MECHANICAL MINING IN THE SOUTHERN APPALACHIAN COAL FIELD

BY

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Mr. Horace Moore----------Electrician

Mr. Bill Geary----------Head Foreman

Mr. Floyd Owen----------Foreman

Mr. Louie Geary----------Foreman

Without the aid of these experienced mining men, the ground covered by this thesis would be limited.

PREFACE

The object of this thesis is to present a review of modern mechanical mining methods, and their advantages over other methods. The subject matter of this text differs from other material on this subject in that it is more general. All other material that the writer has seen discusses the methods used by a certain coal company. This text does not consider any one company, but discusses mining methods that have proven to be most successful. The material has come from the "Coal Age," my experience as a mechanic, and conversations with mining men.

I. General Survey of Field

The first coal mine was probably a one man mine. Some man while roaming along a mountain stream noticed an unusual layer of black substance between the rock. He noticed that the water had washed away the top layer of soil and rock leaving this black layer exposed. Through curiosity, he probably discovered it would burn and carried some of it down to his home. He probably told some friends of his discovery and they began using this substance as fuel. As civilization developed some one found he was a better coal miner than someone else, so he began devoting all his time to mining coal and trading it for other needs. In this way the coal industry was started as many other businesses were started.

Up until the Industurial Revolution, coal mining was carried on in a rather crude way. First, it was dug with some kind of crude pick and carried to the outside of the mines by hand. Later, they carried it in cars or on the backs of animals. By the time of the Industrial Revolution they were hauling the coal in home-made cars which were pulled by mules over two-by-four tracks. Very few "iron horses" were used at that time. The development thus far was probably due to an increase in demand. The mines were selling all the coal they could get at good prices. These good times in the coal fields lasted until a few years after the World War.

During the War many new coal fields had been opened and many substitutes for coal had been found. Following

the War, the demand for coal fell off, prices dropped, and competition became keener. The coal industry was faced with the problem of reducing prices and increasing quality in order to stay in business. Since many other industries had turned to mechinery to solve this problem it was only natural for the coal industry to turn to mechanical mining. Today the coal industry sees the advantages in mechanical mining and ise fast equipping the mines with machinery.

Most of the machinery is in the experimental stage and there is much room for improvement. The improvement will come as the machines are used and their weaknesses are discovered.

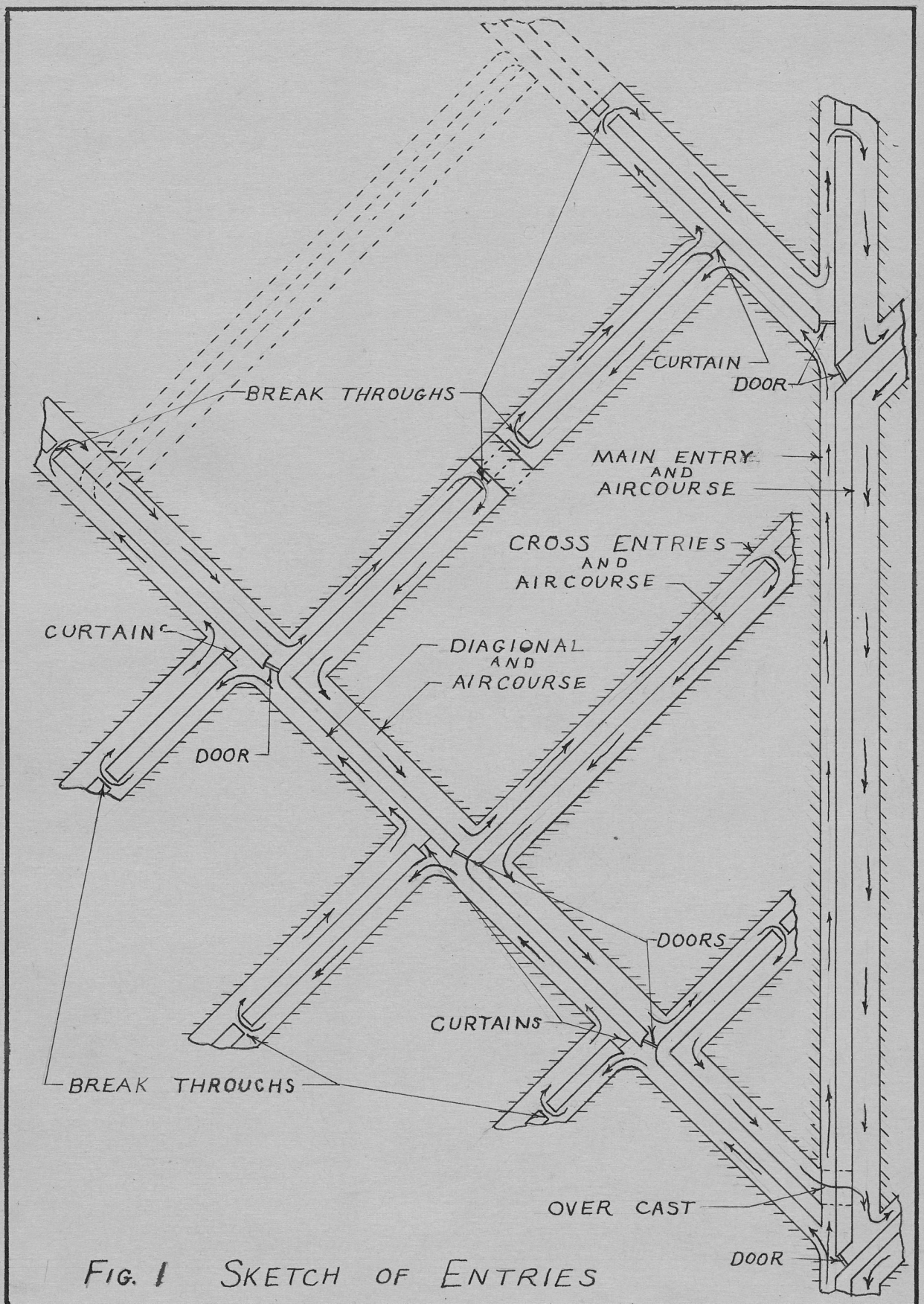


FIG. 1 SKETCH OF ENTRIES

II. Mine Map

Before discussing the different methods and the machinery used it is thought best to discuss the mine layout. The map of a coal mine (Fig. 1) looks very much like the map of a city, with the entries as streets and the rooms as lots. Rooms are driven off of both sides of the cross entries, and will be shown later in detail. The system shown here is one using diagonal entries. This method is used in large coal fields only. In the case of small coal fields the rooms entries are driven perpendicular to the main entry. The great advantage of the diagional system is the reduction in haulage distance. For example, suppose that a cross entry is turned off at a distance of three miles and is driven three miled--a total of six miles. If a diagonal is driven through to thatlpoint it would be about $4\frac{1}{4}$ miles with a saving of $1\frac{3}{4}$ miles. This doesn't seem very much if one thinks of a railroad system on the outside, but under ground where locomotives are making six or eight trips a shift, there ia a great saving. There is also a saving in track, timbering, power lines, ventilation, etc.

Cross-entries are turned off every 400 or 600 feet depending on the depth the rooms are driven. Rooms are turned off of both sides of the cross entries and driven within a few feet of the room from the next entry. The width of the pillow left between the rooms depends on the condition of the roof and the type of coal. If the top is sound and the coal hard, narrow pillows can be left.

With bad top or soft coal a wide pillow must be left.

The arrows indicate the flow of air through the mines. This system is extended as the size of the mined area increases. Notice how the air is carried down the entry to a "break through" and then back down the air course. "Break throughs"are made at various intervials depending on the method used in driving the entries. When a new "break through is made the old one behind it is stopped up--forcing the air on down the entry to the heading. The area between the air course and entry is a pillow left to separate the aircourse and entry. Its width depends on the condition of the coal and the top.

The air is forced into the rooms and to the heading beyondthe break through by means of portable fans and long canvas tubes or by burlap curtains. The air is directed along the entry by means of doors or curtains.. Doors are usually used between the entry and aircourses. Curtains offer resistance to the air and cause it to travel the path of least resistance. The great advantage of the curtain is that the lovomotive does not have to stop and the curtain is much cheaper to install.

