Advances in the Preparation of Anthracite

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Anthracite was first mined in the Wyoming Valley and sold as an article of commerce in 1808. As some preparation has always been necessary to make it ready to burn, the preparation of anthracite must date back over a hundred years. Two vital factors have determined to a large extent the degree and the method of anthracite preparation. These are, first, the character of the beds worked and the methods by which they are mined and, second, the equipment used and practices followed in the burning of the coal.

It is not the intention here to go deeply into these phases of preparation as a paper of no mean length could be prepared on the history of either. Rather, the intention here is to point out the main considerations and to show the influence they have exerted on the preparation of anthracite.

Mining Methods and Their Relation to Preparation

In the beginning of the nineteenth century, the coal beds were virgin with the possible exception of some outcroppings that had been worked, to a slight extent, by the Indians. It is known that the American aborigines had a knowledge of the use of this fuel, because when the Wyoming Valley was purchased from them, in 1754, they mentioned the fact that, by selling the land, they would lose their coal.

Real mining of anthracite began about 1808 when Judge Jesse Fell, of Wilkes-Barre, discovered that the "common stone coal of the valley" could be burned in an open grate. For some years thereafter mining was conducted near the surface. The working places were driven narrow; only the best of the coal was selected and the remainder was left in the ground. Only the lumps could be used, as no market existed for other sizes. As time passed, however, it became necessary either to go farther into the ground or to widen the working places. When these places were widened, falls of roof were apt to occur, making it necessary

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to remove rock from the coal. This was particularly true of the Schuylkill region where the measures pitch steeply and the coal soon reached an excessive depth, judged by the standards of that generation.

At first only the thickest beds were mined, the thin measures being considered worthless; but as the thick seams were worked out, the thinner ones had to be opened. These carried a higher percentage of rock partings and bony coal, which had to be removed before the product could be marketable. This further complicated the methods of preparation. Later, particularly in the Wyoming field, a large part of the first mining in all the beds being completed, it became necessary, if the output was to be maintained, to commence second mining or the robbing of the pillars. The resulting falls of roof added more dirt to the coal, thus further complicating the process of preparation.

In the lower anthracite regions, where steep-pitch mining occurs and the coal is run out of the breasts into the mine cars by gravity, practically no way can be devised to keep the roof from falling and mixing with the mined coal. In many instances, the amount of coal and of rock in a mine car will be equal, while it is common for mined material to run steadily for some time at one-third coal and two-thirds rock. In the upper region, where the coal lies comparatively flat and the mine cars can enter the working chambers, the larger pieces of rock can be separated from the coal and a greater percentage of the latter loaded into the mine car. In the upper field, however, there is more second mining, or robbing, and the rock and bone that is now being produced from the thin beds to some extent compensates for the rock unavoidably brought down in the breasts of the lower regions. It can thus readily be perceived that because of the changes in the methods of mining and the exhaustion of the thicker beds the preparation of anthracite has become progressively more and more involved.

Methods of Consumption and Their Effect on Preparation

If coal were burned by the same methods today as it was 100 years ago, probably the changes in the methods of preparation would be less pronounced than they are. A tremendous advance in the methods of using the coal has, however, taken place. The types of furnaces have changed entirely, so that the coal must be prepared to meet the new conditions.

When Judge Jesse Fell conducted his experiments, he burned "the common stone coal of the valley" in a grate placed within an ordinary fireplace. It is natural to suppose that he used only the coal of larger size; 2 years later, at least, only lump coal was being employed for firing. Ignition may or may not have been secured by the aid of the small hand bellows that formed one of the fire tools that reposed upon the hearths of that day.

Utilization of the finer sizes of anthracite was and still is largely a matter of support and draft. In the early days, grates were crude and of a wide opening. As the volume of the interstitial spaces is much greater in the larger grades, air will freely circulate through a thick bed of large-size fuel, such as grate, when it will move only with difficulty through a much thinner bed of, say, No. 3 buckwheat. When the first attempts were made to burn the buckwheats, it was found that natural draft would not cause sufficient air to move through the fire to maintain rapid combustion. Industrial plants, therefore, introduced forced or induced draft of some sort. The steam-jet blower was doubtless the first, the simplest, and probably the cheapest of these means of creating artificial draft; this was successful in a degree but was soon followed by the fan.

Combustion has been further perfected by placing the fuel on a traveling grate, and passing it successively over compartments carrying different draft pressures. These pressures are so arranged as to furnish the amount of air best suited to the fire conditions existing above them and to provide for complete combustion of the fuel before the refuse is discharged over the end of the grate into the ashpit. Already this arrangement is making present-day silt, or coal passing a $\frac{3}{64}$-in. (1.2 mm.) circular opening and containing probably at least 10 per cent. of moisture, a usable commercial fuel for power production.

Two other means of utilizing anthracite fines that are in limited use are briquetting and the burning of such fines in suspension. The first, while employed extensively in Europe, has never found great favor at the mines of this country. The product of the process is sold in direct competition with the domestic sizes of freshly mined coal. The second method has passed the experimental stage and is just entering that of commercial application. Time will determine the scope and possibilities of this means of anthracite consumption.

Preparation of Coal in the Early Days

From about 1808 to 1830, preparation—what little the coal received—took place in the mine itself. After mining, the miner loaded the larger lumps into a wheelbarrow and either dumped them directly into a canal boat or into a long chute by which they were conveyed to the boat. All sizes smaller than lump were left in the mine, being considered worthless. No power of any kind was used at the mines and all the work was to the rise, no pumps being employed.

In 1830, the first attempt was made to prepare the coal outside the mine. As before, only the large coal was removed to the surface, where it was dumped upon a perforated cast-iron plate. Here men with hammers and picks broke the larger coal to commercial size. It is possible that after falling through the plate perforations the coal was passed over bar screens to remove the smaller sizes, which at that time had no commercial value.

About this time, also, the rake, Fig. 1, was introduced underground. After the coal was cut, the miner used a wrought-iron hand rake having teeth formed to give a clear opening of 1¾ in. (4.4 cm.) to separate all the coal smaller than stove from the larger pieces. The rake was used in parts of the coal fields as late as 1850, and perhaps later, for it was not until 1869 that it was found possible to use pea coal. Probably not until this size became a commercial coal was the rake discarded, but in some mines it was superseded by the slotted scoop shovel.

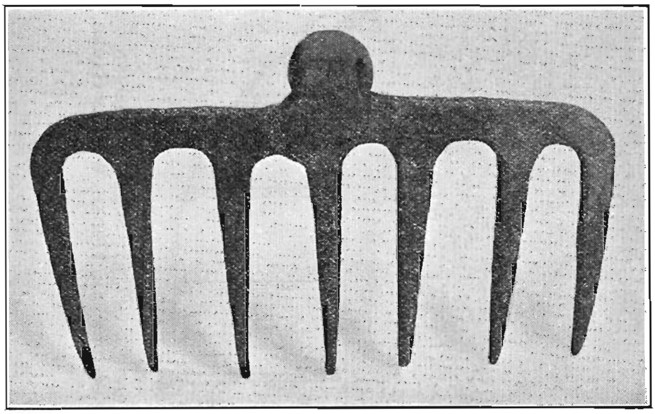


FIG. 1.—RAKE USED IN SEPARATING LARGE FROM FINE COAL IN MINES.

In 1844, J. & S. Battin, of Philadelphia, invented the roll crusher and installed it in their coal yard at that city. The same year the first coal breaker, with circular screens, was erected by Gideon Bast on Wolf Creek, near Minersville, Pa. A 12-hp. engine was used to drive the machinery and the equipment had a capacity for breaking and cleaning 200 tons of coal per day. The success of this building led to the construction of thirteen additional breakers in the same field the following year.

