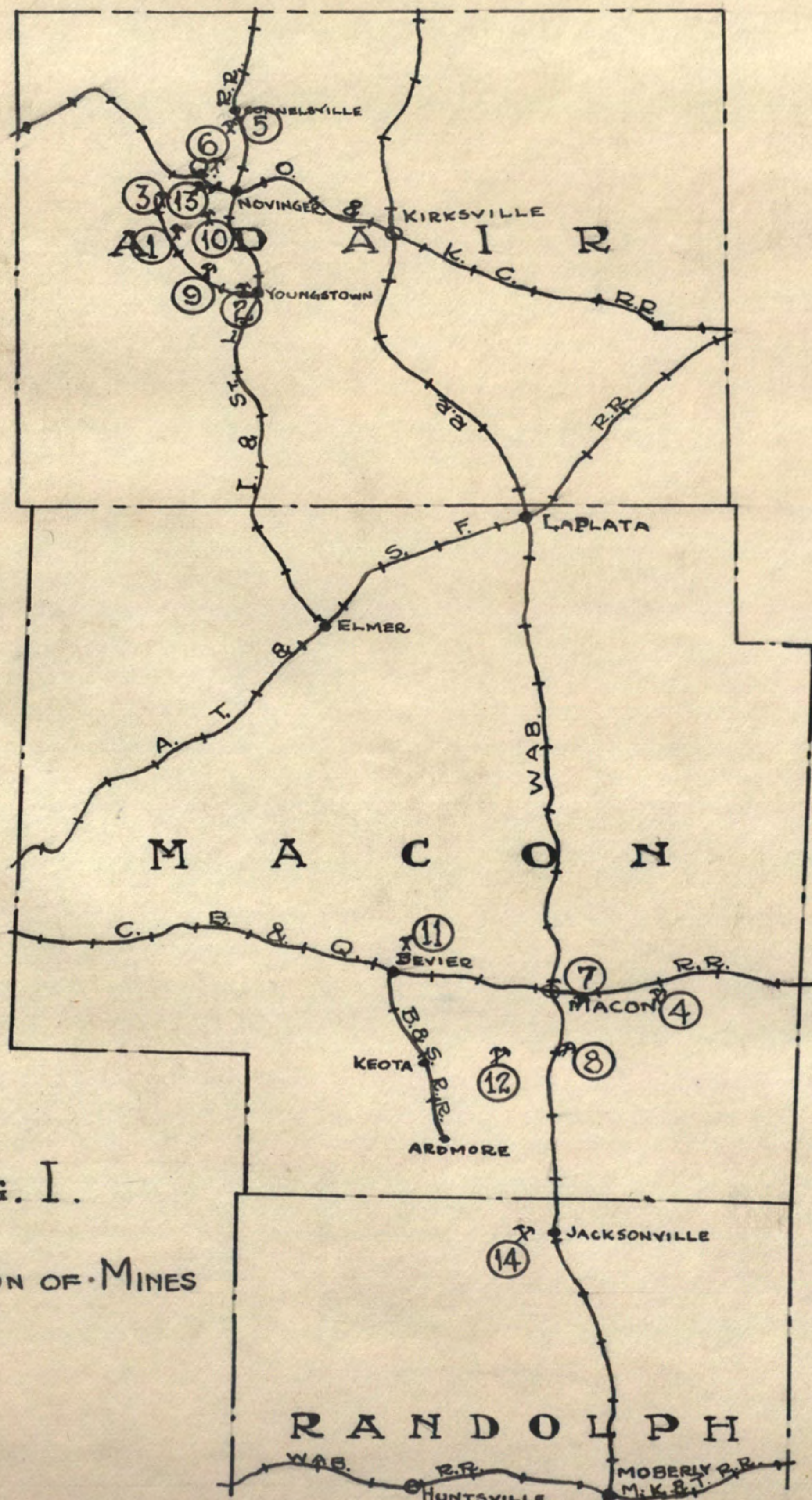

FIG. I.

LOCATION OF MINES

No.	Mine	Location County	Vein Mined	System of Mining	1920 Tonnage	Remarks
1	Adair County Coal Co. #22	Adair	Bevier	Room & Pillar	57,785	
2	Arctic C. & M. Co. #2	Adair	Bevier	Room & Pillar	110,612	
3	Billy's Creek Coal Co. #21	Adair	Bevier	Room & Pillar	54,528	In Receivership
4	Browning Slope	Macon	Mulky	Longwall	265	Wagon Mine
5	Chariton Coal Co. #1	Adair	Bevier	Room & Pillar	38,969	
6	Electric Coal Co. #5	Adair	Bevier	Room & Pillar	39,000	(Approx. Tonnage)
7	Home Coal Co. #1	Macon	Mulky	Longwall	32,592	
8	Home Coal Co. #2	Macon	Mulky	Longwall	11,179	
9	K.C. Midland C. & M. Co. #4	Adair	Bevier	Room & Pillar	176,354	
10	K.C. Midland C. & M. Co. #7	Adair	Bevier	Room & Pillar	53,536	
11	Star Coal Co.	Macon	Bevier	Room & Pillar	53,218	
12	Smith Mine	Macon	Bevier	Room & Pillar	6,000	Wagon Mine (Approx. Tonnage)
13	Spring Creek Coal Co. #1	Adair	Bevier	Room & Pillar	714	Newly Opened
14	Snow Coal Co. #1	Randolph	Bevier	Room & Pillar	50	Newly Opened

Fig. II Table of Mines included in Thesis - (The No. in first column identifies mines in Fig. I)

II- PURPOSE AND IMPORTANCE OF SURVEYS.