Doors are necessary between the aircourse and entry because of the great pressure. In this case the locomotive has to stop to throw the switch and can open the door at the same time. Where it is necessary to put a door on the main entry the doors are made so that they will swing either way and the locomotive only has to slow down.

Two common methods (Fig. 1) of handling the air on the main entry are shown. The first (1) is known as the over cast method. Here the air is carried over the entry to the main aircourse. The second method (2) is the use of the door. This is cheaper to build than the over cast, but it makes it very undesirable if shooting is done during the shift because the territory behind the door is ventilated with back air.

The vacuum to create circulation of the air was first obtained by means of a fire and a tall chimney. Large fans have replaced this method. The most common of these is the outward flow fin type fan.

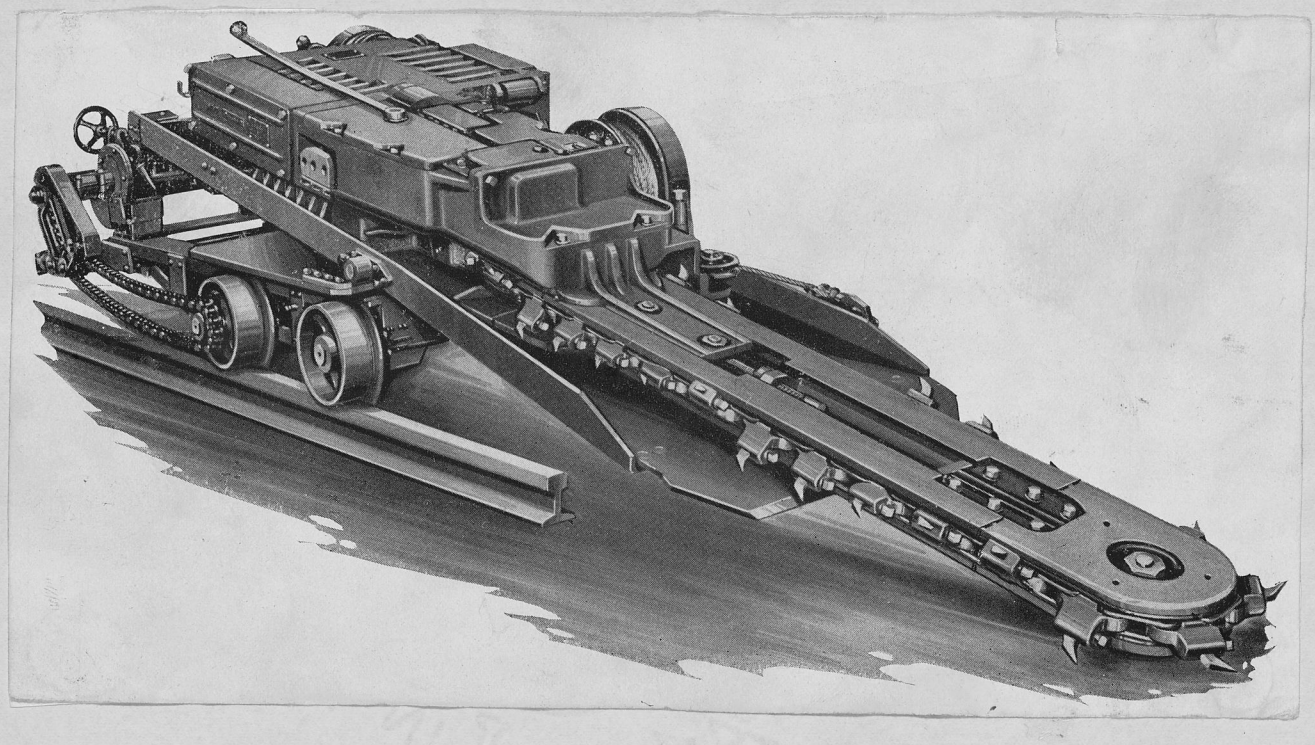


Fig. 2 The Undercutting Machine

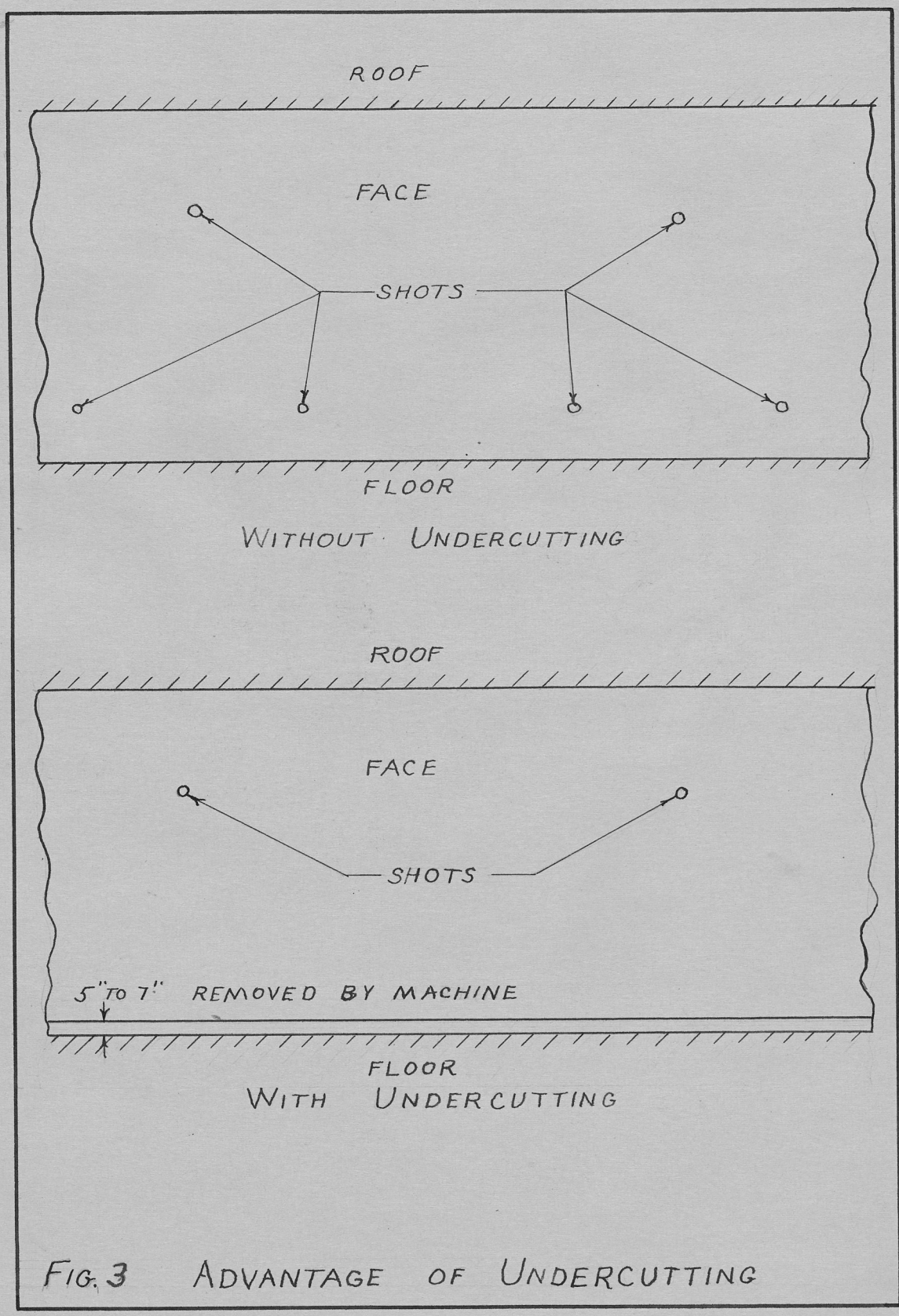


FIG. 3 ADVANTAGE OF UNDERCUTTING

III. Undercutting

The first machine introduced into the coal industry. after the locomotive was the undercutting machine. The undercutting machine (Fig. 2) is merely a big saw that cuts under the coal seams and removes a section from a depth of about 5 to 9 feet.