One of the earliest breakers, Fig. 2, of which a description exists occupied the same ground as the present Pine Brook breaker, in Scranton. Here, after the coal was broken down in the mine, it was raked over and the large pieces, or those over 1½ in. (3.8 cm.) in size, were loaded into the mine cars and hauled to the surface. The mine cars were run on to a trestle and discharged, by the aid of a horn dump, on to an incline. The coal was then pushed by hand or a rake on to a cast-iron plate, which was so perforated that grate coal would pass through. On this plate the large lumps of coal were broken to smaller sizes, the lump and steam-

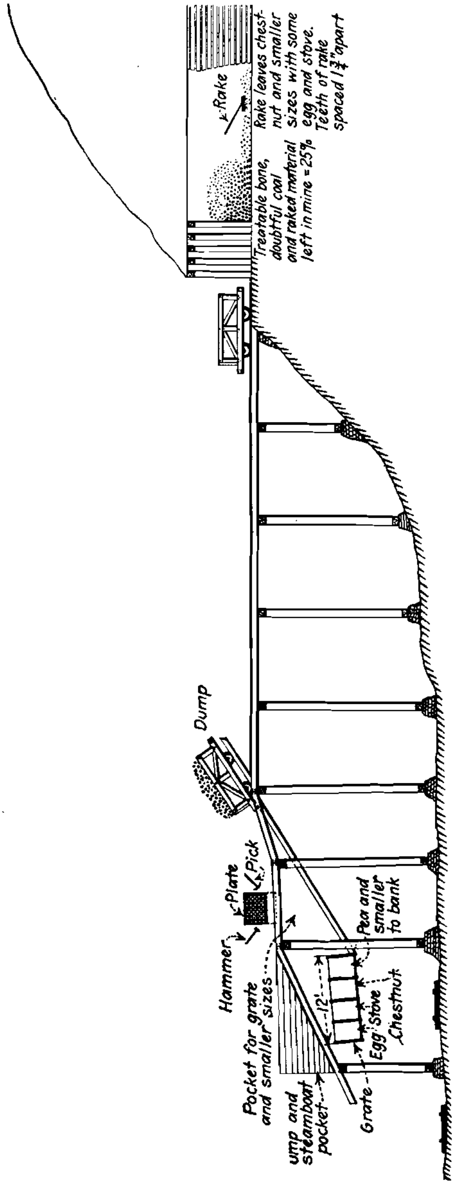


Fig. 2.—Cleaning coal at old Pine Brook colliery, Scranton, based on testimony in royalty trial. Drawing prepared by Mr. Dodge, Wilkes-Barre, Pa.

boat being pushed across the plate to a pocket. The smaller sizes fell through into a hopper, from which they were fed to a revolving screen 12 ft. (3.6 m.) long. The grate, or what is now known as broken coal, passed out at the end of this screen and the rest of the material was separated into egg, stove, and chestnut. All coal finer than chestnut was run to a waste pocket and was transported from that point to a culm bank. This screen was revolved by man power, no mechanical energy of any kind being used in the preparation of the coal. The only impurities removed were those that the men took out when they broke the coal down through the cast-iron plate; the impurities were probably few. It is probable that this breaker was built about 1845, and was ten years old at the time it was described.

Perhaps the greatest improvement of this period was the introduction of mechanical power. This made it possible to use larger screens as well as to break down the lump coal by means of rolls, greatly increas-

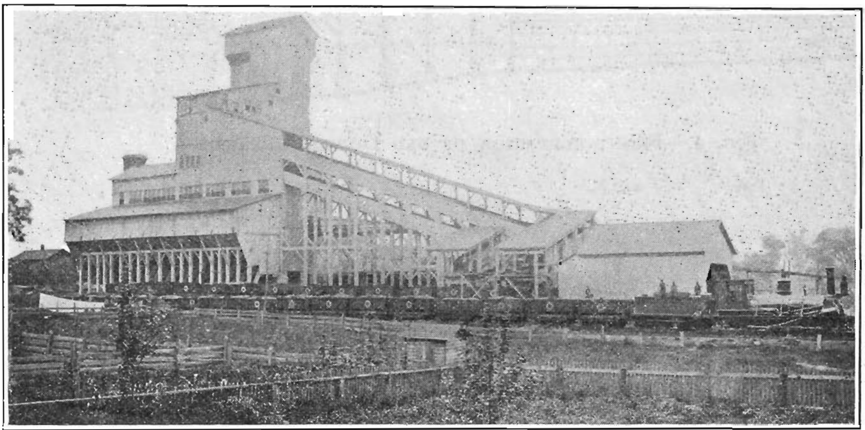


FIG. 3.—OLD DODSON BREAKER, PLYMOUTH, PA., BUILT IN 1869 AND BURNED IN 1897.

ing the capacity of these breakers over those employing the older hand methods. The hand-operated breakers were not, however, immediately superseded, for until about 1860 some were in existence.

The first rolls were made of cast iron with cast-integral teeth. About 1876, a roll having a cast-iron shell into which steel teeth were driven was introduced. In some places, a fluted roll was tried. In addition to these, sometime prior to 1865 a fluke roll was used. The teeth of the roll, in passing through slots in a cast-iron plate, crushed the coal in a manner exactly similar to that employed when breaking it with a hammer through cast-iron plates as has been already described. This method of crushing created as much waste but was more rapid than was the hand methods it displaced.

This brings us to the late sixties. At the old Dodson breaker, at Plymouth, which was built in 1869, Figs. 3, 4, and 5, the lump coal was separated from the smaller sizes and run directly to the lump pocket. The coal that was large and not very clean, together with the fine

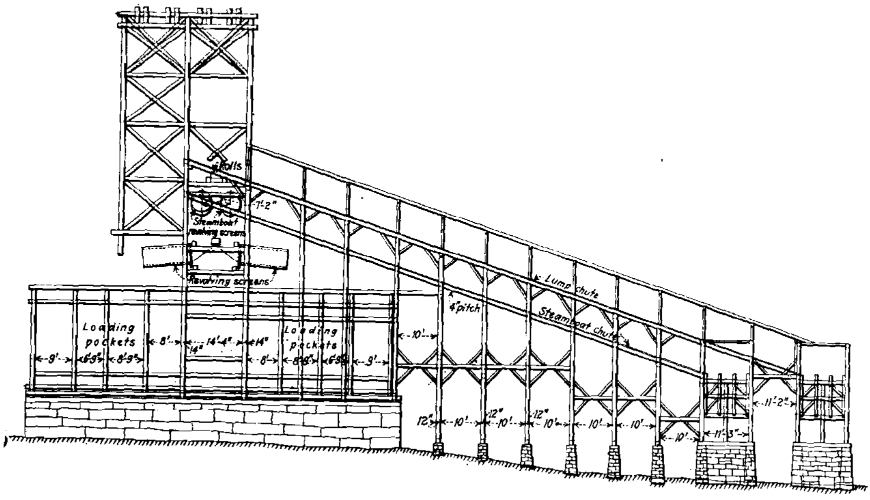


FIG. 4.—FRONT ELEVATION OF OLD DODSON BREAKER.

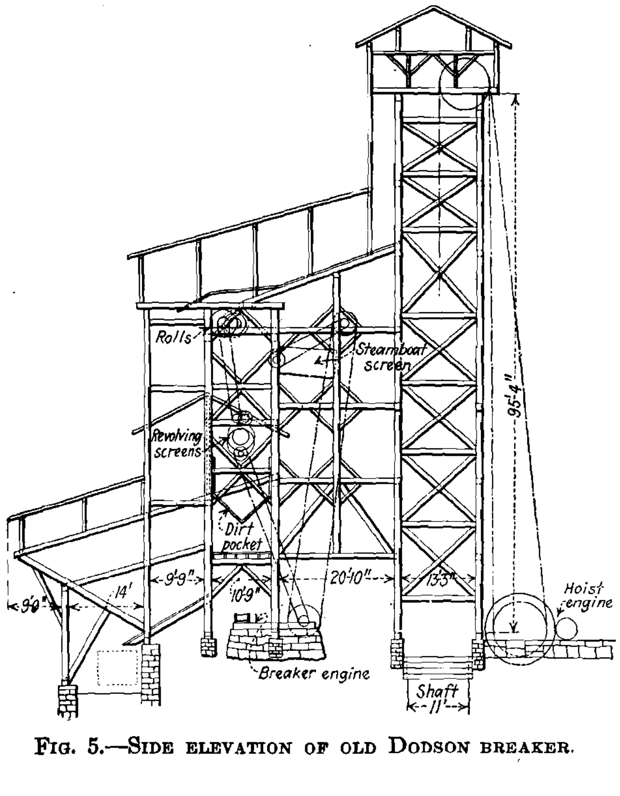


FIG. 5.—SIDE ELEVATION OF OLD DODSON BREAKER.

sizes, was passed to a pair of rolls and crushed; it was then separated into two equal parts, each part going to a separate revolving screen. In these screens only the steamboat coal was taken out, the finer sizes being sent to a second set of rotary screens. It is probable that the steamboat coal was hand-picked before being deposited in its pocket.

The finer sizes of coal that were separated in the second set of revolving screens were likewise hand-picked by boys before going to their respective pockets. No coal smaller than chestnut was saved, all smaller sizes, together with the rock, being sent to the dirt pocket and then removed to the culm bank. As the mine rake was still in use, all coal smaller than chestnut produced underground was left in the mine, so that the fine coal separated in the breaker was only what was made in the crushing down of the larger sizes; therefore, millions of tons of marketable coal now lie buried in the mines and will never be recovered.

