Our system of Coal mining.

Being somewhat familiar with the practical working of coal mines and having spent one of my vacations in the Anthracite region of Penn. I mean to compare our system, as far as possible, with that of the English Miners.

First, as to the greater pay demanded by an American compared with that received by the English Miner. In England, the average yearly production of a miner is from three hundred and twenty to five hundred tons, and their yearly wages amount to 21 £ 9s or about one hundred dollars; in Belgium, the average production is three hundred and fifty tons, the miners being paid at the rate of thirty three and a third cents per diem. In the United States, a miner produces from our magnificent veins not so much as a European from their small seams. Their wages run from two and a half to six dollars a day. As long as our colliers persist in demanding such exorbitant wages, so long will our coal operators labor at a disadvantage.

Second, the use of labor saving Machinery in reducing the working expenses of a mine.

Too much cannot be said in favor of Machinery. Of course I would not favor the erection of a fan to ventilate a mine, when it would ventilate itself, nor would I erect a great system of inclined planes, with an engine at each, when one plane and engine would do as well. Still where by some little mechanical contrivance the ~~mine~~ work could be performed without a man, if you once put it in, it is there and wont strike every other week. I know of an instance of two adjoining mines, where one could put its coal on board the cars for ninety cts. per ton, while it cost at the other two dollars and a half for exactly the same quality. The difference was a fortune in one of the operators' pockets. This was caused mainly by the proper use of labor saving machinery.

Mining Coal.

In this country a vein which does not present five or six feet of pure coal is called unworkable, while in Europe a vein of fifteen or sixteen inches is worked to good advantage. In time to come these small veins will be worked, but as long as a vein of twenty feet pure coal presents itself, the smaller ones will be neglected. In working a mine with economy, it is almost essential, to have a large capital and moreover to use it in developing the mine, without expecting to realize on it in two or three months. In England, in some cases, hundreds of thousands of pounds have been spent and years have elapsed before the investors realized a shilling in the shape of dividends. In England, it is customary to drive all their gangways or galleries before taking a pound of coal from the breasts. In this country, it is usual to open the gangway for a short distance, drive the necessary schutes and headings and immediately begin mining the coal. We may say at once, before our operators can produce marketable coal as profitably in the long run as Europeans, they must have larger capitals to fall back on than they at present, in most cases, enjoy. In order to protect the miners while at work, large pillars of coal are left standing. In many cases they are as large as the breasts adjacent to them, from which the coal has been taken. Now in England as I have already stated, they drive gangways some times the whole length of their mine, or, what is oftener done, divide the mine into sections and work out one at a time, so that having reached the end of the mine or section they begin to withdraw or working back towards the entrance, taking all the coal in their retrograde movement. But in our country the method employed is entirely different. Nature has been so profuse in her gifts as to make us careless in the use of them. Our miners go to work, drive their galleries a short distance and begin taking out coal leaving magnificent pillars standing until they reach the limit of their run. The consequence is that when they wish to withdraw and take out these pillars the surroundings are unfavorable, and if they do succeed in drawing a part of them, it is attended by a great deal of danger to life and limb; so much so, that in some cases the miners refuse to assist in drawing them. A traveller through the coal regions is surprised by seeing immense heaps of what appears to him coal lying in the vicinity. These heaps are composed of coal dust and fine coal, which has been screened from the rest of the coal and is regarded as worthless. I remember one night coming up from Pottsville and seeing a heap of this coal dust on fire. It presented a magnificent sight, a whitish flame covering the whole of it. It had been burning from three to four months, so I was told, and had ignited spontaneously. This dust is produced mainly by the process to which the coal is subjected to reduce it to the different sizes demanded by commerce. In order to break up the coal, it is drawn in cars into a building called a breaker, where it is dumped at the head of a steep inclined plane. Gravity carries it to the bottom of this plane, but in its passage, it runs a part of the distance over iron bars two or three inches apart, The fine coal and dirt are thus sifted from the rest, which continues its journey down the plane, but before it reaches the bottom it has again to pass over some bars placed four or five inches apart. Some of the coal passes through and is carried by schutes to its proper bin. This size constitutes the "Steamboat" coal of commerce. The remainder passes to the bottom of the plane. At the foot of this plane we see three holes, each about a foot square, and on looking into them we see two long toothed rollers, rolling on one another. The coal that is to be reduced to smaller sizes is thrown down these holes and is at once broken up by the rollers. After being broken it is passed into screens, which revolve, besides being slightly inclined so as to allow gravity to operate in carrying the coal forward. At the upper end of the screen the meshes are very fine so as only to admit of fine coal and dust passing through; but the meshes grow gradually larger as we approach the end of the screen. All the coal which passes through the screen is carried by "schutes" to the distributing ~~room~~ screen in the pickers room. The coal which being too large to pass through the meshes of the screen passes out at the end of it and is carried to another small breaker, where it is reduced still more and passes out on either side of it, being carried thence to the distributing screens. These are long screens made of wrought iron strips so woven together as to form rectangular aperatures, so as to admit of the coal passing through. They are cylindrical in shape, with a diameter of about four or five feet. The coal enters by the upper end and is gradually carried on by force of gravity, assisted by the rotating motion given the screen. At first the coal passes over very fine meshes and that which escapes is waste; next it passes over meshes which are somewhat coarser. That which passes through constitutes "pea" coal. The sizes are named in the following order "chestnut," "small stove," "large stove," "egg" and "broken" which passes out at the end of the screen. These various sizes in escaping from the screen pass into "schutes" inclined somewhat. These "schutes" are from fifteen to twenty feet in length, at their ends and along their sides, boys are stationed who detect and pick out the slate which may be in the coal. The coal, after passing inspection, is carried by "lightning schutes" into bins, from which it is passed into cars. All the coal which passes to the bottom of the plane is not broken up, but some is reserved for the use of factories, furnaces &c of the same size as when mined. This is called "lump" coal and commands the highest price, being usually composed of selected pieces, the poorer ones being broken up for the other sizes. The coal which passes through the spaces between the bars I first mentioned is sifted and then carried by "schutes" to the distributing screen.

About ten per.ct. of the coal mined is reduced to dust by the various operations to which it is subjected. As yet no method has been discovered by which this dust can be used with economy, numerous experiments have been made, but their success has been only partial.

Charles C. Gilman.
Theme.
Aug. 1868.

Opening up and working of an Anthracite Coal Mine.

In selecting a subject for my thesis, I have decided to adopt the foregoing for several reasons, the principal of which is, having spent some time at a coal mine, think I shall be able to write more intelligently on this subject than on one in which my whole knowledge is purely theoretical.

I have taken a general case in order to show the different methods employed in working mines, where the pitch is very steep and also where it is very slight. I take a single vein of considerable thickness for these reasons; the veins as yet worked in the Anthracite region of Penn. are quite thick, a single vein is considered, because the majority of the mines are opened only on one, and indeed working two or more veins does not differ materially from working a single one. In this thesis I shall consider the vein to have a run East and West, with a North and South crop, which has been traced and proved for the entire Basin. I shall suppose the distance from the East and West extremities of the Basin to be two and a half miles;

this is commonly called the run of the vein. The width of the Basin from North to South crop half a mile. The Northern dip to be 70°, the Southern 15°. The dip of 70° is taken in order to illustrate the manner of working by the run. The dip of 15° to illustrate the manner of working by the wagon where they are carried into the breasts or chambers.

I shall consider the vein to have the following section, (Pl. 1 Fig. 1) uniform throughout, on top five feet of coal, then one foot of slate, next six feet of coal and one foot of slate, finally five feet of coal; – making a total of sixteen feet of coal and two feet of slate. The top and bottom rocks consist of slates.