The great advantage of the undercutting machine can best be seen in the illustration (Fig 3). From this illustration one can see that without undercutting it is necessary to place several heavy shots near the floor to pull the coal out, and then place a few shots near the roof to break the coal down. The heavy shots near the floor tends to produce a lot of slack, leave the floor uneven which requires excessive picking, and blow some of the coal several feet from the face, thus making it difficult to load.

With undercutting it is only necessary to place a few shots, lightly loaded, near the roof to break the coal down. It is true that some slack is produced by the machine, but it can easily be gobbed and the quantity is much less than the slack produced by the heavy shots. With undercutting the floor is left even, and very little if any, coal is blown away from the face.

The greatest improvement in the cutting has been made in the use of tipped cutters. The tool steel cutters are being tipped with a metal called Bo-rod. This tip is much harder than tool steel. The softer metal wears off leaving a sharp cutting edge.

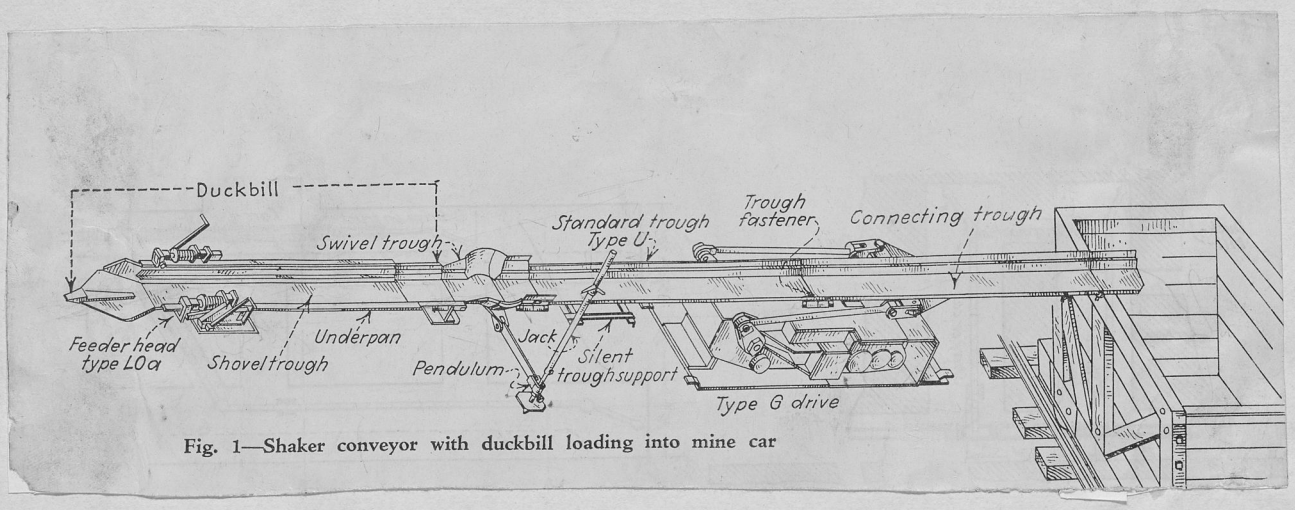
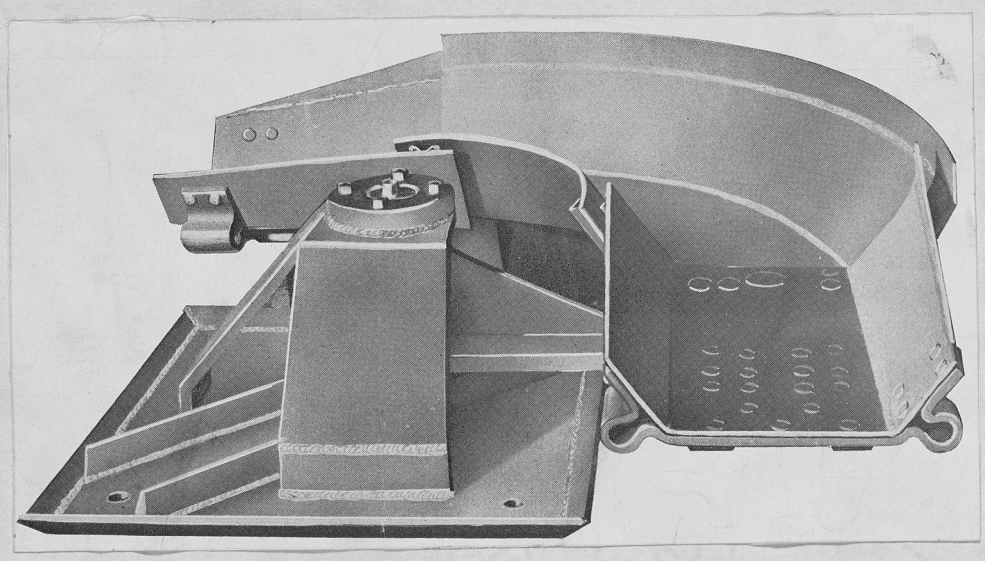
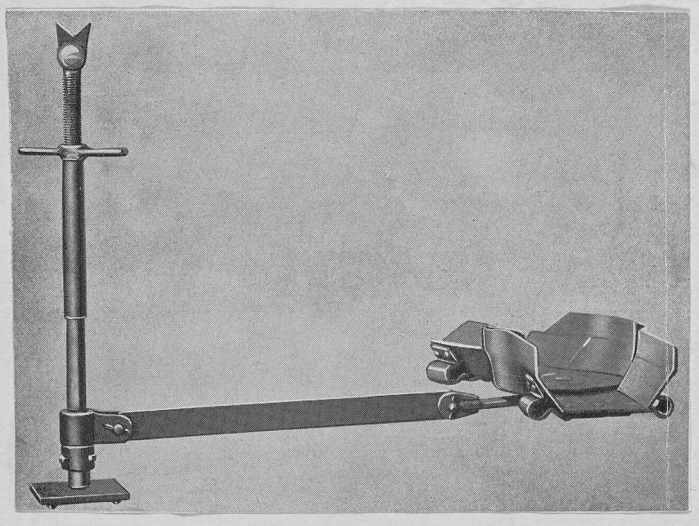