Another interesting breaker of the same period is the old Washington or Reynolds breaker, at Plymouth, Fig. 6. This structure was reported as being in a dilapidated condition in 1869 but was braced and repaired so that it was used for many years afterward. It is interesting to note in connection with the accompanying illustration that 100 men were required to handle the output of this breaker. Of course most of the employees were boys hired to pick the slate and other impurities out of the coal. It did not seem to be the custom in those days to provide many windows to give light. Accordingly it was necessary to remove the roof over the picking chutes or leave them unprotected so that the boys could see to pick the slate. Fig. 7 shows the new Nottingham breaker to which the coal that formerly was treated in the Washington breaker now goes.

Another structure of the same period is the old Alexander Gray breaker, Fig. 8, which stood near the present Hollenbeck breaker in Wilkes-Barre. This was built in 1860 and was torn down in 1874. It was equipped with one set of revolving screens having a total length of 21 ft. 10 in. (6.7 m.) making culm-bank coal, small and large stove coal, egg, and No. 1 broken. Evidently the larger sizes were separated by hand.

Fig. 9 shows the old rolls that were discarded at some time prior to 1874. They were lying in a scrap heap when Mr. Dodge, a consulting engineer of Wilkes-Barre, made measurements of them and drew the original of which this illustration is a copy.

About 1870, the picking table was introduced, at the Hill & Harris colliery, Mahanoy City, Schuylkill County, after a series of experiments made by this firm.

The next important improvement in the preparation of coal was the introduction of the jig into the lower anthracite regions in either 1871 or 1872. The jig did not force its way into the Wyoming field

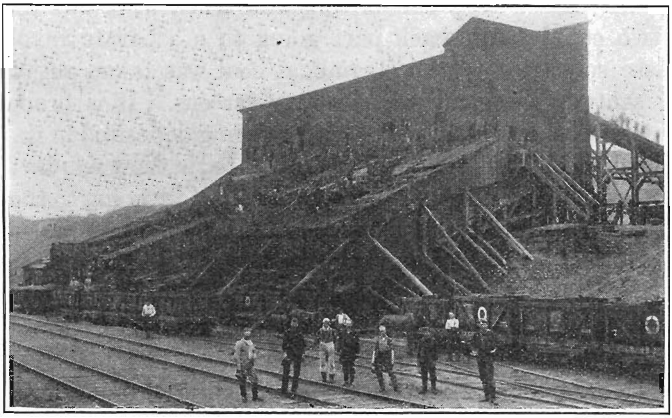


FIG. 6.—OLD REYNOLDS, OR WASHINGTON, BREAKER NEAR PLYMOUTH, PA.; THIS BREAKER WAS IN A DILAPIDATED CONDITION IN 1869.

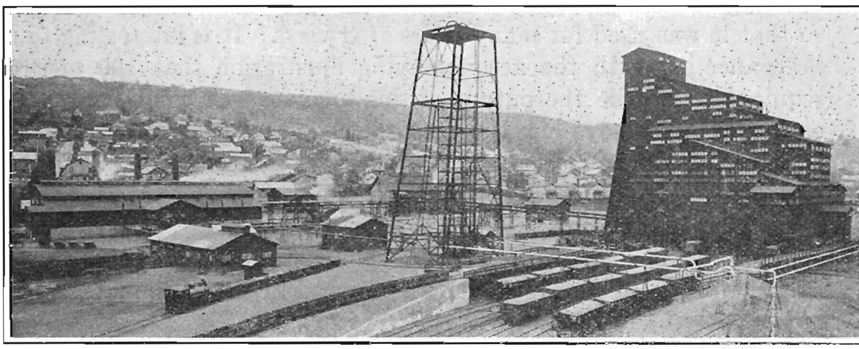


FIG. 7.—NEW NOTTINGHAM BREAKER OF THE LEHIGH & WILKES-BARRE COAL CO.

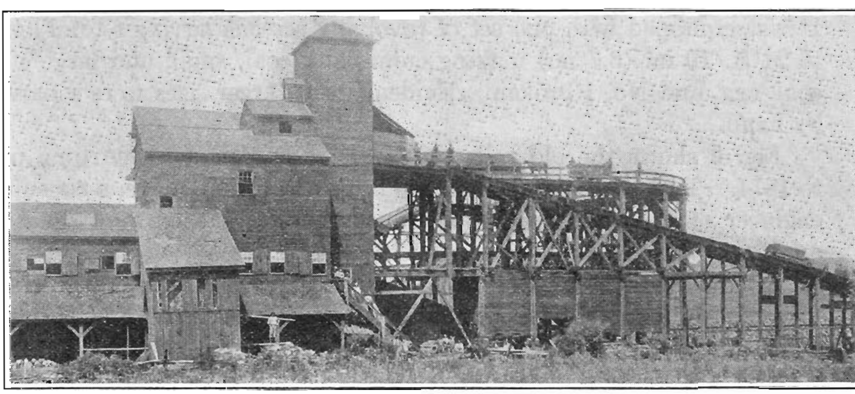


FIG. 8.—ALEXANDER GRAY BREAKER, WHICH STOOD IN WILKES-BARRE NEAR PRESENT SITE OF HOLLENBECK BREAKER. BUILT IN 1860 AND TORN DOWN IN 1874.

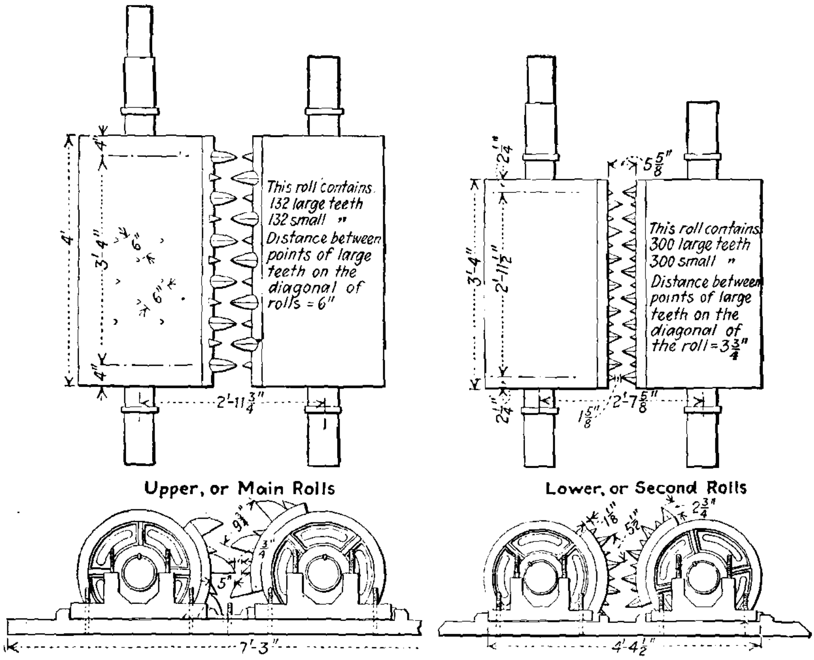


FIG. 9.—OLD ROLLS USED AT BREAKER OF NO. 5 COLLIERY OF LEHIGH & WILKES-BARRE COAL & IRON CO., PRIOR TO 1874.

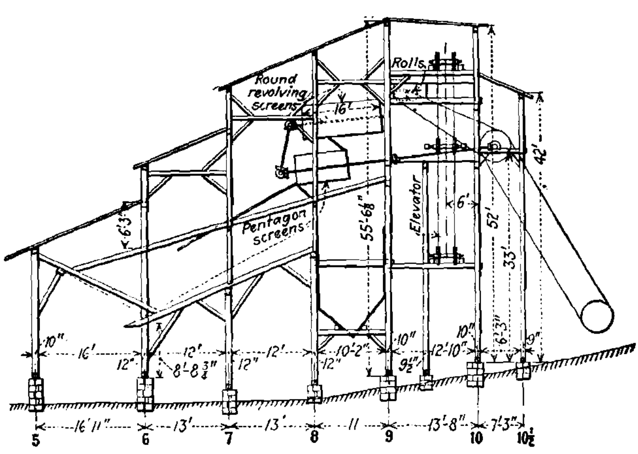


FIG. 10.—SECTION OF OLD FORGE BREAKER OF PENNSYLVANIA COAL CO., BUILT PRIOR TO 1884. ELEVATOR WAS INSTALLED THAT YEAR.

until a much later date because the coal in the upper region was much cleaner and drier than that produced in the middle and the lower fields, and the operators did not look with favor upon the wetting of their coal. In the lower region, conditions were entirely different. The coal came from the working places wet and so completely covered with fine mud that it was almost impossible to tell which was coal and which slate until the fine material and mud were washed off. It was therefore thought better, if possible, to separate the slate when the coal was being washed clean.