1- Map- Required by Law.

The principle object of the survey is for a map. The State Laws of Missouri require a map to be filed at each term of circuit court with the clerk of such court for all mines operating under a license. (Sec. 8426 Laws of Missouri Relating to Mines and Mining.) The owner, agent or operator of each and every mine in the state is required to file an extended map of the mine with the county clerk of the county in which said mine is located during the month of January of each year, and when any mine is worked out or abandoned the map of the mine shall be so corrected and verified. (Sec. 8441 Laws of Missouri Relating to Mines and Mining.)

The law is not strictly complied with in this locality in regard to the filing of mine maps, and when a question arises over same the clerk of the county court usually writes the company requesting copy of the latest map.

2- Establish Boundaries.

The map made from the survey will show the boundary of the company's holdings either in coal owned in fee simple or coal leased, and it will also generally show the adjoining property owners. This gives the company the information desired to obtain practically all the coal that it is profitable to obtain which is owned in fee simple, and it will also show how much it will be profitable to work on a royalty basis.

From the conservationist's point of view it will show all the coal to be obtained, and thus avoid leaving small areas of coal which would otherwise never be recovered.

3- Sights.

With the true meridian established in the underground workings it is an easy matter to put up sights to keep a pair of entries, in the room and pillar system of mining, on their proper course.

A- Haulage.

It is a very important matter to run straight entries especially in case some system of rope haulage is used. With motor haulage sharp curves are objectionable for with the speed obtained in this system of haulage derailments often result in knocking out props which may mean costly falls of rock to handle and the attendant danger to motorman and trip-rider besides the time lost due to the trip being delayed. With the system of mule haulage common to most Missouri coal mines sharp curves often lead to derailments with the attendant loss of time and loss of coal from cars which necessitate the added expense of cleaning roadways oftener.

B- Ventilation.

Straight entries are also of benefit to the ventilation system. The coefficient of friction is much smaller in straight entries than in crooked ones and those having sharp projections on the ribs. The flow of air through straight entries may be compared to the flow of water through smooth, straight pipe, while the flow of air in crooked entries is analagous to the flow of water through rough pipe.

C- Reduce Cost of Entry Driving.

A straight entry like a line is the shortest distance.between two points and for this reason straight entries are shorter than crooked ones and in this manner reduce the cost of yardage, brushing, timbering, steel and ties.

D- Prevent Squeezes.

Parallel straight entries must leave the width of the entry pillar constant and if sufficient pillar is allowed at the turning of the entries, no danger is liable from squeezes due to the removal of too great a portion of the entry pillar. One case of a squeeze came under the writer's observation in a Missouri coal mine where a pair of entries were driven under thin cover, and the result of not leaving sufficient entry pillar was partly the cause of loosing this pair of entries and which must have cost the company at least $25,000.

E- Driving Connections.

Sights are also very important in driving connections between different works. The engineer can calculate the course of a pair of entries to connect with other workings. A foreman in a Missouri coal mine gave the writer an example of a case in which a pair of entries were driven to connect with another pair of entries for the purpose of improving the ventilation. Allthough the foreman pointed out the advisability of securing an engineer to place sights to make these entries meet it was not done, and the result was the pairs of entries were driven 150 feet past each other with an additional cost of $1200. The cost of an engineer and helper to place sights to make these entries meet would have been about $25.

F- Protect Surface Features.

With the use of sights it is possible to stop or turn entries around such surface features as ponds, buildings, tracks, etc. thus offering protection to features the undermining of which might cause serious damage either to the surface or to the underground workings.

4- Royalties.

Many of the Missouri coal mines purchase their coal on a royalty basis, the price rangeing from four to ten cents per ton. Leases to this effect are often drawn up giving the party owning the coal a stipulated sum per month, termed "advance royalty" until such coal is reached. Without the use of a map an intelligent idea of the royalty is usually impossible. With a map it is an easy matter to get the correct workings under the various owners and pay the royalty accordingly.

5- Old Workings.

The map should show the location of old works adjacent to any operation. Many of these abandoned mines are often filled with gas or water. It is of course undesirable to break into the old works, and by an intelligent use of the map, the superintendant will know how close to approach any abandoned mine and still obtain all the coal possible.

6- Air Shaft Location.

Each mine of any size is provided with an air shaft through which the air is either forced into the mine or withdrawn by reversing the direction of the fan. These air shafts also serve as escapement shafts. The Missouri Laws Relating to Mines and Mining (Sec. 8443) requires two outlets for each mine seperated by not less than 300 feet of natural strata. This refers to a mine which is not connected to any other mine.

In the case of a mine opened by a shaft it is necessary to carry the meridian down the hoisting shaft and then to the place determined as the proper point for the escapement shaft, and from these notes to locate this point on the surface. The work of constructing an airshaft is practically always done by sinking from the surface, allthough one case in the Missouri coal fields has come to the writer's notice by work being started at the top and bottom simultaneously.

In case the mine is entered by a slope the method of locating the air shaft is less complicated. A case of the above is given in FIG. III, page 14, in which the air shaft is located at a point where the cover is thin thus saving considerable of the cost of sinking higher up on the hill.

7- Avoid Litigation.

A map serves to show the actual relation between the surface and the underground works. This gives the necessary information required to keep the underground workings within the boundary of the coal owned. It further shows the position of such features on the surface as ponds, buildings, tracks, streams, highways and all plots of ground under which the coal might be reserved for supporting purposes. An intelligent idea of these features will determine the limit of mining to avoid disturbing surface features or encroaching upon the property of another and thus avoid litigation.