Fig. 1—Shaker conveyor with duckbill loading into mine car



Angle Pan



Swivel trough and Pendulum

Fig. 4

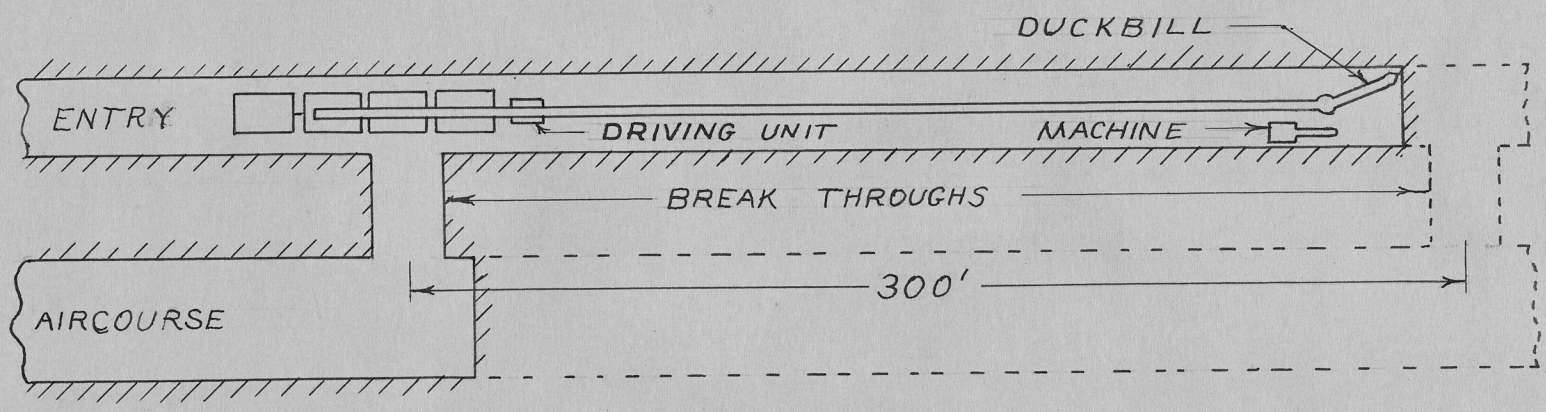


FIG. 5 DUCKBILL IN ENTRY

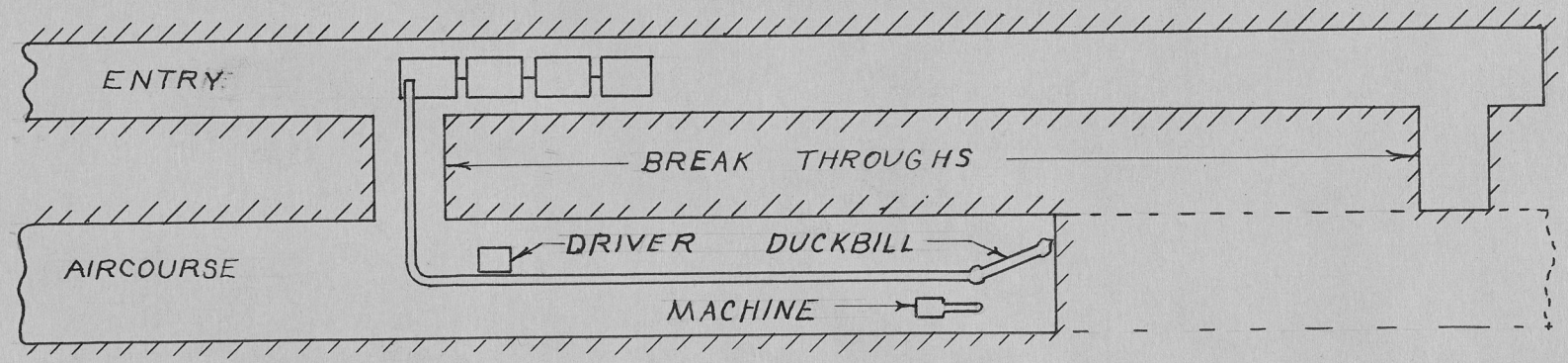


FIG. 6 DUCKBILL IN AIRCOURSE

IV. Entry Driving

Before any rooms can be turned off and coal loaded, it is necessary to advance the entries. The use of the shaker conveyor and duckbill (Fig. 4) have been unanimously accepted for driving entries.

The shaker conveyor is a pan line with a quick motion forward and a slow movement backward. The quick motion forward jumps under the coal before it has time to move and the slow motion backward carries the coal along with the pan line. This motion shakes the coal from the face to the loading point.

The duckbill is connected to the loading end of the pan line. It is similar to a conveyor pan sliding inside of the other. The pan on the inside has a shovel on one end and is held by a clamp controlled by the operator. As the pan line moves away from the face, the operator opens the clamp and a allows the lower pan to slide under the pan with the shovel. After the pan line has receeded the end of its backward motion the operator closes the clamp, and the shovel is pushed under the coal on the forward motion. After the shovel is well under the coal, the clamp is left closed and the coal is worked into the pan line. The duckbill is connected to the pan line by means of a pivot joint which allows the duckbill to be swung to right or left, and can take a width of about thirty feet. The one driving unit supplies the power for conveying and loading.

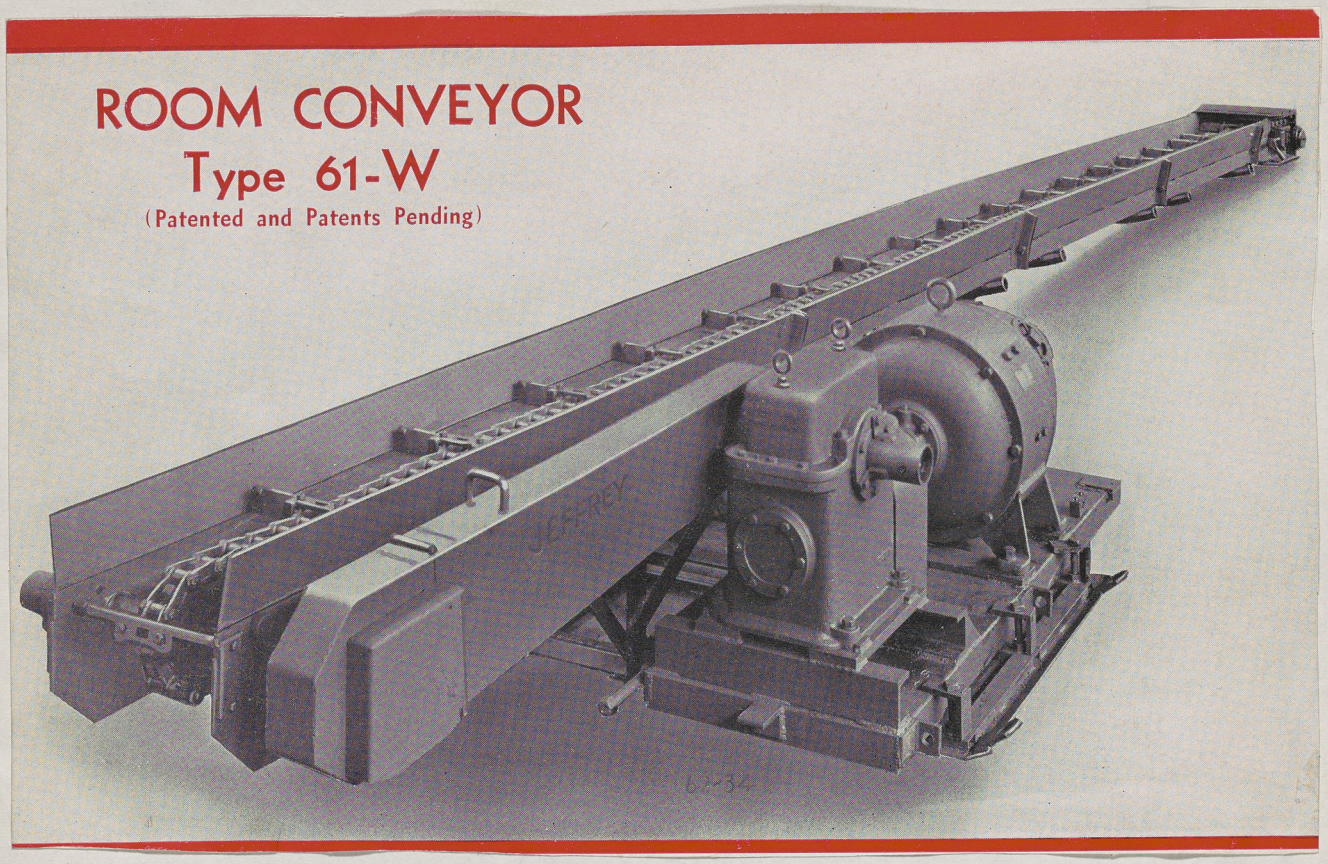
The great advantage of the duckbill can best be explained from the illustrations on the preceding page

(Fig. 5) shows the duckbill working in the entry. Before the duckbill was developed for entry driving it was necessary to lengthen the track after each cut was loaded out and take the to top out after each cut was loaded. One can easily see that this required an unusual amount of track work and handling cars.

By using the duckbill, the entry can be advanced as much as three hundred feet without lengthing the track, and several cars can be loaded before it is necessary to do any switching. The usual practice is to have room for enough cars to load out a cut. After all the coal has been removed, the pan line can be disconnected, laid over against the rib, the buckbill brought back near the driving unit, and the rack can be loaded without lengthening the track. After enough top has been taken to allow the motors to pass, the duckbill is moved into the aircourse as seeme in (Fig. 6).