The subject will be treated under the five following heads

1°. Opening up.

2°. Draining.

3°. Ventilation.

4°. Inside Transportation.

5°. Mining Proper.

The preparation of the coal is not included, because a detailed account of the process would require a great deal of time and space, and properly it does not come under the general head of mining, being merely a mechanical operation to which it is subjected after being mined; so I will not attempt to treat it at all.

Opening up.

Before adopting a system to be pursued in working the bed under consideration, several things should be looked into; we should place the entrance to the mine as nearly as possible in the centre of the basin; -ie- the East and West runs should be nearly equal. If the basin in which the coal lies is very flat its edges not being steeply inclined, a shaft sunk as near as possible in its centre, would be the best manner of opening up the coal. It is always desirable before sinking a permanent shaft, to sink a trial pit or make a boring, in order to ascertain the nature, consistency and depth of the rocks, which overlie the coal

In our Anthracite region, this would entail too great expense and consequently is seldom done.

I will take up the method of sinking shafts shortly. If we employ a shaft to obtain access to our mine, the Breaker is situated directly over its mouth, or what is preferable, a little to one side, so that, on the cars being raised in cages, they may be switched off and run upon trustleing to the Breaker. The advantage gained by so doing is this; in case of fire all anxiety with regard to its being communicated to the shaft is removed by the Breaker being so far distant from it. Trustle work seldom burns, but should the shaft be in imminent danger, it can be rendered secure by cutting a few spans of it, which is easily done.

If the vein under consideration, is situated in quite a steep basin and crops out in a position so as to be accessible, the best and most economical manner of working it, would be by sinking a slope along the vein. Several advantages are gained in sinking a slope over that of a shaft.

1°. The general course and character of the vein is determined as the slope is sunk.

2°. The expense of sinking a slope is slight in comparison with that of a shaft, for the mining is not so hard, and the product of the slope is marketable, while in a shaft it is all refuse.

The shaft has the following advantage over the slope; the expense attending the hoisting of a given number of tons, a given number of feet perpendicularly, is less in the shaft than slope; the wear and tear of machinery being less. Also in a shaft, cars can be raised from a given depth much faster than in a slope, because of the increased distance to be raised in a slope over that of a shaft; these distances bearing the proportion of the hypothenuse of a right triangle to its perpendicular side.

In mines, where shafts or slopes are used, hoisting apparatus and pumps have to be employed.

I will now speak of two other methods employed in opening up in our Anthracite mines; viz- opening up by means of a drift gangway, and by means of a tunnel, cutting the veins at right angles. The first method, is that most generally employed in veins above the water level; they being so situated that they can be easily approached by drifts or passage ways, which run parallel to the strike of the vein.

This method has the advantage of being much more economical than either shaft or slope mining, because neither hoisting or pumping machinery is needed, except it may be, a small engine to hoist the cars to the top of the breaker, but quite frequently the conformation of the ground is such, that the top of the breaker is situated at the same level as the drift, in such a case no hoisting machinery will be required.

Generally mines worked by a drift gangway are allowed to ventilate themselves, but those which are worked by shafts or slopes always require that some provision should be made in order to secure good ventilation. On the subject of ventilation, I will speak more fully in turn.

When veins of coal are situated above the water level, but in such a position that they cannot be entered by a drift, a tunnel is driven across the measures, cutting the veins at right angles, after which, gangways are driven in the veins to either side of the tunnel, and the veins worked up from them.

This method of getting at the coal is happily not often called; I know of an instance in the Mahanoy Basin, where a tunnel cost on an average one hundred dollars per yard.

Sinking Shafts.

In our Anthracite region, the greater portion of the coal mined as yet, has been taken from veins above the water level. Probably, the greater portion of the coal above the water level will be worked out, before that which is situated in the deep basins is mined. The greater portion of the mines below water level are approached by slopes, sunk along the veins. The shafts which have as yet been sunk, are of small depth, compared with those at the English mines, and if one is able to judge from the position and size of our Anthracite Basins, the conclusion would be, that no such immense shafts will ever be sunk, as are common in England, because the amount of coal possible to be hoisted from such a pit, would not pay for sinking it and leave a margin for profit; moreover the slope is looked upon by American miners in the most favorable light, because, probably of its comparative small first cost. The dimensions and form of shafts vary; the dimensions with, the size of the basin to be worked; the form, with the material by which the shaft is walled or timbered. When a shaft is walled with brick or stone, it is generally round or elliptical, when timbered it is most frequently rectangular though sometimes hexagonal in horizontal section.

In Europe, in sinking very deep shafts, a great deal of nice engineering skill has been required, to prevent the sides of the shaft from falling in, while building. In this country, where our shafts are of slight depth, we have not been obliged to contend with this difficulty.

Where the strata are sufficiently hard, the shaft is sunk to its entire depth, and then walled or timbered.

If the strata have not sufficient consistency to preserve a vertical edge, until the shaft is sunk, the following are the methods pursued.

1° If the shaft is to be walled with brick or stone, it is first sunk as far as safety will permit, this depth of course varies with the nature of the strata. (Pl. 1. Fig. 2)

At the bottom the excavation is widened a little, a wheel or frame of oak is placed on the ground and wedged very tightly, and on top the masonry is built.

Digging is commenced again, the hole being brought to its original dimensions, and sunk perpendicularly down another lift, a frame is placed in and wedged as before and masonry built up as far as possible, then the intervening rock is dug away, masonry put in closing the gap, in this way the whole shaft is walled.

2° If the shaft is to be timbered, it is first sunk as far as a vertical edge is preserved, then timber it, now in the shaft dig a small pit, at the bottom of which lay a platform of planks, then by cutting notches in the sides of the pit, raking props are inserted, their lower ends abutting against a foot block; upper, against the lowest frame or setting.

The pit is now enlarged, the excavation is timbered, the frames being connected with those above, a new one is dug and the same operation may be repeated until the shaft has been sunk to the required depth. Sinking stone or brick lined shafts may be performed in two ways, either by "underpinning" or by a "drum curb".

Underpinning does not differ materially from the preceeding method of sinking a timbered shaft.

The shaft is sunk as far as safety will permit, then a strong timber frame is set and wedged, on it another frame and then the masonry is built so as to break joint. A small pit is now sunk in the centre of the shaft and props inserted, as in the preceeding case, then it is enlarged to the size of the shaft, a frame placed in position and masonry built to close up the space intervening between the frames. After the connection is made another pit is sunk and the same process repeated.

A Drum Curb consists of a frame on which the masonry is built and a hollow vertical cylinder of a diameter equal to the outside dimensions of the shaft;

it supports the frame on its upper edge and is bevelled to a sharp edge below. The cylinder should be well built and braced, in order to resist forces tending to crush it in. The process of sinking with a drum curb is this; the shaft is sunk as far as the earth will stand in a vertical position, the curb is placed in the bottom of the excavation and the masonry begun and continued as the curb sinks, care being taken to complete one course before another is commenced, so as to keep the curb loaded equally. The earth being dug away from the interior of the shaft, the increasing weight on the curb causes it to sink and penetrate the earth; so we have three operations going on together :-viz.- 1° digging away the earth; 2° sinking of the curb;- 3° building masonry on top of curb as it sinks. Care should be taken to keep the curb equally loaded in all parts so it may tend to sink vertically.

Temporary Supports for Shafts.