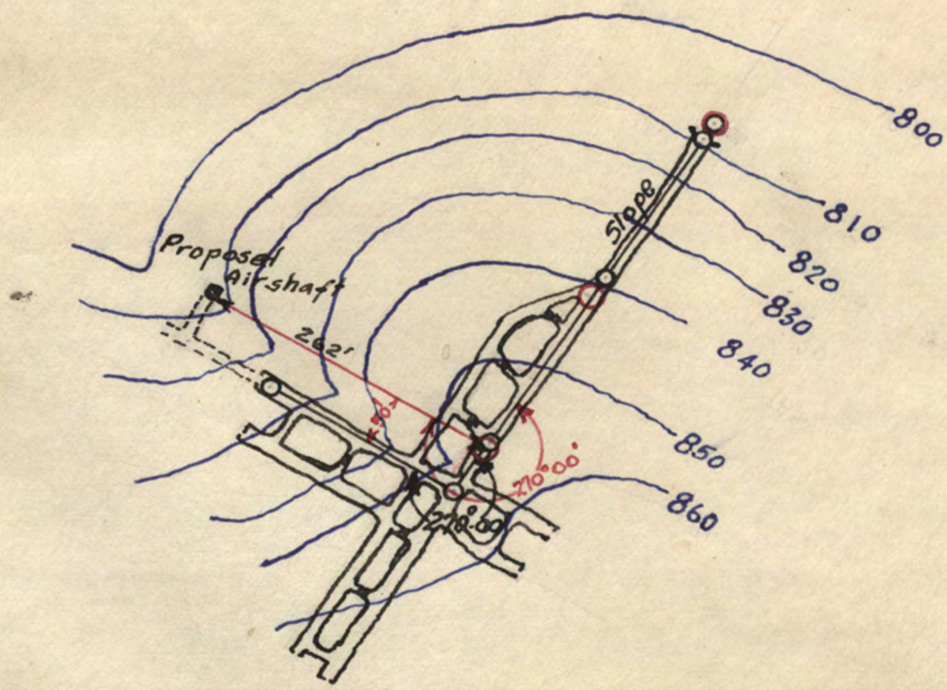

FIG. III

AIRSHAFT LOCATION FOR SPRING CREEK COAL CO.

○ Surface Stations

○ Underground Stations

Contours in blue.

III- INSTRUMENTS USED.

1- Transit.

The transit used in the surveying of the mines included in this thesis was made by the Keuffel and Esser Co. of New York. A brief description, which is taken from Keuffel and Esser literature describing this transit follows.

Engineer's Transit.

"TELESCOPE 11 1/2 inch, achromatic terrestial, with Spirit Level. Object Glass 1 5/16 inch with improved rack and pinion movement. Eyepiece focused by knurled ring with index for resetting. Magnifying power, 24 diameters. Stadia Hairs fixed, ratio 1:100. Improved Clamp and Tangent Screw with counterspring. HORIZONTAL LIMB, 6 1/4 inch diameter, graduated on solid silver to half degrees; opposite double-direct verniers, at about 30° with telescope, reading to one minute. Hinged Reflectors. Two fine Spirit Levels. COMPASS: Needle about 4 1/2 inch. Compass Ring beveled, graduated to half degrees on solid silver. Variation Plate. Full VERTICAL CIRCLE, 5 inch diameter, graduated on solid silver to half degrees. Vernier, double direct, reading to one minute. Guard to circle. CENTRES, anti-friction composition, extra long, and carefully fitted. Four Leveling Screws. Shifting Centre. Improved Clamp and Tangent Screw with counterspring. Tangent and Leveling Screws of Nickel Silver. Weight of instrument with tripod, about 24 pounds.

The tripod used with this instrument is of the Keuffel and Esser Patent Extension type. Special clamps render it practically as steady as a solid leg tripod which is not well adapted to mining work. The tripod is adjustable to any height between 30 and 57 inches. It is generally used at the lowest height in this work.

2- Tape.

The tape used ~~in this work~~ is 100 feet long. ~~It is~~ made of heavy ribbon steel plated with white metal to resist rust. Graduations are etched on babbitt metal at every foot, with the end feet graduated in tenths. The tape is provided with a nickel plated reel which is very useful to quickly get the tape out of the way while surveying when the mine is in operation.

3- Points.

Sighting points are used for foresight and backsight and are 14 inch steel chaining arrows run lengthwise through a piece of thin white paper. The point is held on the station and the light held behind the paper. The cross-hairs are plainly visible against the background of the white paper for sights up to 500 feet without the use of a special cross-hair illuminator.

4- Level Rod.

Very little work with the level has been done by the writer in the Missouri coal mines. A regular Mining Rod of the Philadelphia type is generally used which is three feet long and extends to five feet. A hole is placed in the target, at the center or zero mark, through which the light held by the rodman can be seen. The writer has used a straight 1" x 2" board for a rod on which was held a darning needle run through a piece of thin white paper and held horizontally across the rod. The height of this needle was then compared with a standard Philadelphia surface rod. By this method results were found which were sufficiently accurate, but the process of comparison made the work somewhat slower than with the regular mining rod.

IV- METHODS EMPLOYED.

1- Carrying the Meridian Underground.