With the duckbill in the aircourse, the entry is clear for the track crew to lay the thirty sections of ten feet each. In the meantime the duckbill is advancing the aircourse as shown in (Fig. 6) In this case the driving unit is at the side of the fan line and the pan line has an elbow. They have built an elbow that works on a jack and drives the pan line. After the aircourse has been advanced as far as the entry, the machinery is placed back in the entry as before, and the operation repeated. The break through that has been used during the described operation is stopped up and the new one is used. Since there is no travel through the aircourse, it

is unnecessary to remove the top as in entry. They are able to advance entries from eighteen to twenty feet a shift by the use of the duckbill, which is much faster than the old method of loading by hand into the cars.



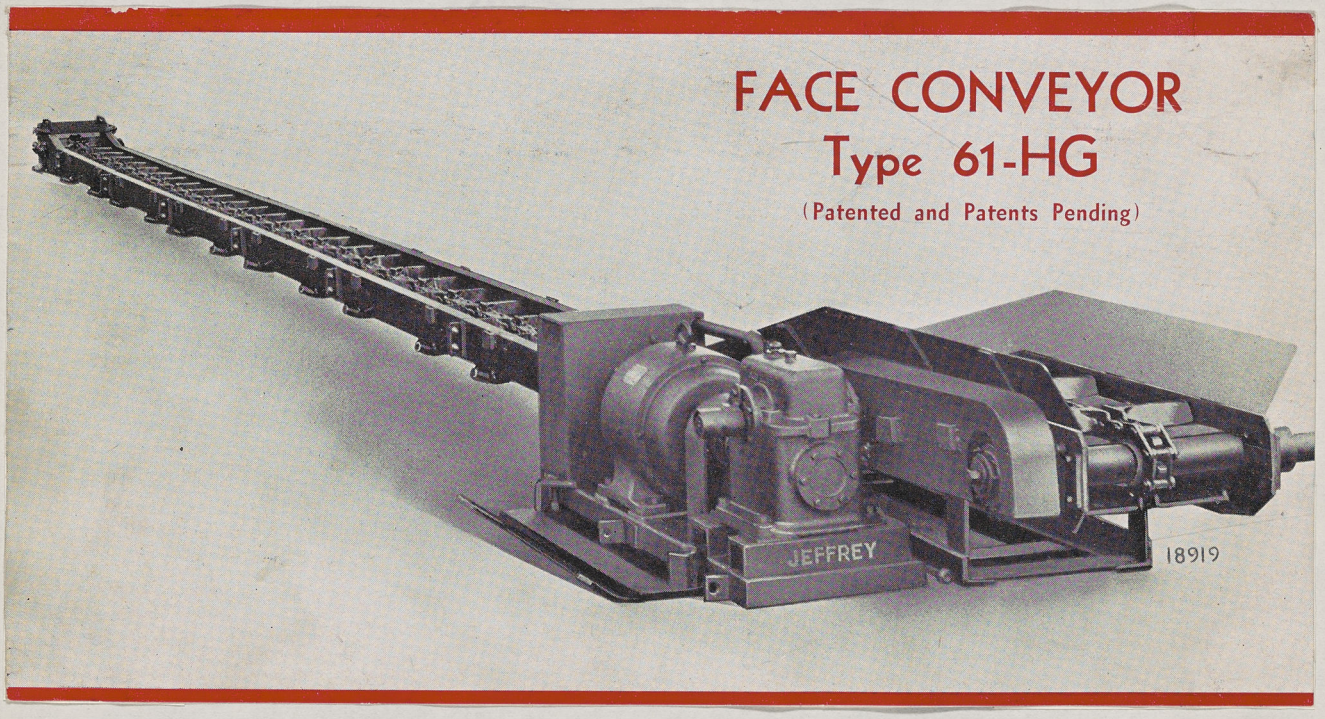


Fig. 7 Flight Conveyor

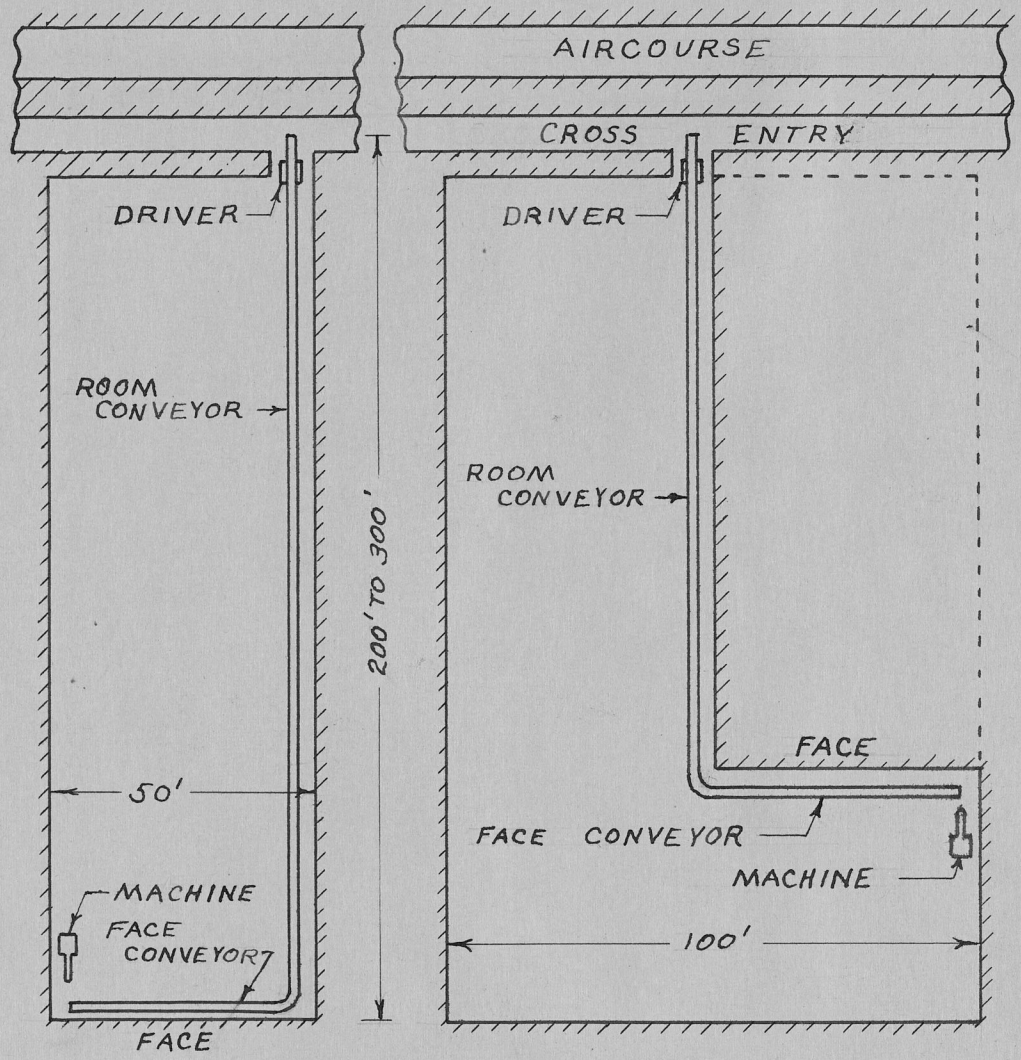


FIG. 8

FIG. 9

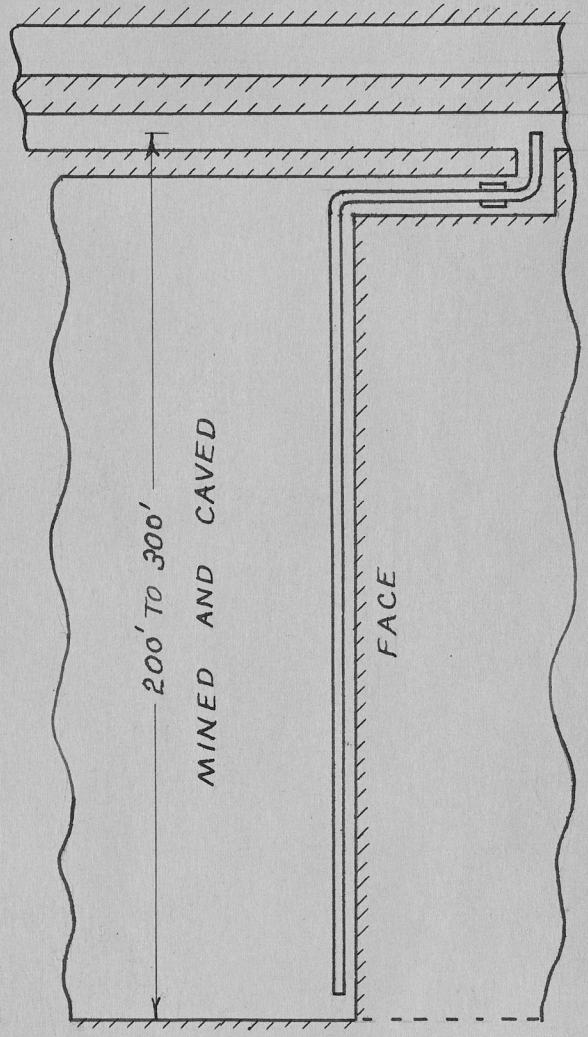


FIG. 10

CONVEYOR MINING

V. Conveyor Mining

With the entries advanced the next step is to remove the coal on each side of the entry. There have been dozens of methods developed for this purpose, but the method that is considered the best today is the conveyor method. Before the day of the conveyor, rooms were driven about 50 ft. wide and loading was done by hand directly into the car. One can see that this required a lot of coal shifting and switching of cars since they only loaded from two to four at a time. The conveyor eliminates all this expense.

With the conveyor, it is unnecessary to lay any track in the room and the switching is greatly reduced. Cars are loaded on the entry. This makes it possible to use larger cars since some of the entry top has been removed. The cars are handled on the entry by a hoist. The hoist pulls the trip of cars along under the conveyor as they are filled. The size of hoist limits the number of cars in the trip. The usual practice is to try and have enough cars to load out a cut. In the case of a longwall this is impossible of course, but it only takes a few minutes to change trips.

The conveyor consists of two parts, the room conveyor and the face conveyor. Loading is done along the face (Fig. 8,9,10) on to the face conveyor. The face conveyor carries the coal to the room conveyor and the room conveyor carries the coal out to the entry and dumps it into the car. Some conveyor manufacturing companies

claim it is best to convey on to the tipple. This method is good for small mines, but not for large mines. In the case of large mines, it is necessary to have a track to carry in workmen, supplies; so why not use the track for coal haulage and leave out the conveyor. A conveyor from the base to the cross entry has proved to be probably the best.

Figs. 8,9, and 10 show the most common methods and probably the best methods of conveyor mining. Figure 8 shows a short wall method of conveyor mining. Usually the face is fifty feet wide. The room is driven to a depth of 200 or 300 feet; then the machinery is taken out and moved to the next room neck. The operations are as follows: the face is undercut,holes drilled for the shots, and loaded. The face conveyor is then moved up against the face and the room conveyor is lengthened. The coal is then shot down and loaded. After loading out the cut, the same procedure is repeated.