Two methods are given by Rankine for supporting shafts, when sunk on the centre line of a proposed tunnel :-viz.- Inside and Outside Support. The use of these is obvious, for the excavation necessary for building the tunnel

which runs directly beneath the shaft, would remove the earth and leave the timbering or masonry without support; therefore, to keep the shaft lining in position and prevent its sliding, these stays must be used.
Support is given from below, if the earth is solid enough in the following manner. A pair of sills from fifteen to eighteen inches square in section and from ten to twelve feet longer than the span of the tunnel, are sent down, each in three pieces, and are laid in horizontal drifts, running at right angles to the proposed tunnel. The distance between the parallel sills is equal to the clear width of the shaft :-ie- distance between its inside walls. The small horizontal drifts should be filled and well rammed after the sills are laid.-

The sills support a square frame on which rests the lowest curb of the shaft. The distance of the parallel sills from the top of the proposed tunnel, varies with the nature and consistency of the ground, it may be taken generally from three to six feet. When the earth is too soft to give support in this way the second method has to be resorted to. Two strong beams are laid parallel to one another, across the mouth of the pit, a little nearer together than its clear diameter. From these sills a strong wooden frame is suspended by means of four wrought iron rods or chains. On the frame rests the lowest curb in the shaft; this support is maintained until the tunnel is walled and a connection made with the lining of the shaft. It is well in all shafts, to have the space intervening between the sides and lining well filled with earth, clay or hydraulic cement, so as to keep out water.

Sinking Slopes.

The work of sinking a slope is comparatively easy to that of sinking a shaft or driving a tunnel, because in a slope we drive constantly in the coal, which is generally more easily worked than the other measures, while in a shaft or tunnel we drive across the different strata of rock. Slopes are very common in our Anthracite region and shafts comparatively rare. The following is the method by which slopes are sunk. An excavation is made at or near the crop of the vein, the dimensions of which are a little larger than those of the proposed slope. The excavation is begun as in an open quarry and is carried on in this way until the rotten coal is cut through or a sufficient top is obtained to commence mining. Mining is now commenced, the hole driven, being of the same dimensions as the proposed slope. The slope is timbered as fast as driven. The mouth of the slope is now timbered, the frames are placed quite near together, the spaces between them being well lined with polings or laggings, earth is filled around and over the timbers; so the mouth of the slope is as close and compact as at any part of its length. In sinking a slope, it is customary to get on some particular rock and follow it down as the bed of the slope, for example, a rock below the coal or some slate in the coal itself.

In sinking a slope, the railroad is built as the work progresses, so that the coal from the face of work is easily removed. In sinking a shaft however, the debris is raised in buckets, which may be elevated by means of a windlass or small engine. In an air slope, the coal is raised in "buggies" or small wagons, which are elevated by means of a windlass, the buggies running on the bottom of the slope.

Driving a Gangway or Drift.

A gangway or drift is a passage way, horizontal or nearly so, its object

being to furnish a means for the transportation of the coal after it is mined. A great mistake is frequently made in our mines by having the cross section of the gangway too small, it impedes transportation, makes it more costly and does not supply a sufficient quantity of air to the men in the breasts; hence less work is accomplished than would be, if the gangway was larger. By making an outlay of from one to two dollars more per yard, Mine Proprietors would make an additional profit in the end.
In the mine under consideration, I take for the width of my gangway sills eleven feet, height in the clear eight feet. Ordinarily a gangway is laid with a single track, which runs in the middle or a little to the side which contains the breast schutes. A gangway should be well timbered, the distance apart of the frames depends on the nature of the roof, of which I will speak when I come to timbering.

A thick pillar should be left between the gangway and breasts, so as to keep the road from being crushed; the size of the pillar depends on the roof and thickness of the vein. Suppose the pillar in the vein under consideration to be nine yards in thickness. Slopes should also be protected on both sides by large pillars. In the case under consideration I shall take the slope pillars as fifteen yards; my slope being of the following dimensions; twenty two feet collar, twenty six feet sill and height eight feet in the clear, divided into three parts, two of nine feet each for wagon ways, the other of four feet for a pump way.

Schutes and Headings.

In our Anthracite mines the method universally adopted in working them, is the Pillar and Stall System. Schutes are passage ways used in this method of mining, to slide the coal from the breasts or stalls into the wagons. Their dimensions are about four by three feet.

Headings are passage ways cut across and connecting the schutes every ten or twenty yards so as to furnish air to the workings. Cross section of headings about three by two and a half feet. The above dimensions for the schutes and cross headings are taken for the mine under consideration. In the Pillar and Stall system, we work what are termed Breasts or Stalls, between every two Breasts there is left standing a Pillar of Coal.

Having sunk a shaft or slope and driven our gangway, a large pillar is left for the protection of the slope; if a shaft has been sunk, no pillar is needed; then the gangway is divided up into lengths of twelve yards for breasts and six yards for pillars alternately. Now in veins which are worked by the run, schutes are cut at both sides of the breast pillar; they are situated at a distance above the bottom of the gangway equal to a foot more than the height of a wagon. These schutes are driven back following up the vein at its angle of dip, until the gangway pillar is cut through. After the schutes have been driven for the required distance, they are connected together by headings. The breasts are now worked in a manner that will be described farther on; the pillars are left standing until the lift is worked out, when if possible they are withdrawn. The foregoing description will be easily understood by referring to Plate II.

Schutes and headings require as a general rule no timbering; the schutes are continued practically as the breasts are worked, by throwing the "goaf" or slate in a heap where the coal used to be, leaving passage ways on either side. After driving the breasts for a number of yards, it is desirable in order to supply the miners with fresh air to drive other headings and close the first set, so as to bring the fresh air nearer the face of work. When each breast has two schutes, one only is used for the discharge of coal, the other to facilitate the passage of workmen and at the same time assist in ventilating the workings; they are called respectively coal schutes and man ways or men schutes.

The mine I have taken as an example, has now a slope sunk, gangway driven, breasts open and ready to work on one dip of the vein. To reach the other side of the basin so as to operate both dips at once, it is necessary that a tunnel be driven across.

The work of driving and timbering does not differ materially from that of a gangway, except in a tunnel the measures are cut across, while in driving a gangway we are in the same vein all the time.

My tunnel has nearly a rectangular section and is seven feet in the clear in breadth and height; this tunnel is driven until the vein is cut on its other dip; a gangway is driven on both sides of it and breasts opened. The tunnel should be nearly if not quite opposite the bottom of the slope.

Air Slope and Air Course.

In small mines sufficient ventilation is supposed to be produced by having two openings at different elevations, the hot air passing out at the top and the cold air passing in at the bottom.

But in a mine of the dimensions under consideration some provision must be made in order to provide a sufficient quantity of pure air. It is not my intention to enter yet into the subject of ventilation, but simply to speak of the air slope and way in connection with opening up the mine. The air slope is driven to within four or five yards of the gangway, a passage way about four by three feet is driven parallel to the gangway, this constitutes the air course. The air course is situated in the top of the gangway pillar and consequently passes over the schutes. The air course should be driven so that its face is always but a short distance from the gangway face, in order to supply fresh air to the workmen.

It now remains, to speak of the means adopted to render the shafts, slopes &c. permanent and safe. In order to protect these passage ways, timbering is generally resorted to in our Anthracite mines, because of its little cost compared with masonry, most mining property being covered by a heavy growth of wood suitable to be employed for frames &c.

Timbering Shafts.

Various methods have been adopted in timbering shafts. The one almost universally adopted in our mines is this; the shaft is sunk to the required depth, the sides being supported by temporary frames. After it has been sunk, holes are drilled in the corners at the bottom of the shaft. In these holes long timbers, twelve to sixteen inches in diameter, are placed in a vertical position, on their upper ends other timbers are placed and so on until they reach the surface. Every few feet strut timbers or bars are placed, in order to secure the posts in position.