The true meridian can be obtained from various sources on the surface. The general methods of obtaining the true meridian are by Solar or Polaris observations, government survey corners and railway alignment notes. The method of carrying the meridian underground is dependent on the way in which the mine is entered, but in Missouri coal mine surveying it will come under one of the following four cases.

A- When mine is entered by drift.

The method of carrying the meridian into the mine where the mine is entered by a drift is a simple matter. The meridian is established by turning the horizontal angle and calculating the course of the line from the known bearing of the connecting surface line. Measurements with the tape are made in the same manner as on the surface.

B- When mine is entered by slope.

The meridian is carried into the mine when the mine is entered by a slope by the same method used where the mine is entered by a drift. Measurements are made either by "breaking chain" down the slope or by taking elevations at top and bottom of the slope and measureing the slope distance, and then computing the horizontal distance from this data. The angle the slope makes with the horizontal varies in different mines, but generally does not exceed 35^{o}; consequently in Missouri coal mine surveying the side or top telescope is not necessary.

C- When the mine is entered by one vertical shaft.

When the mine is entered by one vertical shaft the usual method is to suspend two wires with weights vertically in the shaft. The wires should be placed as far apart possible to secure the greatest length between them. The bearing of the line between these two wires can be obtained by "lining in" the transit with them or by triangulation and computing the bearing from the data obtained. The weights which are hung on the wires are often immersed in water or oil to keep them from swinging. FIG. IV shows method of"lining in".

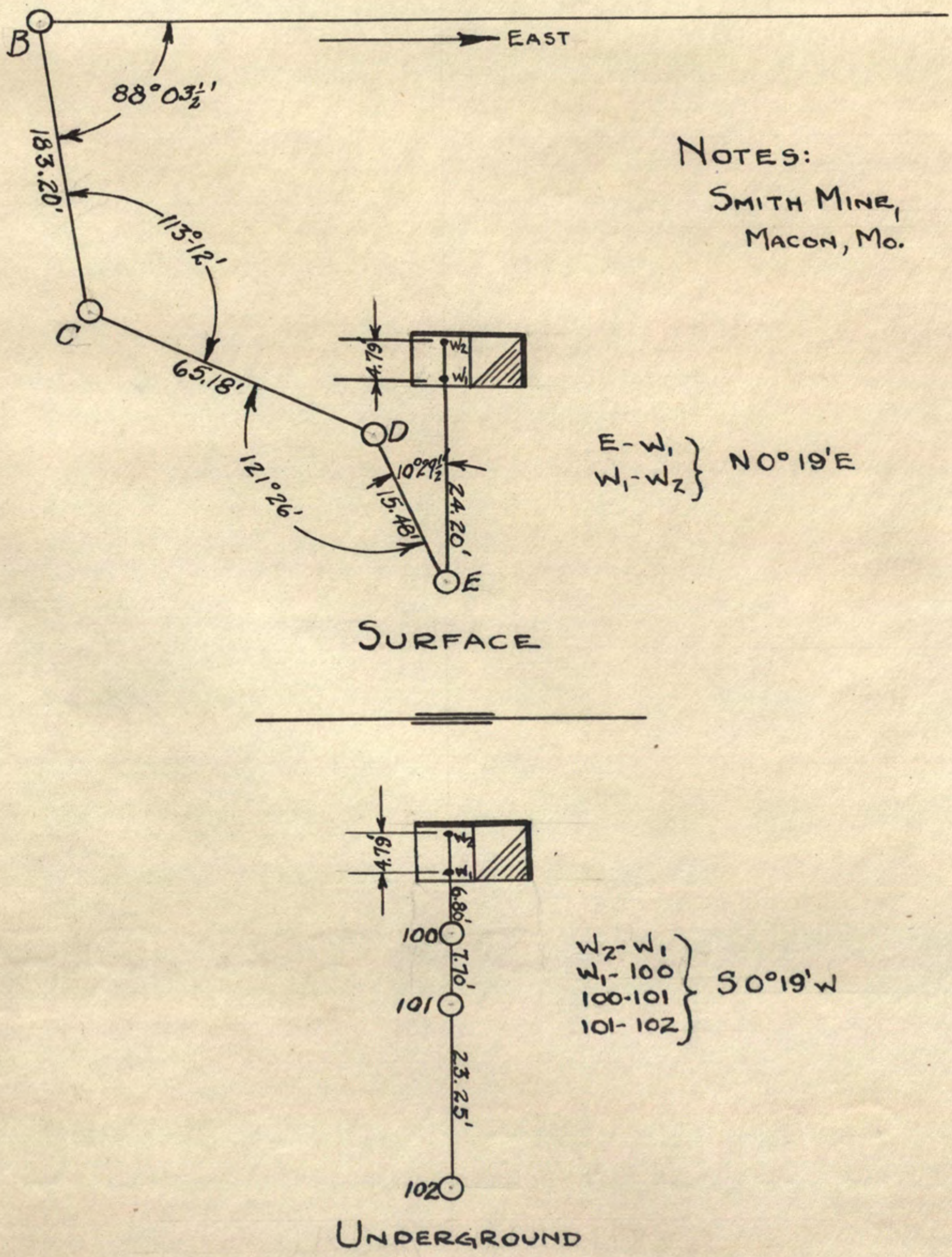

FIG. IV.

CARRYING MERIDIAN INTO MINE BY "LINING IN."

D- When mine is entered by two vertical shafts.

When the mine is entered by two vertical shafts it is possible to secure a long line between the two wires. One wire is usually hung in the side of the hoisting shaft out of the way of the cages in their movement up and down. The use of the cages saves much dangerous climbing. The other wire is hung in the air-shaft. This gives a length between the wires of at least 300 feet.