Because of the small seams in this area, loading is usually done by hand. If the seam of coal will permit the use of a loading machine, the machine can load directly onto the conveyor. If a machine is used for loading it is best to drive two parallel rooms with a break through between and let the cutting and loading machines serve two conveyors. While the cutting crew is preparing one room the loading crew can load the other cut. This isn't a very great advantage when loading by hand because the men that were not cutting can be

drilling, timbering and moving the conveyor.

Figure 9 shows a second method of short wall conveyor mining. In this case the face conveyor is turned through 180° and works back toward the cross entry. Each time the face conveyor is moved up, the room conveyor is shortened, the extra conveyor pan is placed on top of the coal in the conveyor pan and carried out to the cross entry and placed along the rib nearby for the next room. This reduces the number of pillows between the rooms and decreases the cost of moving from one room to the next.

Figure 10 shows even a better method of conveyor mining if the top of the mines will permit this method. It is known as the long wall method. Here the loading face is from two to three hundred ft. long. Usually the top is caved in behind the conveyor which takes the weight off of the pillows. This method is very good for loading machines because they have a much larger cut to load. With this method the machine can be loading a larger percent of the time. If the seam of coal is large enough it is a good policy to lay a track along the long wall face and load with the machine directly into the cars.

All three of the sketches (Fig. 8,9, and 10) show the shaker conveyor. This type is much more economical since there is only one driving unit and it is near the cross entry. It is much easier to move, because there are no chains to splice. If the grade is too steep for the shaker conveyor, the flight conveyor (Fig. 7) can be used.

VI. Haulage

The past few years have witnessed many improvements in the haulage system of the coal industry. The mule has been replaced by small gas motors, the gas motor replaced by small electric motors, and the small electric motors have been replaced by heavy and fast tram motors. The trolley type locomotive has proven to be the best. The cost of battery up-keep on the battery motors is high and since it is necessary to have power inside the mines to run conveyors and other machinery why not run a trolley wire for haulage and let it serve two purposes. State laws prevent the use of gas motors in mines so electricity is the best solution.

There have been some rope and belt conveyor haulage systems, but these have not proven as practical as the trolly type of electric locomotive.

When the coal industry increases the size and speed of thir locomotives, they found that their track was not heavy enough or bedded well enough to carry the load. The twenty and thirty pound rails have been replaced by sixty pound rails. The rough cut ties are being replaced by heavy treated ties. The road beds are being improved and ties are carefully tamped. The old practice was to lay the track in any place in any way just to get it done quickly, but this is not satisfactory for todays weight and speed. Many companies are welding their rails like the street car companies. The thermite process of electric weld is used. It is true that the thermite