Other vertical timbers are placed along the sides of the shaft so as to give more strength; their number and position must be governed by circumstances. Having set the timbers and properly braced them, we nail to them three inch planks in a horizontal position and close together. Between the planks and sides of the shaft all spaces should be well rammed with clay or hydraulic cement, in order to keep out water.

Shafts are generally divided in two parts so that the cages may be kept separate; this is effected by sinking posts as before in the centre of the shaft, bracing them well and nailing three inch planks on both sides as in the previous case.

In order to guide the cages, which are used to raise the cars, guide ways are built in the shaft; they are of two kinds. In the first kind a projecting piece on the cage runs between two parallel pieces projecting from the sides of the shaft; in the second, the cage has two parallel projecting pieces between which runs a single piece which is attached to the sides of the shaft. Another method of timbering is employed, in which short pieces are used instead of long timbers as in the preceding case. Holes are sunk in the bottom of the shaft as before and timbers placed in them, projecting after being set a distance of six to nine feet above the bottom of the shaft, on top of these posts a horizontal frame is secured, then posts of twelve to fifteen inches in diameter and seven to nine feet in length, then frames and so on successively.

The frames and posts are secured, in the following manner; a post abuts perpendicularly upon a frame and is secured in position by what are called "brobs" or iron spikes driven deeply into the frame around the post thus securing it, or what is more commonly done the post may be mortised into the frame. Now as before three inch planks are nailed horizontally on the timbers, and the spaces between them and the sides of the shaft well packed. The shaft may be divided and guides for the cages built as in the preceeding case.

Timbering Slopes.

Slopes sunk at a very steep dip are timbered in a manner somewhat similar to that employed in shafts, but those of less inclination are timbered, in an entirely different way. The following is the method generally adopted; frames are set in the slope perpendicular to the dip of the vein, so that if squeezed they need not slide. This frame consists of a top piece called the "collar" and uprights inclined in from the bottom, mortised or joined in some manner to the collar. These uprights are called "legs". Sometimes, though not always, a bottom piece is used into which the legs are inserted, this piece is called a sill.

Collars and legs are generally used as cut, with the bark on, the sills however are shaved and cut down on two sides so as to set better on the floor of the gangway. The distance between the frames is from three to nine feet. In the case under consideration, my frames will be placed at a distance apart of four feet from centre to centre. Between the collars and roof, pieces of scantling or in our mines small limbs of trees are placed so as to furnish support between the frames; these pieces are called laggins. Between them and the coal all spaces should be filled by pieces of slate. A soft crumbling top requires that the laggins should be placed closely together, while a very hard top slate requires few if any.

Dimensions of timber used for legs twelve to eighteen inches in diameter, for collars ten to fifteen inches and for sills twelve to eighteen inches.

Timber of these dimensions being easily obtained, it is more economical to use it because of its solidity and durability compared with that of a less diameter.

The laggins have no particular size, being composed of the limbs of trees which are used for legs, collars &c. Frames should always be cut and fitted outside, as the limited working space inside would cause a great loss of time in joining them. When sills are not used the legs are secured in the following manner, holes are sunk at the sides of the gangway inclining inward; in them the legs are placed and secured and on the collar being raised to its position the frame is complete.

Timbering gangways in many cases is precisely the same as that employed in slopes, but there are several cases in which only part of a frame is required, in order to render ample protection; for example, I will take the following cases.

Case 1°. (Pl. III. Fig. 1.) Where there is a very hard top slate in quite a steep pitching vein, no timbering is required, though to be perfectly secure, timbers are placed perpendicular to the roof. The section of the gangway is not rectangular, but still economy of construction is preferable to beauty of appearance.

Case 2°. (Pl. III. Fig. 2.) When the top is rotten and the sides are good, collars only are used; they are placed in position by inserting them in holes, driven to receive their ends, in the top of the gangway walls. Laggins are laid from collar to collar.

Case 3°. (Pl. III. Fig. 3.) When one side is good, one leg and a collar are employed, the other end of the collar being inserted in a hole, driven to receive it, in the upper part of the gangway. Laggins are used where needed.

Case 4°. (Pl. III. Fig 4.) In this case both sides and the roof need supporting.

The desired support is obtained by using two legs and a connecting collar.

Case 5°. The floor in addition to the sides and roof need supporting in this case, therefore we are obliged to use a complete frame collar, legs and sill.

The wagon rails are laid in the previous case upon the frame sills. If the frames have no sills, rail sills are laid on the bottom of the gangway, sometimes in places cut to receive them.

At the point of its entrance to the gangway, every schute should have a wooden platform, projecting into the gangway a short distance.

This platform is of the width of the schute and has a depth of five or six feet; its object is to furnish room for a shoveller to stand and transfer coal to the wagons and also to prevent the coal from sliding into the gangway and blocking it up. Sometimes in working breasts, props have to be erected to sustain the roof directly behind the miner, they are placed perpendicular to the load to be sustained. I shall consider Draining and Ventilation under different heads though it may be maintained, that they should be embraced under the general head of "Opening up".

Draining.

In a mine which is worked by a drift gangway, sufficient pitch is given to the gallery to allow the water to flow out. The gangway should be lowest on the side farthest from the breasts, so as to keep the side nearest the workings as dry as possible. No definite pitch can be given to be observed in driving a gangway, the only way in which the right one is judged at, is in seeing that the water flows freely from the gangway. An Engineer who has charge of a mine, which is not worked by a drift, should ascertain, if it is possible, at a comparatively small additional expense, to drain it by means of an "Adit" thus doing away with pumping machinery. If it is impossible to drive an "Adit" pumping machinery or some mechanical contrivance must be resorted to, in order to drain the mine. If the mine, is worked by a shaft, a hole is sunk in its bottom to the depth of several yards, all the drains lead into it; this place is called the "sump". A slope has a sump hole at its foot, it is covered by planks and the drains lead into it. The water after it, is collected in the sump holes is pumped from them to the surface. Two kinds of pumps are in common use, - viz.- lifting and forcing or plunger pumps.

Lifting Pumps.

In some mines which do not accumulate much water, the pumps are only worked at night, being driven by the hoisting engine, by making some attachment to the pump rod. In such cases the sump should be of a size sufficient to hold the accumulation of from eighteen, to twenty four hours. Lifting pumps are constructed precisely as the common house pumps only on a larger scale. It consists of a long hollow tube of iron, which is sometimes lined with wood to keep it from contact with mine water, which usually contains free Sulphuric Acid. This tube is perpendicular in a shaft, while in a slope it follows the dip of the vein. The end of the tube should be fitted with a copper or brass piece with holes as large as a pea perforated in it. The object of this, is to keep out pieces of coal which would choke the pump.

Near the end of the tube is placed, what is termed, the lower box, it consists of a cylindrical wooden or iron frame with a common leather flap, or if the diameter of the box is too great, it may have two or more valves. These valves all open upwards. To the end of the pump rod is attached the upper box, the construction of which is precisely the same as that of the lower one. Care must be taken in putting it in position, that it shall descend to a distance from the bottom, less than the height of a column of water sustained by one atmosphere. Sometimes, instead of the common flap valve a ball clack is used. The valve is of the form of a perfect sphere, if it is of large size it is cast hollow; it is enclosed by wire guards to ensure its falling into the right position. Simplicity in the construction of pumps should be the principal object, so that in case of accidents they can be easily repaired.