From 1872 until some time in the 80's no important inventions were made in the preparation of anthracite, but the existing types of machinery were improved and better results were obtained. In 1884, the Pennsylvania Coal Co. built the Old Forge breaker, which was one of the best equipped at that time; Fig. 10 shows the breaker as it was designed. In this breaker, the coal without separation was passed through the rolls, going thence to two sets of revolving screens, where it is presumed that lump, steamboat, and broken coals were separated, the fine material passing through to the pentagon screens below, which had the same diameter as the first set and were 10 ft. long. This breaker is the first in which the writer has found that the pentagon screen was used although it may have been used before this period. This type of screen did not prove satisfactory as it entailed too much breakage; however, there is one set of these screens still operating in a breaker in this region.

The Pennsylvania Coal Co.'s old No. 8 breaker at Dunmore, Fig. 11, built in 1889, embodies some new features. The coal was brought over a trestle, in mine cars, to the top of the structure and dumped directly on to a set of bar screens, which separated two sizes from the rest of the coal, presumably the lump and steamboat. The finer coals fell through the bars to a set of revolving screens below. Unfortunately, what sizes were prepared is indeterminate, but nevertheless some of the coal was taken in an elevator to the top and front of the breaker and there prepared.

The lump and the steamboat coals were passed over picking chutes where the rock was removed and run to the rock chute. The lump coal went either to the lump pocket or to the main rolls and was crushed, thence passed to revolving screens for further sizing. The coal from the screens was passed through chutes, where the slate was removed by boys. The steamboat coal seems to have gone to a set of pony rolls to be recrushed, as no pocket seems to have been provided for it. From the pony rolls, the coal went to a revolving screen and was sized. At this breaker the following sizes were made in 1889: Lump, broken, egg, stove, chestnut, pea, buckwheat, and bird's-eye. It is probable that the bird's-eye coal was the same as present-day rice, or No. 2 buckwheat. All coal finer than the bird's-eye went to the bank.

In No. 8 breaker, the effect that had been obtained by raking the coal in the mine was produced on the surface by the use of machinery. The fine sizes that needed no crushing were removed from the coal as soon as it was dumped, the large sizes alone being sent to the rolls for crushing. In this breaker, all the revolving screens were driven by gears, the rolls only being driven by belting. Here also the pentagon screen was employed. No provision was made to store coal at the head of the breaker so as to provide for a regular feed to the screen bars or other devices. The coal came at such irregular intervals as to interfere greatly with its preparation.

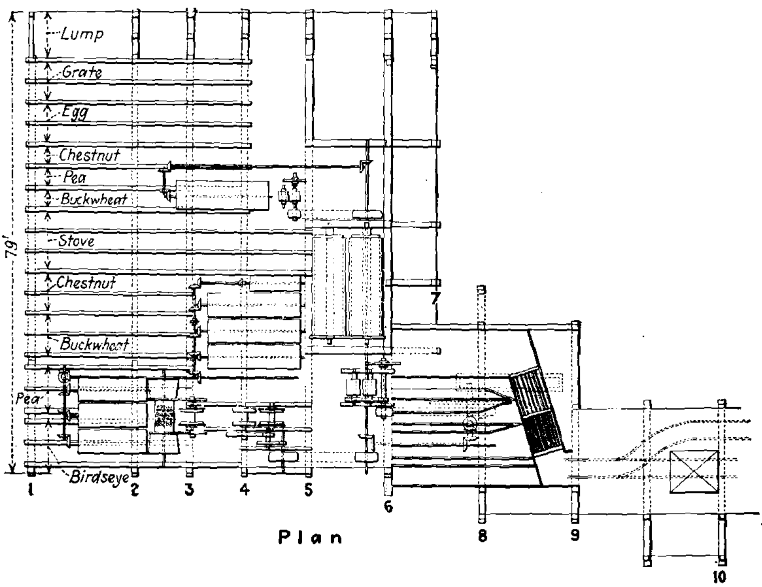
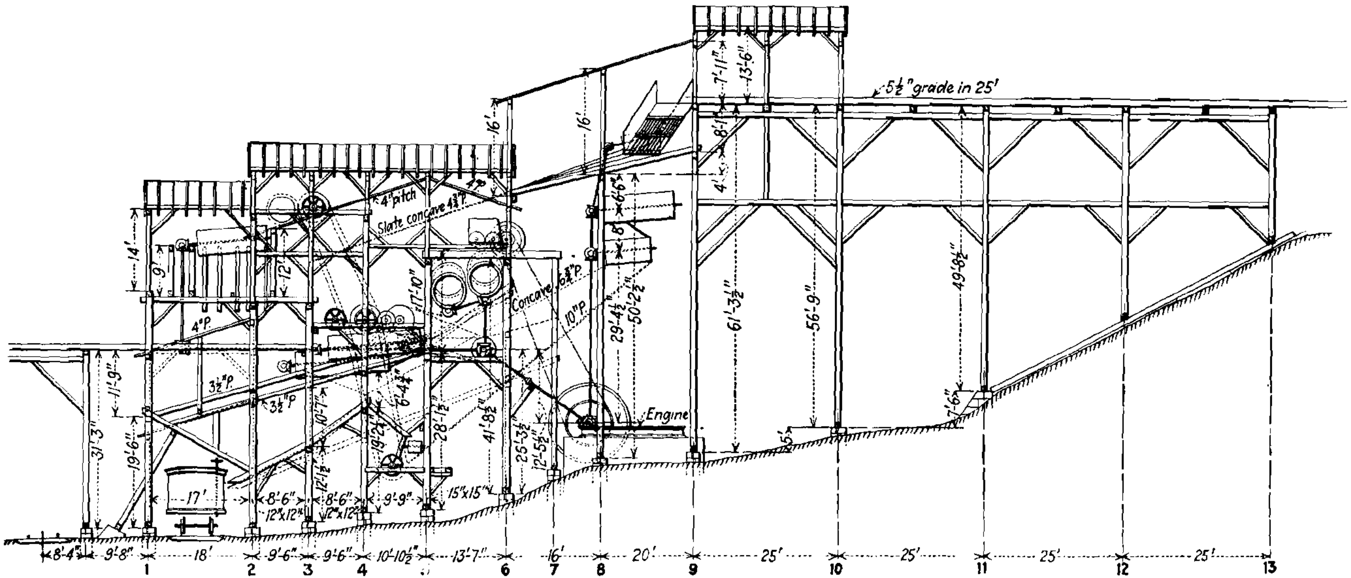


FIG. 11a.—OLD NO. 8 BREAKER OF PENNSYLVANIA COAL CO. AT DUNMORE, PA., IN WHICH THE COAL WAS SIZED BEFORE IT WAS SENT TO THE ROLLS.

Although this breaker was built when shaker screens were making their appearance they were not used, showing that they were not then considered sufficiently perfect to warrant their installation.

Just previous to the introduction of the shaker screen, Eckley B. Coxe, of Coxe Brothers, Inc., of Hazleton, invented the gyratory screen which this firm used for a number of years. These screens were satisfactory as to sizing and capacity, but their maintainance cost was high an account of the unbalanced vibration.

The Anthony shaker screen was among the first built, but this was preceded by a shaker that was supported on rollers and operated at an extremely high speed. The Anthony shaker was hung by wrought-iron rods. The suspension members were fastened to the shaker by a pin



Elevation

FIG. 11b.—OLD NO. 8 BREAKER OF PENNSYLVANIA COAL CO. AT DUNMORE, PA., IN WHICH THE COAL WAS SIZED BEFORE IT WAS SENT TO THE ROLLS.

and the top connection was a ball-and-socket joint instead of being attached rigidly, as is the Parrish shaker, which is the one in common use at the present day. The present type of shaker was not fully developed until 1907.