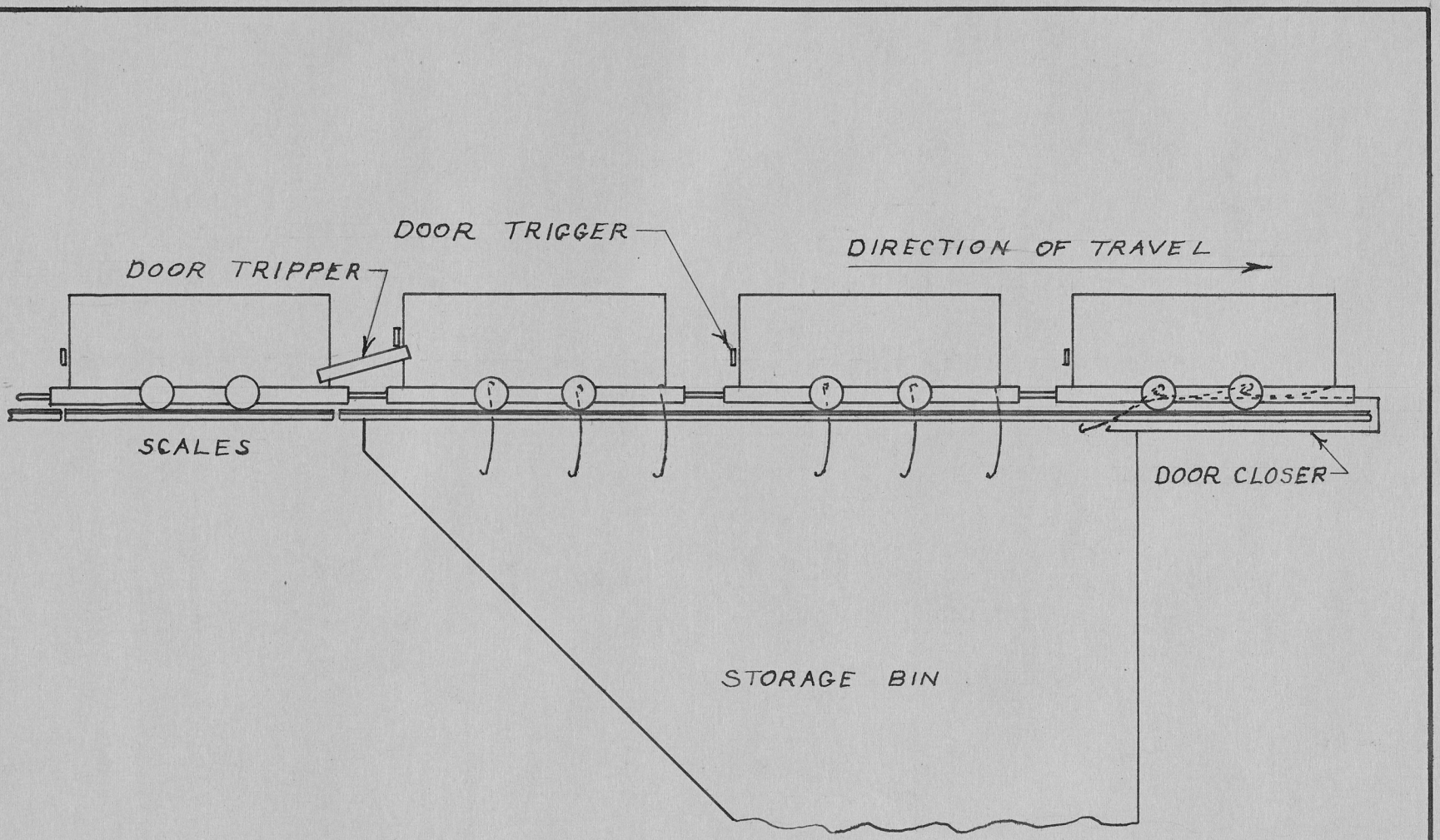


FIG. 11 WEIGHING AND DUMPING THE DROP BOTTOM CARS

weld cost about $5.75 as compared with $4.25 for the spliced joint which includes anglebar, bolts, lock washer, joint bands; but the great economy in up-keep, conductivity, and increase in safty offsets the excess cost. Since the temperature inside the mines is the same the year round it is possible to weld the rails. The treated ties cost about sixty cents (60¢) each, overall charge, as compared with about forty cents (40¢) each for the non-treated tie, but the increase in the life will offset t this extra cost.

The development of the all steel drop bottom car h has also taken a big slice off the haulage cost. Besides being strong and mounted on ball bearings, the cars are very easy to dump. The reduction in dumping cost is the greatest economy. Figure 11 is a sketch showing the operation envolved in weighing and dumping the drop bottom car. Details have been omitted for clearness. All operations are performed without stopping the trip of cars. As the car passes over the scales, the weighman reads and records the weight. As the car passes the door tripper, the trigger is lifter and the doors released allowing the coal to fall into the bin. The door tripper is an incline bar close enough to the track to catch under the trigger as the car passes by. The trigger releases the doors. Notice how the bin is inclined with the motion of cars. This reduces the shock of the falling coal. When the bin is empty,

the coal falls a short distance and slides down the side of the bin. When the bin fills, the doors will drop on top of the coal and remain closed until they reach a point not filled and opens gradually. This is another effort to reduce the slack. As the cars leave the bin, the door closer pushes the doors up and they latch automactically. The door closer is nothing but a big timber between the rails that is high enough to close the doors as the cars pass over it. It only requires one man to dump the dump bottom cars, they never stop, and do not have to be uncoupled. This is much better and cheaper than the old method where the cars had to be uncoupled, stopped and dumped separately. This requires more time and much more help than the drop bottom cars.