Forcing or Plunger Pumps.

are more frequently

employed in draining mines, requiring less power to operate them than the lifting pump. In the lifting pump, the water is raised with the rod, while with the forcing pump it is forced out as the rod descends. The pump consists of a plunger which if of considerable size is cast hollow. This plunger works inside of a cylinder, the piston passing through a stuffing box. The cylinder in which the piston works, is connected with a similar one in a parallel position, which has two boxes supplied with clack valves, one box is placed below the tube connecting the two cylinders, the other above. Now to operate the pump, by means of a small hole in the upper box, the space between the boxes and plunger, which is raised, is filled with water; the piston is lowered and the water is forced above the upper box, on raising the piston water rushes in to fill the void. Thus the operation goes on, as the piston is lowered water is forced above the upper box and as it is raised water rushes above the lower one, to supply the place of that which has just been displaced. Above the stuffing box, a hole should be drilled, in order to allow the air which collects between the sides of the cylinder and plunger to escape. It is generally advisable if the slope or shaft is of a depth much over one hundred yards, to divide it into two pump lifts, one pump raising the water a certain distance and throwing it into a reservoir, the next lifting it from the reservoir to the surface. Burat gives three cases where the total depth is divided into different lifts. The amount of water to be raised fixes the diameter of the pump. Calculate at first the weight of the column of water to be raised from the bottom of the sump to the surface, this will give the pressure on the piston, call it P. Now construct the pump rod of sufficient size to sustain this pressure, we are then enabled to calculate the total weight of the wood and iron of which the rod is composed, call it T. Now on comparing these cases we find them to be three in number. 1° $P > T$; 2° $P = T$; 3° $P < T$.

Case 1° The weight of the column of water is greater than that of the rod, we divide the column into two parts; the upper one represents a column of water whose weight is equal to that of the pump rod, the lower one the complement of that weight. The upper lift should be worked by a force pump, the rod being raised and abandoned to itself. In the lower lift the water should be raised by a lifting pump.

Case 2°. Where $P = T$ the weight of the pump rod is equal to that of the column of water to be raised. The whole column may be raised by a forcing pump, but if it is desirable that the piston should have a considerable velocity in its descent, a lifting pump may be employed at the bottom to raise the water a short distance. Lifting pumps have the advantage of being able to work when drowned.

Case 3°. $P < T$. In this case the weight of the rod exceeds that of the column of water to be raised. Forcing pumps should be used entirely, unless we may prefer to use a lifting pump for a short distance at the bottom of the shaft or slope. In this case since the weight of the rods exceeds that of the column of water to be raised, a counterbalance must be used so the effective weight of the rods shall only slightly exceed that of the water. The most common kind of counterbalance is that which resembles the walking beam of an engine, one end being attached to the pump rod by a chain, the other supports a platform on which weights are placed in sufficient numbers to produce the required result.

In some mines, where only a small quantity of water collects, which can be easily pumped out during the night shift, a separate engine is not required for this work. If however a considerable quantity of water accumulates, it becomes necessary to employ a special engine. The Bull Engine is much employed for this purpose in the Anthracite mines.

It consists simply of a cylinder, its piston being connected inflexibly to the pump rod. If the pump is erected in a shaft, the engine is erected perpendicularly over it, if in a slope it is inclined at the angle of dip. Steam is admitted at the lower end of the cylinder, it raises the piston and consequently the pump rod, on the downward stroke the piston is abandoned to itself. The Bull Engine is very wasteful of power but as fuel and consequently steam is very cheap, it is much used; economy in the use of fuel not being sought so much as simplicity of construction. Simplicity, strength and durability are the great objects to be aimed at in erecting Colliery engines. After the water is discharged from the mine it is easily run into some brook or creek, the surface of the country being so undulating. Other methods beside pumping are resorted to, in draining mines. One method is that of which an example exists in the Mahanoy Basin. At a colliery near Mahanoy City, a shaft has been sunk and divided in two compartments of which one is used for hoisting coal, the other, water. The water is raised in a large bucket whose diameter is five and a half feet and height six feet. In the bottom of the bucket is a valve, which is opened when it is sunk in the sump, by the pressure of the water, on raising the bucket, it closes, arriving at the surface, a car with a projecting trough is run directly under it, a door is opened and the water discharged into the wagon, which is wheeled off and its contents disposed of. Another method of draining, is to have attached to the bottom of each cage a cask which when it is lowered sinks into the sump hole, the pressure of the water opening the valve with which each cask is supplied, on being raised the water is drawn off in troughs which are run under the barrels. In the case under consideration, I shall use a common plunger pump of ten inches diameter, the plunger to be of cast iron, it should be kept well greased to keep from corroding. As the first lift is only one hundred yards, the water can be raised by one pump. My sump hole is formed by driving the slope down some twenty five feet below the gangway and then driving a hole of the same cross section as the gangway and parallel to it, for some fifty feet. The continuation of the slope and the gangway should be very strongly timbered.

Ventilation.

This is one of the most difficult and perplexing subjects that has ever troubled the Mining Engineer. How to ventilate, so that a constant supply of fresh air can be furnished to the most remote part of the workings, is no easy problem. In most mines above water level, natural ventilation can be made available, the air entering at the lower and escaping at the higher level. Natural ventilation depends greatly for its effectiveness, upon the difference of temperature of the air outside compared with that inside the mine. It is obvious if the difference in temperature between the inside and outside of a mine is very slight, little or

no draught will be produced and consequently the greater that difference the better will be the ventilation.
When furnaces are employed, ventilation is secured by the heat produced by a fire in the mine rarefying the air, causing it to expand, communication being furnished with an upcast shaft an upward current is produced, this causes a consequent downward movement of the air in another shaft. The furnaces in a mine which contains gas are generally supplied with pure air from the downcast shaft, the air which is carried off is lead into the upcast shaft by what is called a dummy drift (Pl III Fig 5.). The furnace should be so built that there can be no danger from fire, and as little waste of heat from absorption by the measures through which the shaft passes as possible. To establish a furnace, it is only necessary to excavate a chamber, drive a passage to the upcast shaft and erect the furnace in the chamber. In England, furnace ventilation is used almost exclusively, the galleries being of fair size and generally very straight.
Mechanical ventilation seems to be the best adapted for the mines of Continental Europe and the United States. The exhaust fan, as a means of ventilation,

is coming into general use in the Anthracite mines of Penn. It consists of four iron blades fixed to a horizontal axis and revolving in a box. This box is closed except in three places, one in the centre on each side, for a sixteen and a half feet fan they should be four and a half feet in diameter, the third aperature is the place of exit for the air. The box is built in a slightly spiral form, the blades having one half inch clearance, after passing the point of exit, it increases to two and a half feet just before reaching the point of exit. The fan box is roofed over, so only air that comes from the mine can enter it. I shall ventilate my mine by means of a fan sixteen and a half feet in diameter. English Engineers prefer Furnace to Mechanical ventilation, while French and Belgian Engineers prefer Mechanical ventilation to all other means.

Ponson gives the following reasons for preferring Mechanical to Furnace ventilation.

1°. A shaft should be devoted to ventilation.

2°. In case of an explosion, the machine may be so situated as not to be injured. A furnace after an explosion, is liable to ignite the gas which may remain in the mine.

3°. Obtain as good ventilation as by a furnace.
4°. Machines at the surface are constantly under control or supervision.
5°. Cost of maintaining ventilating machinery not much different from that of furnaces.
6°. No danger from explosion.

Steam Jets and Waterfalls.