A traverse is run between the two plumb wires on the surface, connecting same with some line of known bearing. The course between the two wires is then calculated both for bearing and distance. A traverse is also run between the two wires underground assuming a bearing for the course of the first line. The bearing assumed is usually one of the four cardinal directions to simplify computations. The line between the two plumb wires is then computed both for bearing and distance.

If the distance as computed on the surface checks within the practical limits with the distance as computed from the underground traverse the survey can be considered correct. By swinging the underground traverse to make the line between the two plumb wires correspond to the bearing of the line between the wires on the surface the bearings of the lines below are known.

The wires used in plumbing should be as small as possible. In this work #20 copper wire, ordinary "stove pipe" iron wire and chalk line have been used. The objection to chalk line is the stretch and twist which keeps the attached weight in motion. In case the wires cannot be sighted on in motion and the swing bisected, a paper with vertical lines held behind the wire will determine the limit of the swing which can be easily bisected.

FIG. V, page 20, shows the true surface traverse and the assumed underground traverse with the angle of correction through which the underground traverse must be swung.

FIG. VI, page 21, shows the necessary computation.

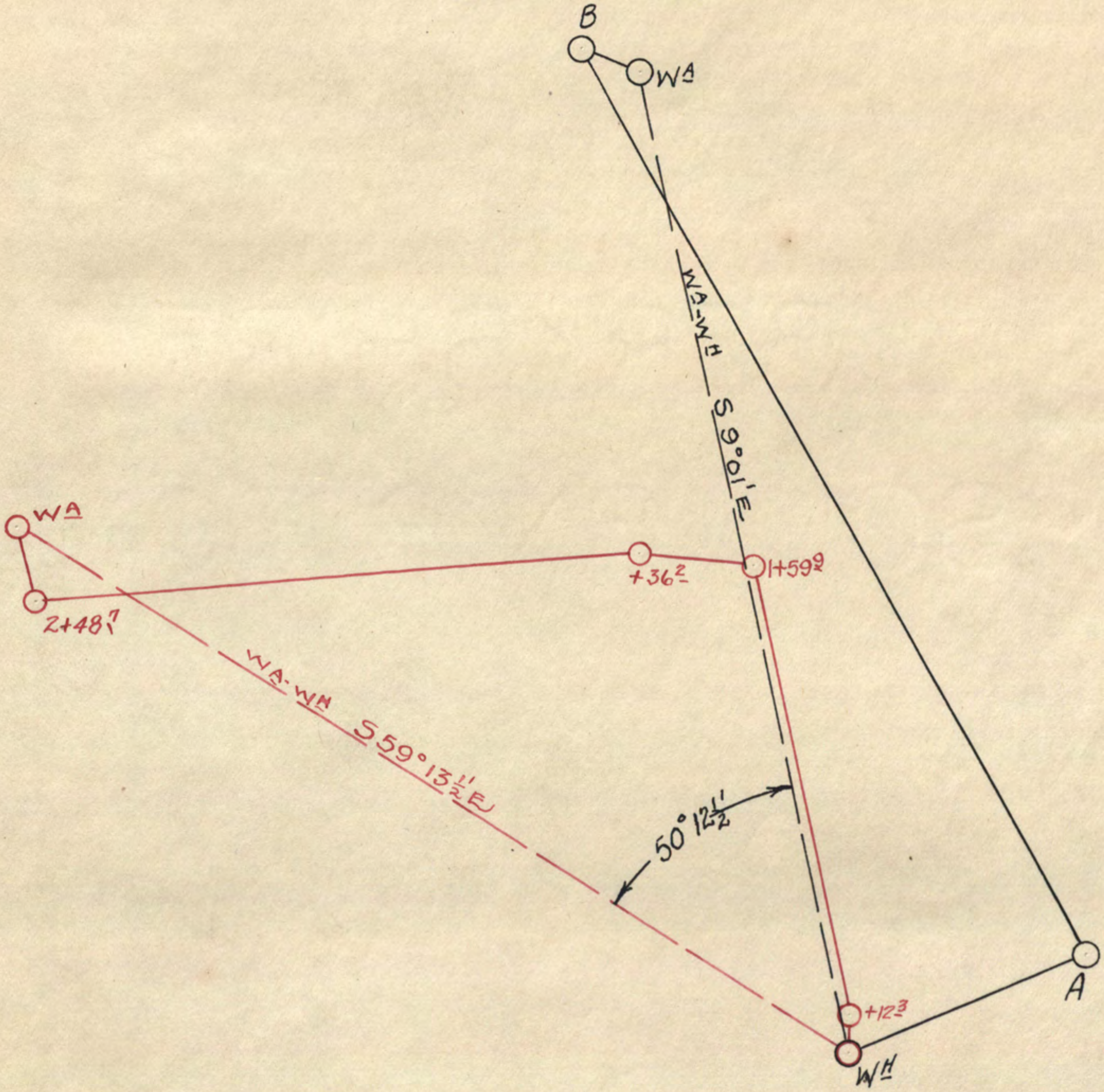

FIG. V - TWO SHAFT METHOD.