About the same time that the shaker was introduced the mechanical picker was invented, which revolutionized breaker design. Many types of these machines have been designed. The Zeigler picker, built about 1890, was the first of the "jump" pickers, and from it the various other designs involving the same principle have been evolved. This device

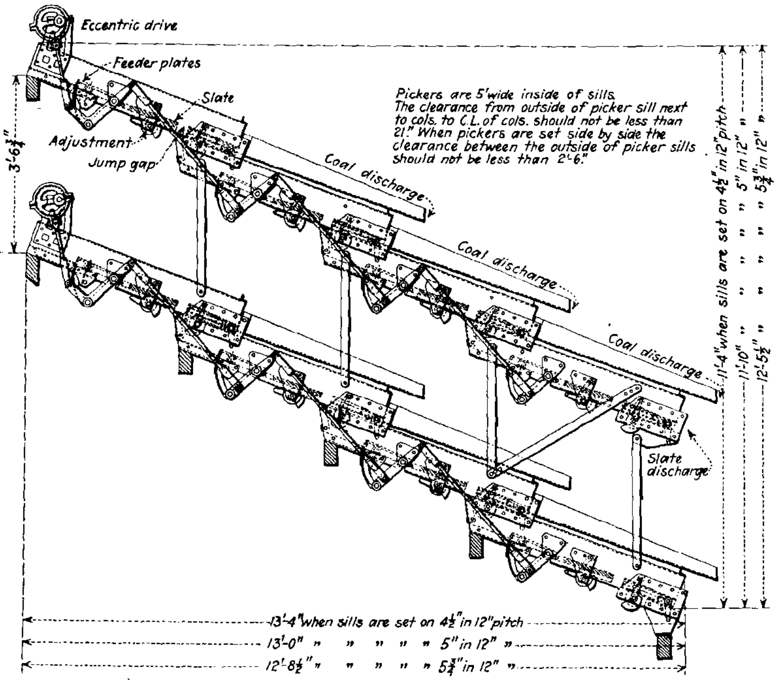


FIG. 12.—DEVERS PICKER, ONE OF THE SLOT-TYPE PICKERS, DIFFERS FROM THE OTHERS IN THE METHOD OF OPERATION. THE FEED IS RAISED AND LOWERED BY MEANS OF A CAM AND THE ANGLE OF THE SLATE IS LIKEWISE ADJUSTABLE.

was followed, about 5 years later, by the Thomas picker, in which the mine product was passed over a slate slab. Friction between this slab and the slate in the coal was of course greater than between the slab and the coal. The slate accordingly was retarded as it passed through the picker and fell through the slot, whereas the coal leaped over it. The Thomas picker had only one slot. The next year, the Emery picker, which worked on the same principle but was a multiple-slot machine, was introduced. This device has been improved from time to time and now can be regulated to handle widely differing materials. Other inventors have worked out pickers operating on the same principle as the Emery but embodying various improvements. Among these is the Devers picker shown in Fig. 12.

Many devices that will remove flat slate from coal have been invented. Among them is the Mowery, which is now in use at the Kingston Coal Co.'s No. 4 breaker. This picker operates as a shaker. The bottom plate is cut in a number of places, about half way across, and the edges of these cuts are turned down making slots. As the coal and slate pass over this plate the pieces of coal, being thick and rounded, do not pass through the slots but roll over them. The slate, however, when it reaches these slots tips up and slides through them. Of course any flat pieces of coal will naturally pass through the slots along with the slate. It is necessary therefore to pass the flat and the rounded product of the picker over some other type of picker. This machine was invented in 1905. Another flat-slate picker was invented by Colvin in 1910.

The Norman flat-slate picker consists of a number of rollers revolving in the same direction and so spaced as to permit the flat pieces of slate to pass through while denying passage to the rounded coal. The slate is thus caused to tilt and drop through the openings. The rollers are sufficiently inclined to cause the coal to move across them endwise. These pickers are still used to some extent, but as all mechanical pickers seem to be going out of use they also are passing away.

Another device of this kind that deserves mention is the Ayers picker. This consists essentially of a tilted traveling belt on to one end of which the unpicked material is fed, the belt traveling in an upward direction. The slate, being heavier than the coal and having a greater frictional resistance upon the belt, is carried up and discharged at the top, while the coal rolls down the belt and leaves it at the bottom. This picker is still used in a few places.

Probably the best known of all pickers is the anthracite spiral, which came into limited use about 1902 and into extensive use about 1904.

The Rolls

On the kind of rolls used and their operation depends, in large measure, the percentage of prepared sizes. Any excess production of the smaller sizes reduces the sum realizable from the output as a whole. Many types of rolls are now on the market and some coal companies have designed rolls for their own use. The main purpose of the designer is to obtain a roll that will crush or break coal to a certain size with the least amount of over- or under-size. All roll tests show the percentages of the prepared sizes of coal together with the smaller.

The accompanying set of curves, Fig. 13, was made from data secured in a long series of tests by the Lehigh & Wilkesbarre Coal Co. The rolls upon which these trials were made are of a design worked out by this company's mechanical engineering department and are particularly suited to its conditions. It will be noted that the amount of prepared

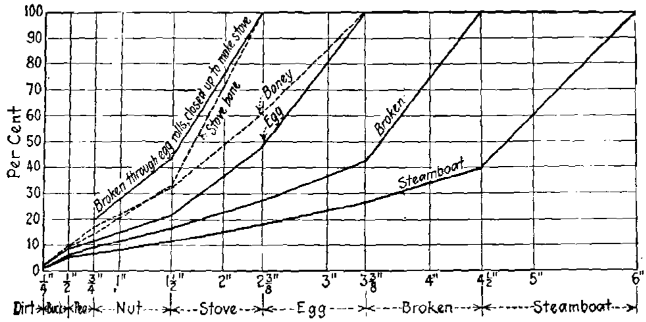


FIG. 13.—PERCENTAGES OF DIFFERENT SIZES OF COAL OBTAINED BY ROLLS AT COLLIERIES OF LEHIGH & WILKES-BARRE COAL CO.

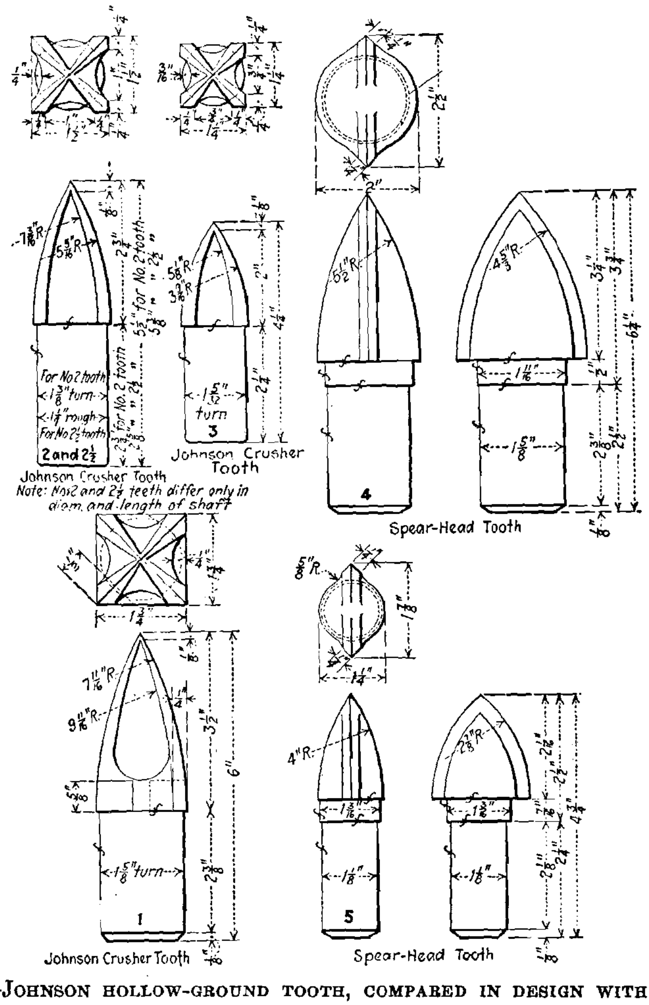


FIG. 14.—JOHNSON HOLLOW-GROUND TOOTH, COMPARED IN DESIGN WITH THE OLD-FASHIONED SPEAR TOOTH.

sizes of steamboat coal, that is, coal broken down from lump to steamboat, is 93.4 per cent., broken coal 91 per cent., egg coal 88.8 per cent.

Table 1 shows the results of a long series of roll tests made in different parts of the anthracite fields. The name or make of the roll, the locality where the test was made, the results obtained, and any special features of the roll are given.

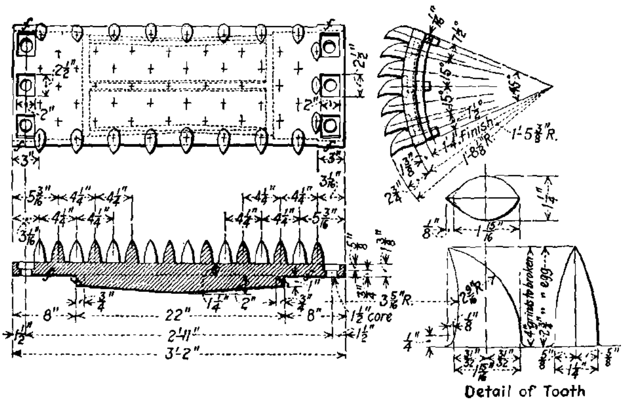


FIG. 15.—HAWK BILL TOOTH WHICH IS USED TO A LARGE EXTENT IN THE ANTHRACITE FIELD FOR THE CRUSHING OF COAL.