These methods of ventilating have been used to some extent but are now becoming obsolete. The steam jet is used only when steam can be produced very cheaply, the waterfall, only when the mine is drained by means of an adit or in some way rendering raising the water again unnecessary. Steam jets are of little value in deep shafts, in shallow ones however, they may be used to advantage. Daddow in his work on coal mining, compares the steam jet to a steel spring, its action being in its own vicinity and its energy soon expended. On being released from tension the steam expands rapidly in an upward direction, drawing the air after it, consequently producing an upward current; if however the pit is deep, the steam condenses, falls behind, and actually retards the current. In a shallow pit, the steam jet may be made available, the steam not having time to condense before arriving at the surface. The various methods for producing a current of air being described I will now endeavor to show the manner in which it is conducted through the various passages of a mine. In a mine where natural ventilation is employed, the current enters at the drift entrance and passes out through a passage way in a higher level. The air on entering passes along the gangway until it strikes a door which is placed between the first and second breasts, it is turned aside and passes up the breast schutes. On arriving at the face of the breast, the air passes along it and down the other side of the "goaf" until it reaches a heading through which it passes into the second breast along its face and into the third breast, so on successively until it arrives at the end of its course when it passes into a passage way at a higher level and escapes. As the breasts are advanced new headings are driven, the old ones being closed, in order to bring the air nearer the face of work. The door in the gangway should be kept closed except when wagons are passing. Sometimes no door is used the air passing along the gangway and up all the schutes. In this system of ventilation only that portion of the mine which lies between the drift entrance and the return air hole can be properly ventilated, all parts of the mine which lie beyond the return hole are supplied with an insufficient quantity of air. To remedy this, after having driven some distance beyond the air hole, a new outlet is driven and the old one closed.

Conduction of air when ventilating machinery is used.

To explain this method of distribution of the air I will take as an example the mine I have under consideration. In opening up, I described the sinking of an air slope and driving of an air course. I shall assume that twenty breasts have been opened and are ready to work. In the heading beyond the last breast, a hole is driven into the air course, as more breasts are opened, other holes are driven and the old ones closed. The course pursued by the air is this, the main current descends the slope, at the bottom it divides into three parts, one portion going through the tunnel, the rest into the East and West gangways. At the first breast schute, the air passes up and along the face of work, thence by a heading to the next breast and so on successively to the end of the working where it is drawn into the air course through a hole cut into it from the last breast heading. The air is drawn out of the air course by an exhaust fan, to supply the place of that which is removed a fresh column constantly descends the slope. In this way a constant current of fresh air is kept in motion throughout the works. It would be advisable to place two doors between the first and second breasts, so as to cause a strong current to pass along the first breast's face. If no doors are used feeble currents will pass up each breast schute, the ventilation thus secured is not as effective as though the whole column of air entered through a single schute. In the vein I have under consideration, both dips are to be worked at the same time, the slope being sunk on the North dip and a tunnel driven across to the vein on its opposite dip. The method I shall adopt to ventilate the South dip is this, the air on arriving at the bottom of the slope is divided into three parts, which pass along the East and West gangways and through the tunnel, on arriving at the extremity of which, it is divided and passes along the East and West gangways of the South dip. The air is passed through the breasts precisely in same manner as the other dip. The air course in the South dip is connected with the air slope by a box which runs in the upper part of the tunnel, it is of the same cross section as the air course. When two currents of air meet, as at the foot of the air slope, a wooden partition or shield is built to deflect the currents up the shaft or slope. When an air course has to be carried across a gangway or other passage, it is better to carry it over than under it, for if carried under, water will collect in the lowest part thus impeding the passage of the air.

Inside Transportation.

The methods of transporting coal from the underground workings to the surface differ in various countries. Two general systems of transportation are in vogue; first, with light cars, light loads and quick transportation; second, with heavy cars, heavy loads and slow transportation. The first method is generally employed in England, and in thin veins in this Country. The second method has been universally adopted in the Anthracite region of Penn. The cars used in the New Castle region have the following dimensions and weight.

Weight of car 6.50 cwt.
" " load 10. "

Dimensions, 4 feet long, 3 feet wide; 2 feet high, inside measurements. Diameter of wheels 14 inches, without counting flanges; running surface, two and one fourth inches; gauge, two feet and a half; rails, twenty two pounds to the yard.

The following are the average dimensions and weight of cars used in the Penn. Anthracite mines.

Weight of car 30 cwt.
" " load 60 "

Dimensions, 8½ feet long; 3½ feet wide; 3½ feet high, inside measurements. Diameter of wheels 18 inches. without counting flanges; running surface 1½ ~~inches~~ inches; gauge, 3⅓, 3½, 4. 4⅔ ft.; rails twenty eight pounds to the yard. The track should be laid as the gangway is driven, so as to carry off the coal taken from the face of work. Various kinds of rail employed. In most of the small Anthracite mines, the common strap rail is used; it consists simply of a flat bar of iron which is nailed on string pieces laid on top of the sleepers. The objections to strap rails are that they are not durable, are liable to break, the ends being detatched will fly up and throw cars off the track. When a gallery is to be used but a short time, they are preferred to other kinds on account of their cheapness.

Another kind of rail employed consists of a bar of wrought iron, from one to two inches thick and two or three deep placed edgewise and secured by bolts to iron chairs. That which is now most in favor on account of its durability, is the T rail, weighing from twenty five to thirty pounds per yard. In the mine I have under consideration, I shall use T rails weighing twenty eight pounds to the yard.

In constructing mine wagons, the wheels and axles may have one of two relations to each other.

1°. The wheels may be so fixed as to be movable about their axle, when adjusted in this way the wagon has a greater facility for moving in curves.

2°. The wheels may be so fixed as to be immovable about their axle, when adjusted in this way, the wagon will be able to surmount an obstacle on the track easier, than if the wheels were adjusted as in the first method

Hoisting cars in a slope.

The most common method is to attach the car to a wire rope, which passes over a drum near the mouth of the slope and is so arranged, that when one end is at the bottom, the other is at the top, so one car is raised while another is lowered. Commonly cars are attached to the rope by means of chains which are riveted to it. Another method of making a connection, which does away with the necessity of hooking and unhooking cars is this; a small compactly built truck, called a "pusher" is used, it runs on a track placed inside the main wagon way. The "pusher" is attached to the end of the rope. It is used in this way; the "pusher" attached to one end of the rope is lowered to the bottom, passing into the sump below the gangway level, then the wagon to be raised is pushed to the foot of the slope, passing directly over the "pusher", the drum being set in motion, the "pusher" is raised bringing the loaded car with it. When a car is lowered, the "pusher" runs in front, the car being held back by it. In steep pitching veins the cars are raised in cages. Slope cages consist simply of a frame so placed on wheels that a car when run on it will be raised in a horizontal position. On arriving at the top of the incline the car is run off and an empty one substituted in its place.

In the mine I have under consideration, such a cage must be used. I shall use for hoisting a steel wire rope one and a half inches in diameter, it should be kept well tarred in order to protect it from rust.

Mining Proper.

In mining an Engineer should make it a point, to take out all the coal at the least cost and exposure of the lives of the miners. In our Anthracite mines, the Pillar and Stall system is used to the exclusion of all others, so my description will be limited to this system. In this system, each lift is divided in breasts and pillars, the breasts are worked for coal, the pillars are left standing until the lift is worked out when if possible they are withdrawn. When the veins dip but little, not exceeding 15° the breasts are worked by the wagon:- ie - the wagons are carried into the breasts through schutes which run diagonally instead of with the dip of the vein. When mining by the wagon, the coal is thrown from the face of work directly into the car.