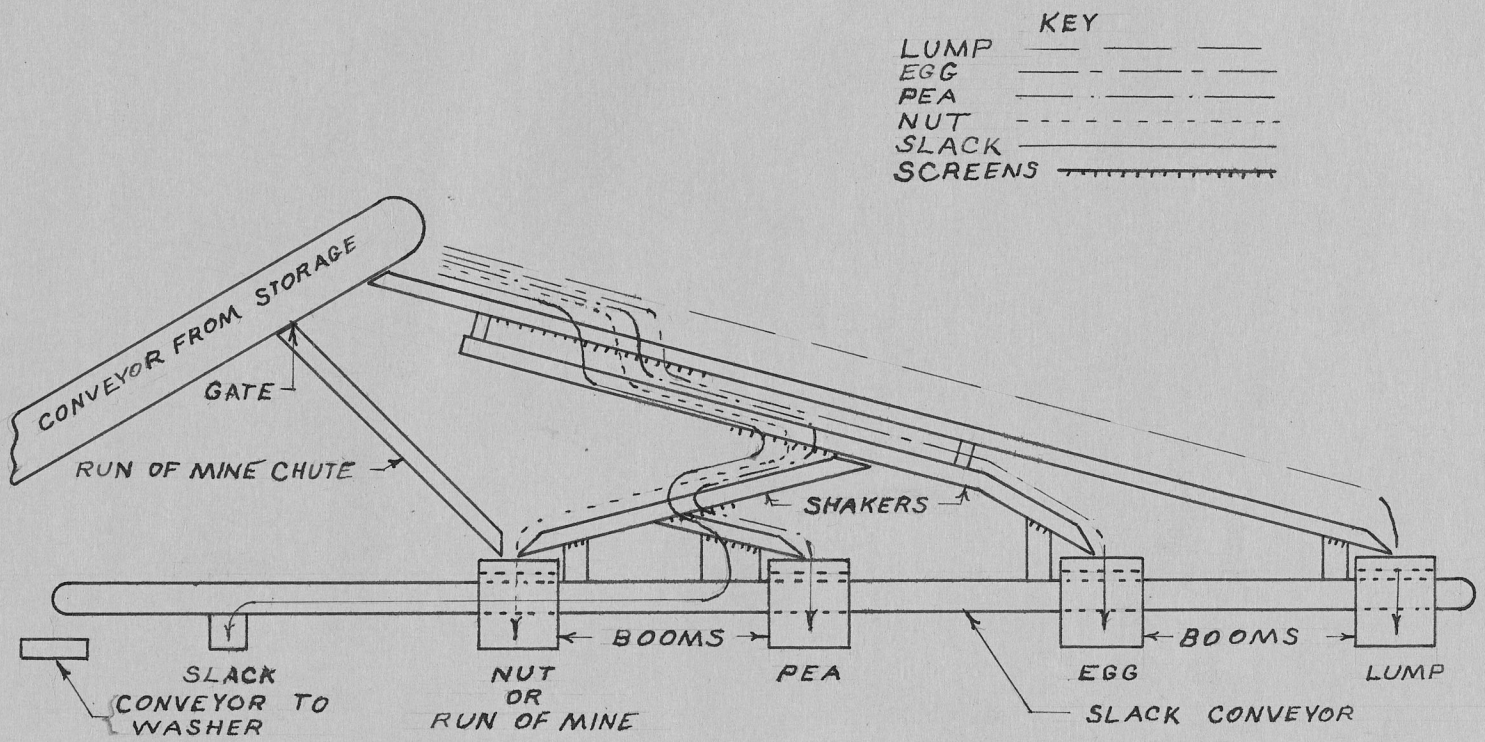


FIG. 12 GRADING PLANT

VII. Grading

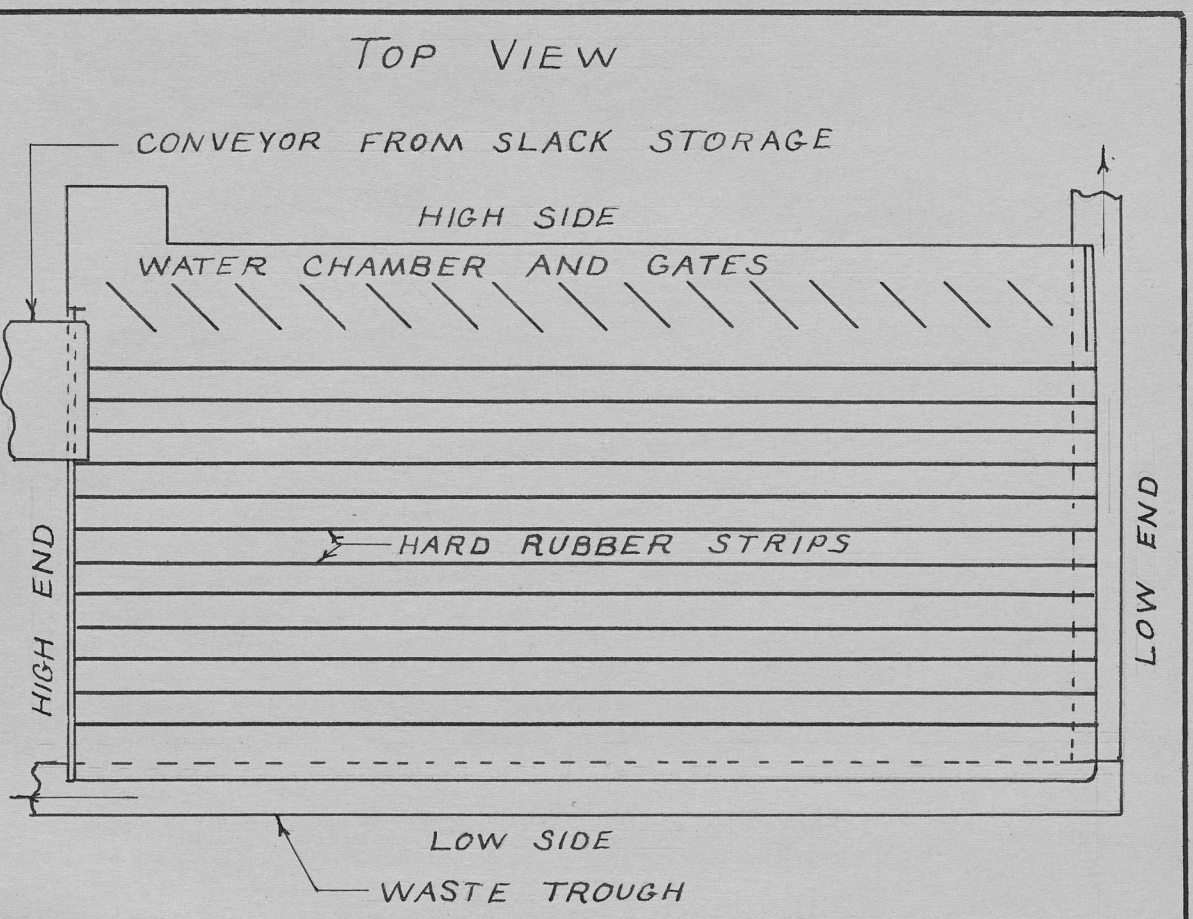
Grading coal is an extra expense forced on the coal companies by the public indirectly through competition. Some company saw its chance to sell to other company's customers by offering graded coal to the public. The practice has spread until it is impossible to operate a large mine without grading the coal. The first grading was done on homemade screns similar to the ones used by mortar mixers. The coal was dumped into the screens and the fine coal fell through as the coal slid down the screen. These old screens had to be inclined so much that much of the fine coal went over them. Next followed the shaking screens. The shaking screens made it possible to reduce the slope of the screens and was much more efficient.

Figure 12 shows a sketch of a modern grading plant. the construction and driving mechine has been left out. The material for this shetch came from the author's experience in a coal mine while a student. This plant was built in 1935 and has all the modern features. It is an all steel plant and the power comes from A. C. motors with V type pulley. The coal is lifted from the storage bin by a flight conveyor and emptied on to the main shaker. The shaker works the coal down across the first screen where all coal falls through except the lump. The lump is carried on down to the lump boom. The coal that falls through the first screen travels to the second screen where all coal falls through except

the egg. This continues, as shown by the line, until all grades have been seperated. The screens, shich are but sheet metal with holes in it, can be changed easily, and by changing screens, it is possible to have 45 or 50 different grades and have five grades running at one time. Notice the little screens at the end of each shaker pan. This screen takes out any slack that might have gotten over the other screen or any that might have chipped off of larger lumps. All slack is dumped onto a flight conveyor that runs the lenght of the plant. The slack conveyor carries the slack to the slack shoot where it empties into the car. By closing the gate to the slack shoot, the slack can be conveyed to the conveyor leading to the washer. Since they rarely ever wash anything but the slack, this system works very nicely. If one wants to wash o other grades, remove the small screens and allow the coal to empty onto the slack conveyor. When they operater wants to dump run-of-mine coal, they pull the gate, shown at end of run-of-mine shute, and take the coal out of the conveyor before it reaches the screens. The same boom is used for the nut and run-of-mine.

The booms are used to lower the coal to the cars. They are conveyors about fifty or sixty feet long. They are fastened at one end to the construction work of the plant and are swung from an electric hoist at the other end. When an empty car is brought under the

boom, the boom is lowered to the bottom of the car and is raised as the car fills. This is another effort to reduce the slack caused from handling. Each boom has an operator who picks out any rock or rubbish that might be in the coal



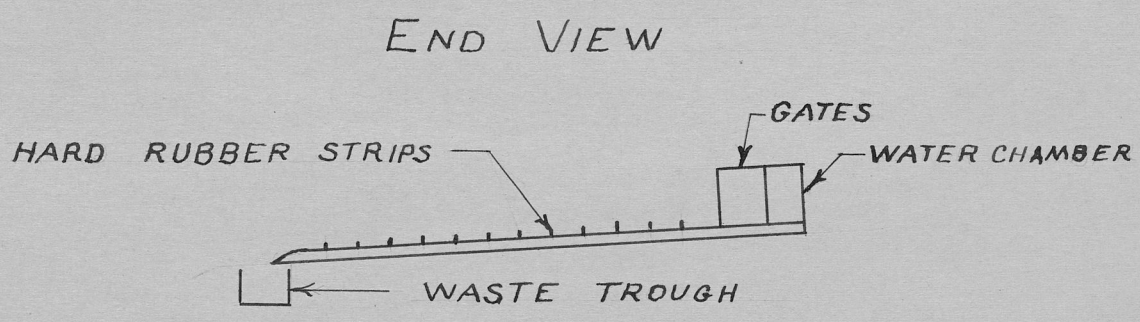


FIG. 13 WASHING TABLE

VIII. Washing

The main purpose of washing coal is to reduce the ash content. Most of the ash is in the slack so one rarely ever finds coal companies washing any other grade. In a few cases they wash the larger grades just to make it look better.

There are various types of washers. Some washers spray the coal and others dip the coal in a vat, but the most economical washer is the table type washer. Figure 13 shows two views of the table washer. The table top has a number of parallel hard rubber strips set in it, and extending about $\frac{3}{4}$ of an inch above the top of the table. For larger coal these strips would extend higher. The table slopes along the diagional. That is, it has a low side and end. The coal is fed onto the table at the highest corner by a conveyor leading from the slack storage bin. The water enters through gates all along the high side. The table has a vibrating motion that makes the coal travel toward the lower end. The water passes across the table perpendicular to the rubber strips. The rubber strips guide the small lumps of coal to the lower end of the table and into the conveyor at the end, while the water carries the dust, dirt and lighter material across the table to the lower side. The waste is carried in a trough to a pump, conveyor or some means of carrying it away from the washer. The coal from the end of the table is drained and lifted to the storage bins where it stays until time for loading into railroad cars.

IX. Conclusions

In conclusion, the author wishes to say that any company wishing to sell coal on the market, and competing with other coal companies must use the most modern mechanical mining methods. The public is demanding such grades of coal and prices, that the coal companies can not operate otherwise.

It is true that mechanical mining has reduced the miners income, but at the same time it has lightened the work of the miner. The miner objects to having his income reduced, but at the same time he demands lower priced products. Capital cannot stand the loss, because if it did, it would be a matter of a few months until there would be no business. If the consumer demands lower priced goods he will have to stand the reduction in income.

Today mechanical mining in the Southern Appalachian Coal Field is in its infancy. If the demand for coal would increase and stay up for a few years, there would be a much greater increase in mechanical mining within the next five years than there has been in the last fifteen.

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APPROVAL

The foregoing thesis is hereby approved as a creditable study of an engineering subject, carried out and presented in a manner sufficiently satisfactory to warrant its acceptance as a prerequisite to the degree for which it has been submitted. It is to be understood that by this approval the undersigned does not necessarily endorse or approve any statement made, opinions expressed, or conclusions drawn therein, but approves the thesis only for the purpose for which it is submitted.

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