The Johnson hollow-ground tooth, differs from the old-style spear tooth in having four cutting edges spaced equidistant around its periphery, as shown in Fig. 14. Here is also shown the shape of the old type of spear tooth. In Fig. 15 is shown the "hawk bill" tooth which is of manganese steel. In Fig. 16 is shown one of the older type of teeth likewise made of manganese steel. The spaces between the cutting

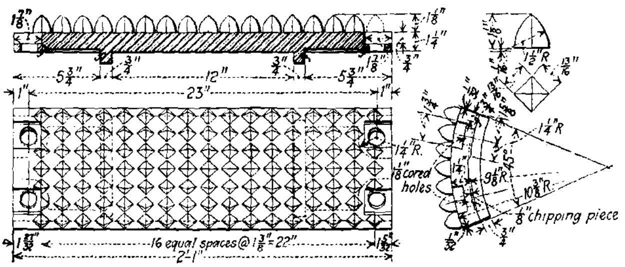


FIG. 16.—THE OLD-FASHIONED SPEAR TOOTH AND ITS ARRANGEMENT ON THE SEGMENTS.

edges of the Johnson roll tooth are concave, so that the only part of the tooth that comes into contact with the coal is the cutting edge; whereas with the older types, which possess only two cutting edges, the sides of the tooth present an unbroken surface to the coal, resulting in a grinding instead of a cutting action. It is also claimed that the wear on this type of tooth is such that the cutting edge is constantly maintained throughout its entire length of service.

Table 1 shows that in tests Nos. 26 and 27, made with Johnson teeth, the percentage of the prepared sizes secured exceeds the percentage made at the same colliery with another type of tooth. Furthermore the percentage of the larger sizes of coal is greater for the Johnson than for the other types of teeth. Test 35 shows that, while almost no broken coal was made by the Johnson tooth, yet the percentage of prepared sizes was greater than in test 34 when 36.4 per cent. of broken coal was produced.

A recent invention by Frank Pardee, shown in Fig. 17, is in daily service in the Coleraine breaker. This machine consists of two shafts, which are revolved toward each other by gearing. On one shaft is mounted a steel plate carrying cutter teeth on its periphery; these are similar to the teeth on a circular saw, but the distance between the adjacent cutters is equal to about the diameter of the pieces to which it is desired to break the coal. Thus an egg crusher would have teeth 2⅜ in. (6 cm.) apart. The other shaft carries plain steel disks. The cutters and the disks revolve in parallel and alternate planes, their tops moving toward each other.

The movements of the feeder and the cutter are synchronized, so that each piece of coal is delivered in front of a tooth, which carries the coal forwards against the opposite disk. This acts as a fulcrum, against which the cutter breaks the coal. Between adjacent cutters, as well as between the disk wheels, spring spaces are placed. Any coal that lodges between either the cutters or the disks will push back the spring, thus preventing the coal from being crushed. The coal is so fed to this device, by a new and ingenious spiral feeder, that each piece of coal is delivered with its major axis at right angles to the plane in which the cutters revolve.

The following is the result of a test run on one of these rolls:

	Per Cent.
Over 3¼ in.	0.00
Over 2$\frac{5}{16}$ in.	71.42
Over ¾ in.	21.42
Over ½ in.	2.38
Over ¼ in.	2.85
Over $\frac{3}{16}$ in.	0.48
Over $\frac{1}{16}$ in.	1.07
Smaller	0.48

The material was crushed directly from broken into egg coal without any oversize, giving a total of 92.84 per cent. of prepared sizes. With the common roll, it is generally expected that the highest yield of prepared coal will occur when there is 15 to 20 per cent. of oversize made in the roll.

TABLE 1.—*Results of Tests at Various Breakers*

Name of Colliery	Name or Make of Rolls	Size	Special Characteristics	Size of Coal Crushed	Speed, Ft. Per Min.	R.p.m.	Date	Steamboat, Per Cent.	Broken, Per Cent.
Short Mountain..	Solid cast	No. 2	Teeth diagonal and alternate	Broken	918	115	1910		
Williamstown...	Manganese	No. 2	Alternate	Broken		80	1911		1.3
Williamstown...	Manganese	No. 2	Teeth	Broken		80	1911		9.0
Williamstown...	Manganese	No. 2	Alternate Teeth Removed	Broken		80	1911		7.0
Williamstown...	Manganese	No. 2	Each sheet	Broken		80	1911		3.8
Wm. Penn......	Manganese	No. 2		Steamboat	301		1920		43.0
Cameron........	Manganese	No. 2		Steamboat	256		1920	12.5	38.8
Luke Fidler.....	Manganese	No. 2		Steamboat	233		1920	2.9	26.2
Slott...........	Manganese	No. 2		Steamboat	364		1920		42.7
Pennsylvania....	Manganese	No. 2		Steamboat	345		1920		29.0
Wm. Penn......	Manganese	No. 1		Lump	905		1920	51.0	21.0
Cameron........	Manganese	No. 1		Lump	250		1920	64.5	6.5
Luke Fidler.....	Manganese	No. 1		Lump	1107		1920	38.1	16.7
Scott...........	Manganese	No. 1		Lump	1008		1920	30.0	21.9
Pennsylvania....	Manganese	No. 1		Lump	240		1920	36.0	20.5
Richards........	Manganese	No. 1		Lump	288		1920	43.3	17.8
Cameron........	Manganese	No. 3		Broken	246		1920		15.3
Luke Fidler.....	Manganese	No. 3		Broken	281		1920		5.0
Richards........	Manganese	No. 3		Broken	289		1920		35.0
Jeddo No. 4.....	Lloyd	No. 2		Steamboat and broken		135			
Jeddo No. 4.....	Lloyd	No. 1		Lump		135		38.0	20.0
Highland No. 5..	Lloyd	No. 1		Lump		135		41.8	29.0
Highland No. 5..	Lloyd	No. 2		Steamboat and broken		135			
Lansford No. 5..	Lloyd	No. 1		Lump		135	1920	41.4	19.8
Lansford No. 5..	Lloyd	No. 1		Lump		135	1920	30.5	24.0
Lansford No. 5..	Lloyd	No. 1		Lump		135	1920	45.1	23.6
Lansford No. 5..	Lloyd		Johnson hollow ground tooth	Lump		135	1920	46.1	22.5
Lansford No. 6..	Lloyd	No. 2		Steamboat		135	1920	9.6	38.7
Lansford No. 6..	Lloyd	No. 2		Steamboat		135	1920	0.6	43.6
Rahn No. 11....	Manganese	No. 2		Steamboat		135	1920	21.0	35.4
Rahn No. 11....	Manganese	No. 2	Johnson	Broken		135	1920		26.0
Rahn No. 11....	Manganese	No. 2		Steamboat		135	1920		4.4
Rahn No. 11....	Manganese	No. 2	Johnson	Steamboat		135	1920		5.9
Tamaqua No. 14.	Lloyd	No. 2	Johnson	Steamboat		135	1920		36.4
Tamaqua No. 14.	Lloyd	No. 2	Johnson	Steamboat		135	1920		0.5

TABLE 1.—*Results of Tests at Various Breakers*—(*Continued*)