○ SURFACE
○ UNDERGROUND

Line	Mean Hor ∠ R.	Bearing	Needle	Distance	Latitude N+	Latitude S−	Departure E+	Departure W−	Corrected Bearing
Underground → Assumed Bearing W^H - 12^3 → North									
W^H - 12^3		North		$14.^{37}$	$14.^{37}$				N50° 12½' E
↓ 12^3 — $1+59^9$	169° 23'	N10° 37' W		147.60	145.07			27.19	N39° 35½' E
↓ $1+59^9$ 36^2	109° 01'	N81° 36' W		36.20	5.29			35.81	N31° 23½' W
↓ 36^2 $2+48^7$	166° 40⅓'	S85° 4⅓' W		212.56		18.26		211.78	N44° 43' W
↓ $2+48^7$ W^A	261° 10'	N13° 45⅔' W		20.72	20.13			4.93	N36° 27' E
					184.86	18.26		279.71	
W^A W^H		S59° 13½' E		325.56		166.60	279.71		S 9° 01' E
Surface → True Bearings from Base Line									
W^H A		N67° 58½' E	N59½° E	82.00	30.75		76.02		
↓ A – B	86° 04'	N25° 57½' W	N34½° W	332.75	299.18			145.65	
↓ B – W^A	319° 23½'	S66° 34' E	S74½° E	20.18		8.03	18.52		
					329.93	8.03	94.54	145.65	
W^A W^H		S9° 01' E		325.93		321.90	51.11		
Notes from Survey Arctic Coal & Mining Co., Mine # 2									

FIG. VI.

COMPUTATIONS FOR TWO SHAFT METHOD

2- Traversing.

A- Surface.

The surface features are located by running a random traverse and obtaining the necessary land corners, buildings, tracks, roads, etc. that should be shown on the map. In the Novinger Field the topography is rough and ridge roads offer a good course to run the random traverse. From these roads the various land corners are often easily located by turning the necessary angles and measureing the distance. The traverse in many surveys is not closed and extreme care must be exercised in the field work. The party for that surface traversing is usually the same party as is used below, consisting of the transitman and two rodmen. Owing to the inexperience of the help the transitman carries one end of the tape to avoid the gross errors usually encountered in chaining over rough ground by inexperienced helpers.

B- Underground.

The underground traversing is done by a party of three consisting of the transitman, backsightman and foresightman. The method employed is for the transitman to set up on the last point established, the backsightman holds the backsight on the point on which the last set-up was taken on the previous survey and the foresightman advances toward the face of the entry as far as a good sight can be obtained. The transitman then backsights and turns the angle to the right to the foresight. This angle is then doubled for a check on the work, and an additional check on the bearing of the line is afforded by reading and recording the needle bearing.

The backsightman is then called up to the transit and takes the zero end of the tape and advances toward the point established by the foresight. He then holds the zero on the tape at the center of each room-neck, cross-cut and other features which should be shown on the map while the transitman reads the "plus" to properly locate these features. When the full length of the tape is reached, the rear-chainman lines in the head chainman by means of the light at the point of foresight. This proceedure is repeated until the full line is measured. The tape is read, and to avoid mistakes the rear chainman also reads the two nearest footmarks so that no mistake will be made by recording the wrong footmark. This proceedure is repeated until the face of the entry is reached. The last point is usually located at the last cross-cut so that if sights are required, the line can be carried through the last cross-cut into the other entry. In many mines the period between surveys is so long that only one entry, of a pair, is traversed. It is common practice to abandon part of the back entry for haulage as soon as a number of rooms are finished, and the haulage is taken through a cut-off to the one haulage entry. Track and ties are often taken up in the back entry so that the points established in this entry are lost. The back entry must then be drawn in by what few measurements are obtainable at cut-offs and the last cross-cut of the previous survey. The writer does not recommend this method, but sometimes no other choice is available.

Sights are set by calculating the horizontal angle to be turned from the bearing of the last course. Sights are usually placed over one rail or in the center of the entry. Holes are drilled in the roof from 4 to 6 inches deep and about one inch in diameter. In these holes wooden plugs are driven and the spads are lined in on these plugs and driven up. A string is tied to each spad and should be tied about an inch below the spad so that when the weights are attached the strings will hang perfectly plumb from the center of the spads. In some mines two spads are placed for sights while in other mines the foremen prefer to use three spads for fear that one will be lost. The spads are set from 18 to 30 inches apart.

The help used in this work are most often inexperienced, and the brunt of the work falls on the transitman. Results are not as accurate as could be obtained with a corps of trained helpers.

FIG. VII, page 24, shows a sample page of notes as taken by the above described method.

B.S. – Sta.	F.S.	Hor. L.R.	Needle	Bearing	Distance	Remarks
Arctic Coal & Mining Co., Mine #2, 11TH EAST.						2/11/'21 Bocho Giachino – R. Flag. Jocko Rovetto – F. Flag. Burkhart – ⊼
18+56^{1} – Main North = 0+00 11TH East.						
17+77^{4} – 18+56^{1}	49^{2}	280°55'	S84°E	S76°27½'E	49.2	△ 49^{2} Nail 10" inside left rail.
		201°48'				
		280°54'				
18+56^{1} – 49^{2}	2+51^{3}	195°58'	S67½°E	S60°29½'E	202.1	△ 2+51^{3} Nail 8" inside right rail.
		31°56'				
△49^{2} +8 R_1 $\overline{165}$ and x-c; +52 R_2 $\overline{165}$						
+63 x-c; +93 R_3 $\overline{165}$; +108 R_4 $\overline{165}$; +165 R_5 $\overline{165}$						
49^{2} – 2+51^{3}	4+76^{7}	175°55'	S72½°E	S64°34½'E	225.4	△ 4+76^{7} Nail 6" inside right rail
		351°50'				
△2+51^{3} +21 x-c; +42 R_6 $\overline{165}$; +70 x-c;						
+76 R_7 $\overline{165}$; +112 R_8 $\overline{165}$ and x-c; +151 R_9 $\overline{165}$;						
+169 x-c; +192 R_{10} 120.						