When the vein dips 35° and upwards the coal is worked by the run:- ie - the coal as soon as mined is thrown into schutes in which it slides to the gangway where it is transferred to wagons. When the dip is very steep, the coal is taken from the breast schutes only fast enough to make room for that which is mined from day to day, the miner standing upon it in order to reach the face which is nearly above him. After a shot has been fired in a steep dipping breast, the utmost caution must be exercised in reentering it, because large masses of coal may have been loosened so that the least motion will detatch them, thus exposing the miner to great danger. Veins which dip between 15° and 35° are generally worked by the run, it becomes necessary sometimes to line the schutes with sheet iron to facilitate the passage of the coal, at other times rakes are used to draw the coal down the breasts.

Methods employed in getting coal.

There are numerous methods in vogue for "getting" coal as it is termed. Whichever one is adopted we should always take advantage of the divisional planes into which the veins are divided. There exists in the lower part of many of our red ash veins layers of soft, imperfect coal which are called "mining". This imperfection is taken advantage of in mining the coal. By using sharp pointed picks, holes are dug in the mining for some three or four feet in depth and clear across the breast, the coal above is thrown down by using iron wedges or by a few well placed shots. Sometimes the coal will fall after the holing has been made without farther labor; coal in this condition is said to be slippery. Pillars should be left in undermining coal, which is slippery or props may be erected, these supports can be easily removed when the undermining is finished. In the mine under consideration, the coal will be mined, in the following manner. I have a lower bench of five feet, by shots I shall blast this out, thus undermining the rest of the vein, the upper benches can now be easily thrown down by a few heavy shots. Superintendents should see that the breasts are worked up with square faces & that the breadth and height does not diminish. It is a trick with miners when working by the running yard, to contract their chambers in breadth and height thus leaving behind a great deal of coal. Care should be taken to have two faces of the coal exposed, so as to be able to blast more effectively. A fracture will always follow in the line of least resistance, so if the distance from the bottom of a hole, in which a shot has been placed to a face of the coal, is less than the depth of the hole, the mass will be blown off; if greater, the shot is liable to be driven backward. In drilling holes to insert charges, drills of various lengths are used according to the room available; they are steel pointed and weigh from ten to sixteen pounds. After a hole has been driven to a sufficient depth, it is cleaned out and a cartridge wrapped in coarse brown paper is inserted, sometimes the cartridge is contained in a sheet iron cylinder. In the end of the cartridge some fine powder is placed for priming and the fuse inserted. The hole is now carefully tamped with wet clay, the fuse is lighted and the charge exploded. Very frequently the cartridge is not exploded, it then becomes necessary to put in a new fuse and priming. This is a very dangerous operation and should not be attempted until the fire is certainly extinguished.

Withdrawing.

I will consider the breasts in the first lift to have been worked out, it only remains to draw the pillars. One method employed when the roof is to commence at the end of the run and drive schutes through the pillars, then withdraw sending the coal down through the pillar schutes which have been driven. The most common way however is to commence at the top of the pillar and work off as much as possible. In our Anthracite mines on an average thirty to thirty five per. ct. of the coal is left in the mines and twelve to twenty per. ct. wasted by the breaker so in reality not much over fifty per. ct. of the coal in a given vein reaches a market. As pursued at present our system of mining is very destructive, we are destroying the rescources of the Country at a rapid rate, some improvement must be made or before we are aware our Anthracite Basins will be exhausted.

Having attempted in this thesis to give a description of the various operations necessary for the "opening up" and working of Anthracite mines and believing these operations are truthfully detailed.

I subscribe myself,

very respectfully,

Chas. C. Gilman.

'68.

Plate 1.

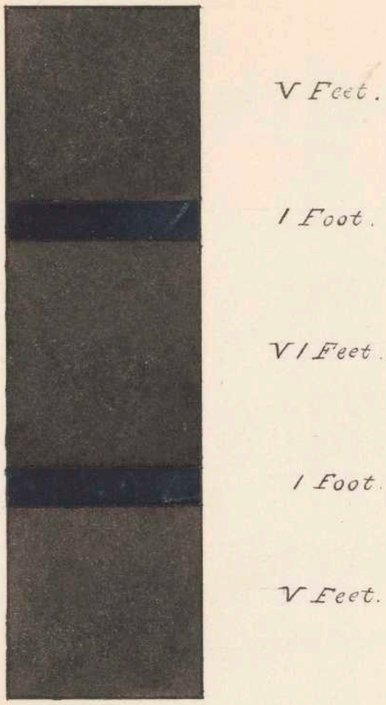

Fig. 1.
SECTION
of
VEIN.

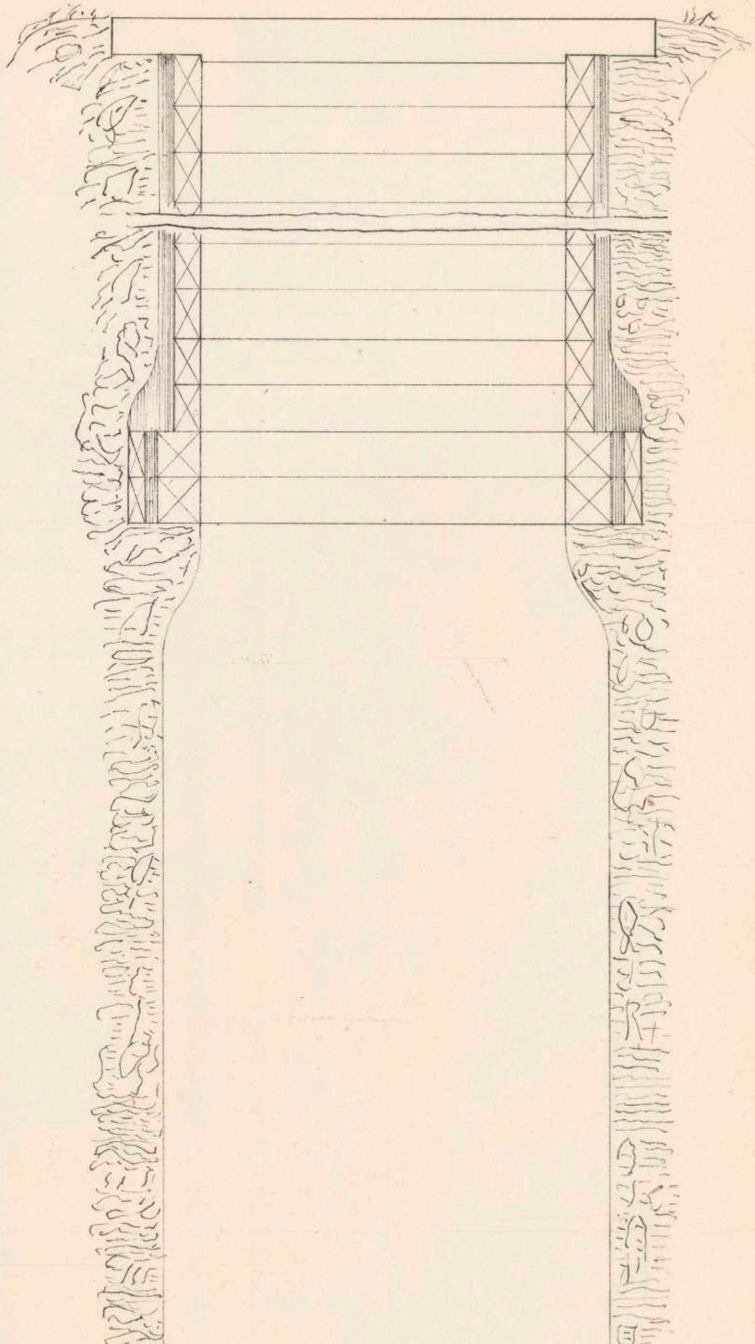

Fig. 2.
SINKING
A
SHAFT.