Egg, Per Cent.	Stove, Per Cent.	Chestnut, Per Cent.	Prepared Sizes, Per Cent.	Pea, Per Cent.	Buckwheat, No. 1, Per Cent.	Rice, Per Cent.	Barley, Per Cent.	Buckwheat No. 4, Per Cent.	Total Small Sizes, Per Cent.	Number of Teeth Per Shell	Condition Teeth	Test	Remarks
47.5	21.0	13.5	82.0	6.0	5.5	3.5	1.75	1.25	18.0	896	Fair	1	
37.3	27.7	16.2	82.5	5.0	6.0	3.6	1.2	1.7	17.5	840	Good	2	
39.5	22.9	13.2	84.6	4.5	4.0	3.0	1.5	1.8	15.4	840	Good	3	
39.4	22.8	14.8	84.0	5.0	4.5	3.3	1.7	1.5	16.0	840	Good	4	
40.0	23.0	14.9	81.7	5.9	5.6	3.7	1.4	1.7	18.3	840	Good	5	
21.0	12.5	9.0	85.5	6.0	3.5	4.0	1.0		14.5			6	
12.5	13.7	9.2	86.7	4.2	4.3	2.0	2.5	1.3	13.3			7	
18.0	18.4	16.0	81.5	6.8	4.9	3.4	2.4	1.0	18.5			8	
19.0	12.7	11.7	86.1	4.7	4.2	2.6	1.5	0.9	13.9			9	
35.0	21.0	11.2	96.2	1.5	1.2	0.5	0.3	0.3	3.8			10	
8.5	6.0	4.8	90.3	3.0	3.2	3.0	0.5		9.7			11	
4.5	7.8	6.0	89.3	3.5	3.7	1.0	1.5	1.0	10.7			12	
12.4	9.5	10.0	86.7	6.0	3.3	1.9	1.4	0.7	13.3			13	
14.7	11.7	10.0	88.3	4.2	3.7	2.1	1.1	0.6	11.7			14	
15.3	11.3	10.0	93.0	3.0	2.5	0.8	0.5	0.2	7.0			15	
12.3	8.1	6.3	87.8	4.3	2.7	2.3	1.8	1.1	12.2			16	
38.7	18.0	15.8	87.8	4.5	2.2	3.0	1.5	1.0	12.2			17	
26.0	33.0	23.0	87.0	5.0	2.5	2.5	1.5	1.5	13.0			18	
27.7	15.6	11.1	89.4	3.8	2.8	1.9	1.4	0.7	10.6			19	
52.0	28.0	10.0	90.0	3.0	3.0	2.0	1.0	1.0	10.0			20	10 tests average
19.0	8.0	6.0	91.0	3.0	2.0	2.0	1.0	1.0	9.0			21	7 tests average
20.0	4.5	2.0	97.3	1.0	0.7	0.7		0.3	2.7			22	
63.4	19.2	9.6	92.2	2.8	2.0	1.7	1.0	0.3	7.8			23	
11.1	8.2	8.3	88.8	3.6		7.6			11.8			24	
15.5	9.2	10.1	89.3	3.8		6.9			10.7			25	
7.6	7.9	8.6	92.8	2.6		4.6			7.2			26	
9.6	4.9	7.3	90.5	3.4		6.1			9.5			27	
20.9	10.6	9.3	89.1	3.8		7.1			10.9			28	
27.4	9.8	8.7	90.1	3.4		6.5			9.9			29	
16.6	8.6	7.2	88.8	4.0		7.2			11.2			30	
39.0	15.3	10.6	90.9	3.9		5.2			9.1			31	
37.2	28.3	16.2	86.1	3.5		10.4			13.9			32	
51.8	20.5	11.0	89.2	3.8		7.0			10.8			33	
32.8	11.5	8.9	89.6	3.5		6.9			10.4			34	
54.8	22.8	12.0	90.1	4.1		5.8			9.9			35	

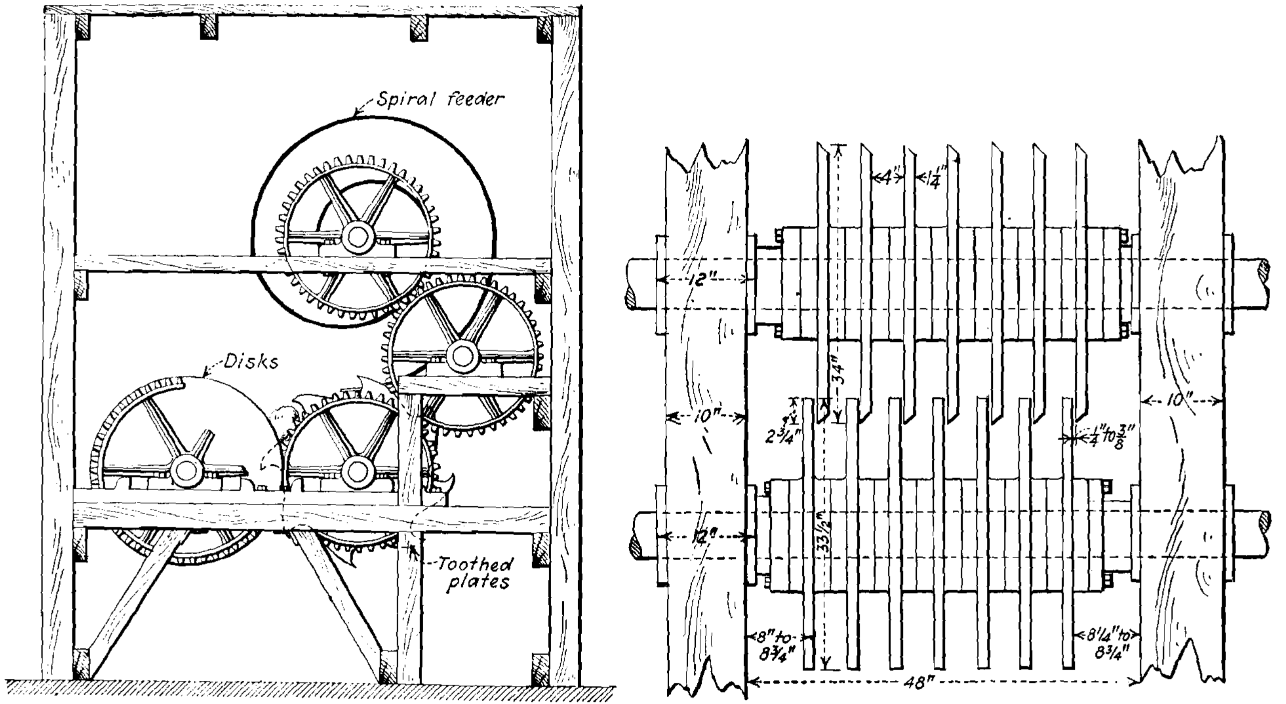


FIG. 17.—PARDEE ROLLS, AN ENTIRE DEPARTURE FROM PRESENT ROLL PRACTICE. THE COAL IS FED TO TEETH BY A SPIRAL FEEDER SYNCHRONIZED WITH TEETH OF ROLLS

Shaking Screens

The design of shaking screens has become so nearly standardized that few improvements have been made during the past several years.[1] But a few details will be given concerning the current practice at certain plants.

In the new Wanamie breaker of the Lehigh & Wilkes-Barre Coal Co., the following areas, in square feet of screening surface, are allowed for one ton of coal per hour; the large screen area is provided so that it is possible to handle and screen the coal properly during the morning when the tonnage for a short period is unusually heavy.

	Square Feet		Square Feet
Broken	2.4	Pea	6.4
Egg	1.9	No. 1 Buckwheat	4.2
Stove	2.3	Rice	6.9
Chestnut	2.3	Barley	7.8

The Susquehanna Collieries Co. uses the following areas:

	Square Feet		Square Feet
Egg	0.75	No. 1 Buckwheat	1.50
Stove	0.75	Rice	1.75
Chestnut	0.875	Barley	2.00
Pea	1.25		

In both cases the broken and egg coals are screened dry whereas the other sizes are screened wet.

Feeders

Under ordinary conditions, when the breaker begins operations in the morning there is an abundance of coal, produced possibly by the night shift or left over from the preceding day. This means that during the first few working hours too much coal may be presented for the breaker to handle properly; later, the rate at which the coal arrives decreases and the breaker may not receive its capacity supply. At times during the day, the delivery of coal may be irregular so that at one moment the preparation equipment will be overtaxed whereas a few moments later it may not have sufficient coal to operate properly.

These abnormal conditions may be met in two ways: First, by making the capacity of the breaker so great that the breaker will be capable of handling all the coal delivered to it. This method requires the construction and equipment of a building far beyond the average needs. The second method is to provide storage hoppers to bridge over the peaks. This is the better method, for then the breaker can be so designed that the cost of construction and operation may be reduced to a minimum.

[1] Paul Sterling: Preparation of Anthracite. *Trans.* (1911) **42**, 277.

In most cases these hoppers are placed at the top of the breaker; they may be so located, however, that both the coal passing through the bull shakers and that leaving the main rolls will go to them. In addition to this storage, many companies have arranged storage pockets in front of, and feeding, the jigs. If the coal comes too rapidly for the jigs to handle, it is placed in these storage pockets so that it can be fed as desired.

In order to accommodate a temporary excess of coal and assure its being fed properly from the hoppers or storage pockets to the breaker equipment, feeders are used. In some places these are operated by hand, but the more common method is to employ an automatic feeder. The number of openings and the quantity of coal admitted can be regulated to suit the conditions existing at the plant.

Feeders are of many types. The ordinary gate feeder, in which a gate is raised and lowered at suitable intervals, is objectionable as coal is liable to get under the gate, in which case it is crushed or it interferes with operation. But where the gate rises through the coal to shut off the flow and sinks below the pocket or chute floor to allow the material to flow, the gate does not break the coal. Feeders having a door opening outward and then closing have the disadvantage that a large lump of coal is liable to prevent the door from closing properly. Many varieties of the reciprocating feeder have been invented but they all operate on similar principles. Their advantages are many. The device is driven by an eccentric, which pushes the plate backwards and forwards; it usually operates at the bottom of the pocket. The coal feeds down to the feeder, which pushes it forwards on to the shaking screens or other piece of preparation equipment and then returns for another load. The revolving feeder is similar in appearance to a shrouded gear or pinion bearing, say four teeth and a corresponding number of feeding compartments. Coal runs into these compartments and is discharged as the feeder revolves. The rate of feed depends entirely on the size of the feeder and the number of revolutions made per minute.