FIG. VII SAMPLE PAGE OF FIELD NOTES.

3- Stations.

A- Kind.

1- Surface.

Permanent surface stations are usually 1/2 or 5/8 " diameter iron rods from 12 to 15" long. These are driven into the ground until the tops are about flush with the ground surface. Properly witnessed these iron rods are not hard to find and are less liable to be disturbed than wooden pegs.

2- Underground.

In underground surveying many different kinds of stations are used. Spads in timbers or plugs; nails in ties; spikes or iron rods in the bottom and cross marks in the roof are those most commonly used. Most of these have their advantages and disadvantages.

Spads in timbers are sometimes lost by the timbers being replaced or shot out. The liability also from one side of the set of timbers to get subsidence weight may also throw them out of their true position. Spads in plugs are often lost by falls of roof. The advantage of this kind of station is it's ease of location.

Nails in ties are easy to locate, but the disadvantage is the liability of track being shifted or the tie being removed on new trackwork as the laying of a room switch.

Large spikes or iron pegs driven into the bottom below the track level make the most permanent and substantial station. They must be driven low enough to avoid their being removed when cleaning roadways. The disadvantage of this station is that it is harder to locate than the other varieties mentioned.

A crossmark in a circle cut in the roof is the usual station in longwall work in the Mulky vein. The circle and cross are then blacked by holding the flame of a miner's lamp close to the marks. In longwall work in the Mulky seam a five foot cap rock overlying the draw-slate froms the roof of the skip roadways. This limestone does not scale readily and stations placed in this cap-rock may last for years. The disadvantage of this station is the settlement of the rock over the gob may possibly throw the station slightly out of it's true position.

B- Numbering of Stations.

1- Surface.

The surface stations are usually lettered and properly referenced to avoid confusion. Sometimes they are numbered consecutively from 100 upward or any number chosen. The quantity of surface stations is much less than the underground stations; therefore no especial system of numbering is required.

2- Underground.

The underground stations are numbered principally by two different methods. One of these methods is to designate each station in an entry by a number and the initials of the entry thus "3WN9" means the ninth station in the third west on the north side, or "6ES5" meaning the fifth station in the sixth east on the south side. In case the mine is one sided (operating on one side of the shaft only) the second letter can be dispensed with. This system has the advantage of properly locating each station with respect to the entry in which it will be found, but lacks the advantage of giving the information of how far the station is in from the mouth of the entry.

The railroad system of numbering is often used in numbering stations. If this system is used the zero is generally taken at the shaft for the main entries and at the intersection of the main and crossentry for the cross entries. The stations are then numbered progressively toward the face. Each station should be properly referenced in the notes thus: Station 9+36.7 Main East = Station 0+00 5th North. This would indicate that the 5th North had been turned at 936.7 feet from the shaft.

This system of numbering stations gives the advantage over the other system in that it gives the distance the entry is in from the mouth or shaft depending on whether the entry is a crossentry or main entry. In locating stations this system allows the engineer to measure from some known point and quickly locate any succeeding station.

Station numbers are marked with white chalk on the roof, rib or timbers in plain letters and with the usual triangular station symbol.

4- Leveling.

As it has been previously stated not much leveling has come under the writer's observation in the Missouri coal mines. Grades at the shaft are usually determined by elevating the inside end of the loading track at the bottom until the loads come toward the shaft with the desired rapidity. Empty tracks at the bottom are likewise lowered until the empty cars leave the shaft quickly.

The coal seams in this locality are fairly flat lying. In some places in the various mines gentle dips are encountered, but little work is done in lowering the peaks on the ridges and filling the valleys.

One case of leveling was encountered for draining a small wagon mine. This mine was entered by a slope, and the coal dipped slightly upward from the foot of the slope and left a pocket of water at this point. Profile levels were taken from a point in the mine at the water surface which was two feet deep to a point outside which would give sufficient fall to carry the water away.

Stakes were set at the ground level every 25 feet and a rod reading taken to the nearest .01 foot. The grade was then calculated and the cuts given the owner of the mine. He then started at the mouth of the drain and laid 6" drain pipe with open joints covering the pipe as the work progressed. After the drain was completed no further trouble was experienced with water.

FIG. VIII, page 28, shows the profile of the ground and the grade of this drain.