Plate II

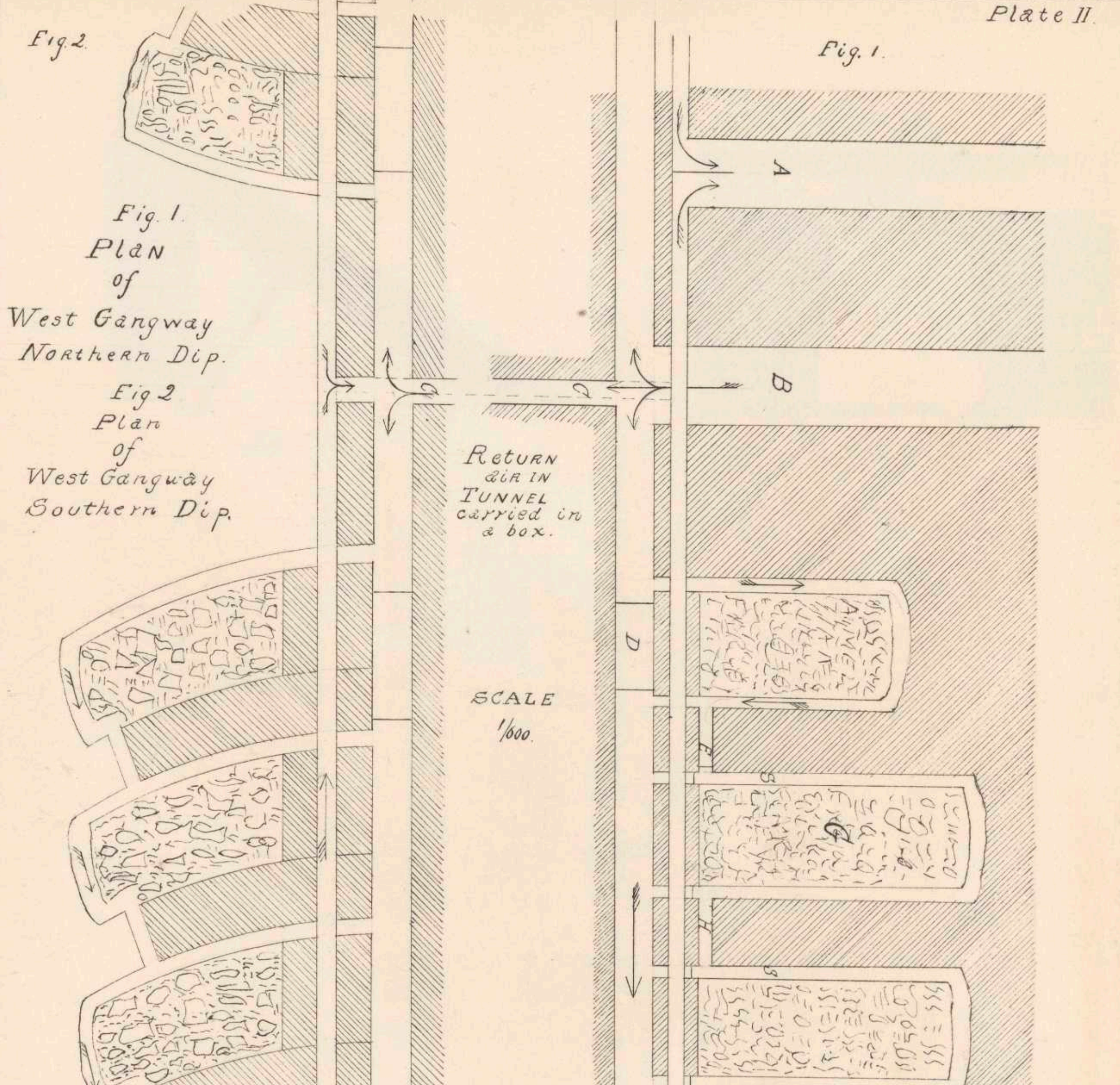

Fig. 1.
Plan
of
West Gangway
Northern Dip.

Fig 2
Plan
of
West Gangway
Southern Dip.

REFERENCE.

Schutes	S.	Headings	H.
Goaf	G.	Air Slope	A
Slope	B	Tunnel	C
Doors	D	Stoppings	E

Direction of air. ⟶

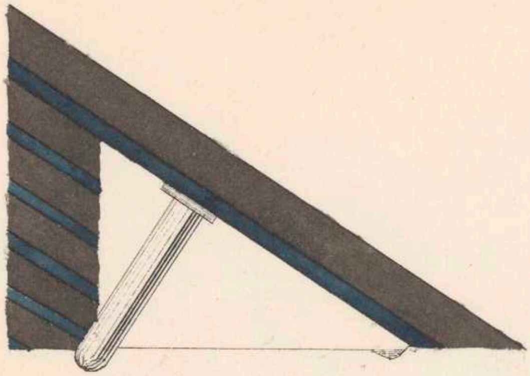

Fig. 1.

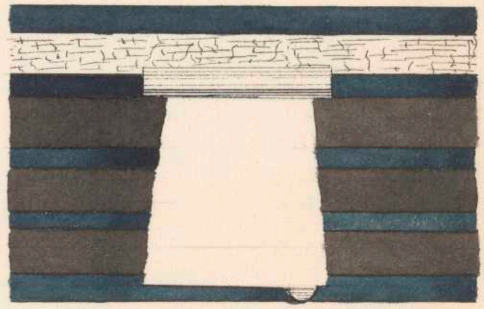

Fig. 2

a. Upcast Shaft
b. Gangway
c. Inlet air course
d. Return air course
f. Furnace
g Doors

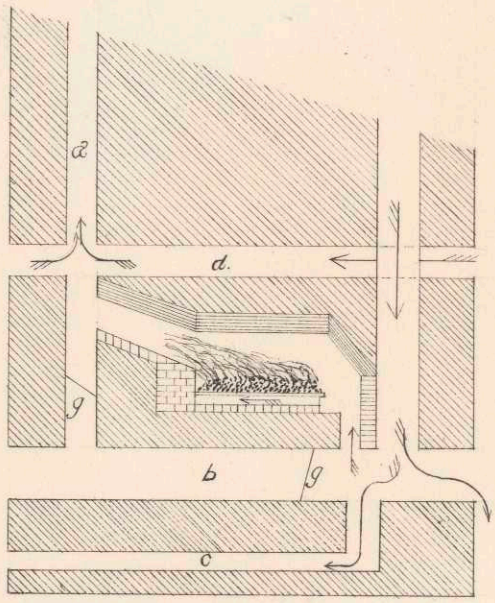

Fig. V.

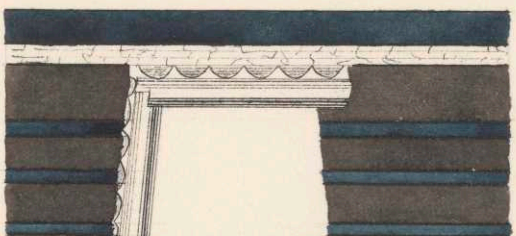

Fig. 3.

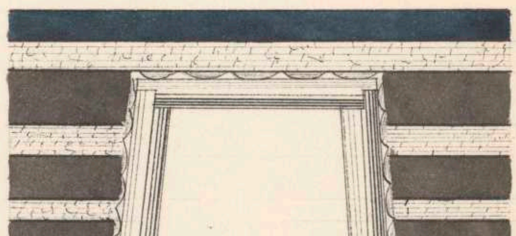

Fig. 4