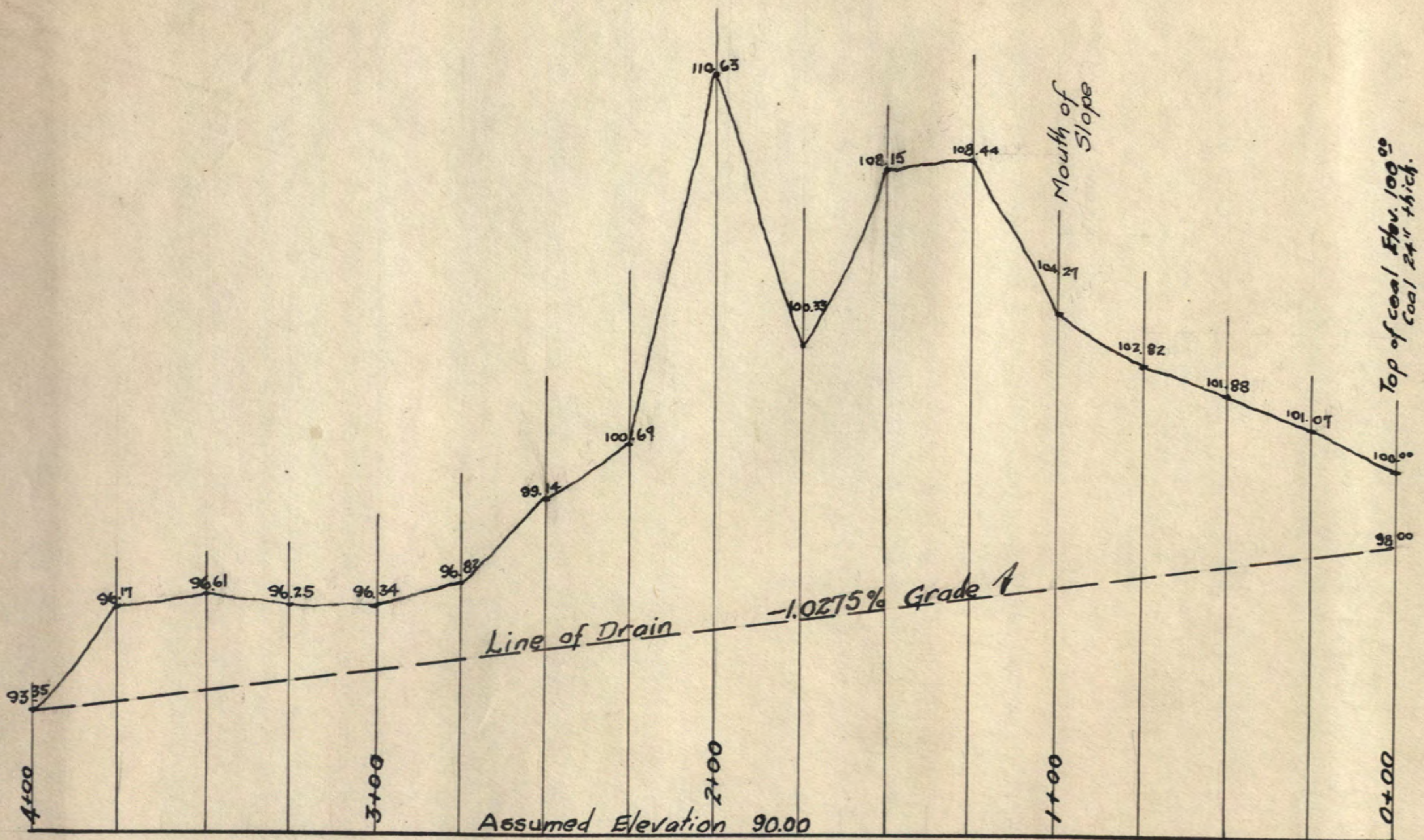

FIG. VIII PROFILE OF DRAIN FOR E.M. BROWNING'S SLOPE

Scales - Hor. 1" = 50' ; Ver. 1" = 5'

5- Plotting.

Mine maps of the size included in this thesis are usually made on a scale of either 1"=100' or 1"=200' depending on the extent of the territory to be worked. The plotting is done by either of two methods viz: protractor and scale or total latitudes and departures.

A- Protractor and Scale.

The protractor and scale was the general method of plotting the maps of most of the mines included in this thesis until the writer took over the work. One large mine which was in over 4000 feet from the shaft was plotted with protractor and scale and on a scale of 1"=100'. The map is exceedingly large and cumbersome. Engineers in general will not recommend the plotting of such a large territory by the use of protractor and scale.

B- Total latitudes and departures.

The most approved method of plotting large territories is by the method of total latitudes and departures. Most engineers are familiar with this method and it's many advantages over other methods; therefore no detailed discussion of it is needed here. In calculation of latitudes anddepartures a Gurden Traverse Table is of exceptional value in reducing the tedious labor involved in calculating latitudes and departures by natural or trigonometric functions. It is needless to say that extreme care must be exercised to insure accuracy of this work and all calculations are checked to avoid errors.

The maps appended to this thesis show one longwall mine, the Home Coal Co's mine #1, plotted with protractor and scale. The other map of the Star Coal Co's mine is on the room and pillar system of mining and was plotted by the method of total latitudes and departures. The second map mentioned above shows the more systematic mining in the recent workings of the mine due to more frequent visits of the engineer.

V- CONCLUSION.

In conclusion it is the writer's opinion that more frequent surveys and the keeping of the mine maps more up-to-date would more than justify the added engineering expense involved. This conclusion is justified by the loss of territory due to squeezes, the crooked entries involving the extra expense of driving and the litigation involved in undermining surface features of importance.

No better summary of the relation of the engineer to coal mining can be found than to quote A. T. Shurick, Associate Editor of Coal Age in his book "Coal Mine Surveying" in which he says: "The average mining man is too prone to look upon the work of the engineer (or surveyor as he is perhaps more commonly termed in the mining regions) as something uncanny or bordering on the supernatural. He is usually regarded as an expensive luxury, or a necessary evil. No tangible evidence of his labors is notable on the tonnage sheets of the mine he is working in- in fact, it is more often the case that he leaves a trail of profane "skinners" who have been delayed, in his wake. Nevertheless he has come to stay and each year finds him occupying a stronger foothold, until now one of the best criterions of an efficient management is shown in the excellence of its engineering practice."