Chutes

The three pieces of equipment, employed in the preparation of coal, where most degradation occurs are the rolls, the chutes, and the pockets. The general manager of one of the larger companies has said: "It is difficult to give figures on chute tests because of the varying conditions, but it is probably safe to say that the total breakage in handling coal from shakers to the lip screen at the loading pocket would be from 10 to 12 per cent." The loss from this cause during a year may be very great, for the prepared sizes of coal are worth, at the mine, from $7.50 to $8 per ton, while the steam sizes are worth only from $1.50 to $3.50 per ton.

The operators are using various types of chutes and chute linings in order to decrease the breakage, reduce the space taken by the chutes, and increase the life of the chute linings.

At first, when the coal was prepared near the top of the breaker, it was carried to the pocket by long inclined chutes; in one breaker

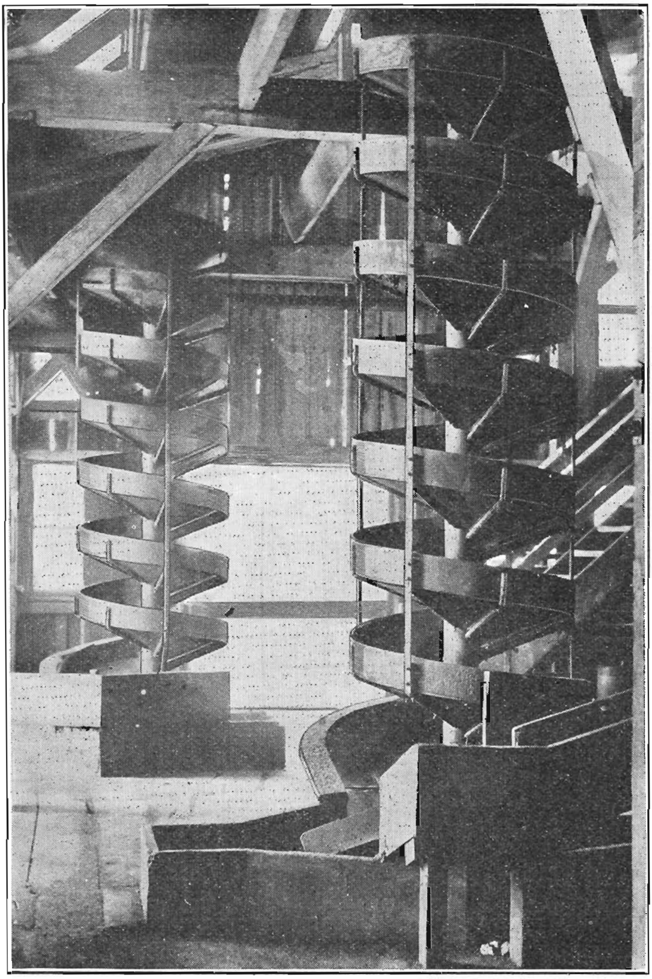


FIG. 18.—STEEL SPIRAL CHUTES USED TO LOWER COAL HIGH IN BREAKER.

one of these chutes was 350 ft. (106.7 m.) long. The friction of the coal on the chute lining and against the sides, together with poorly designed curves, caused much unnecessary coal breakage. To-day shorter chutes of different design are provided. Among these are the spiral cast-iron chute, the spiral steel chute shown in Fig. 18, and the spiral built-up chute shown in Fig. 19. The advantage of this type of chute is that it takes up little space and the coal passes around curves so designed that the breakage is reduced to a minimum; the objection to it is that the acid water soon corrodes the lining.

A type that is coming into favor is the box chute, shown in Fig. 20. This is a square, verticle wooden box lined with sheet iron. The coal passes down an inclined chute leading to its top, in which is placed a pan that

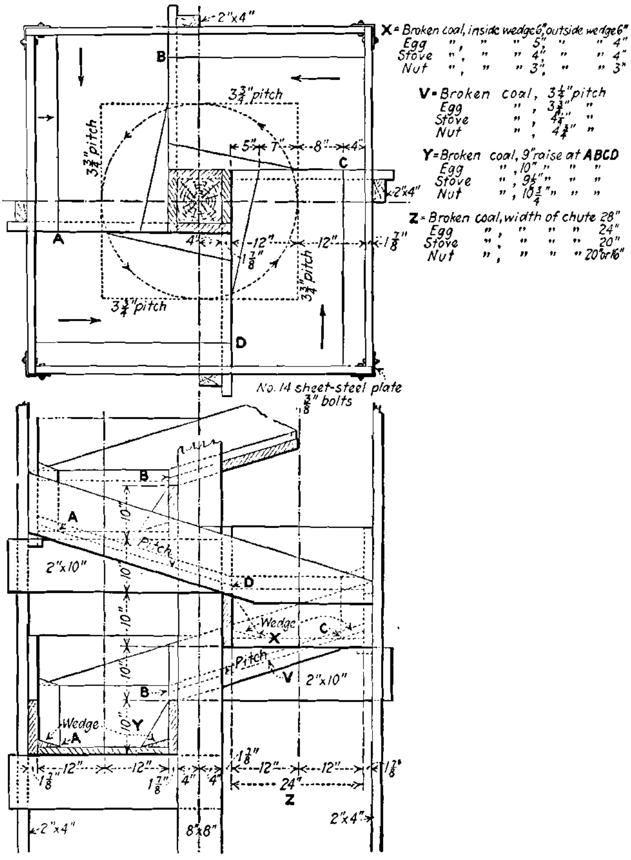


FIG. 19.—BUILT-UP SPIRAL CHUTE MADE OF WOOD AND SHEET IRON.

rises and falls in accordance with the amount of coal upon it. This pan is connected by a lever and wire rope to a door in the bottom of the vertical chute. When the pan ascends, the door closes; and when the pan is forced down by the weight of coal the door opens. The vertical box is constantly filled but as the coal backs up the inclined chute, the pan is depressed and the bottom door is opened, allowing the coal to pass out. When the weight of coal on the pan is not sufficient to keep it down, it rises and the door closes. In this way the box is kept full of coal.

As there is some breakage in the square corners, in the chutes now being built the corners are rounded. One disadvantage of the box chute is the difficulty of relining it; it is probable, however, that round vitrified clay pipe can be substituted for the box.

In many places a shaking chute conveys the coal from one point to another. The advantage of this construction is that the shaker can lie at a small pitch and reduce the vertical distance to a minimum. Retarding conveyors are also being used for lowering coal. By their use breakage is reduced greatly but they require power for their operation.

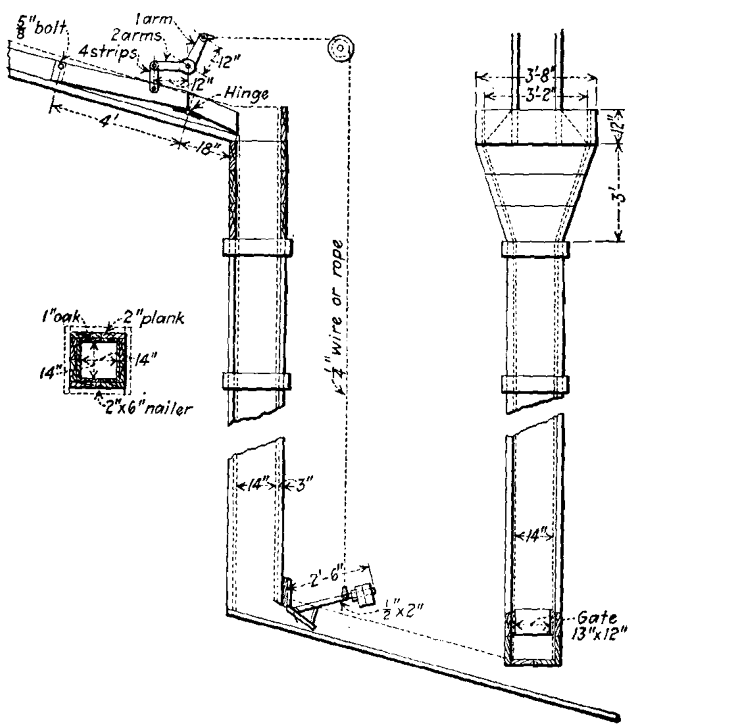


FIG. 20.—BOX CHUTE USED BY SUSQUEHANNA COLLIERIES CO. TO LOWER COAL IN BREAKER AND REDUCE BREAKAGE.

In the White chute, shown in Fig. 21, the coal is fed through a spiral chute provided with a control regulating the amount of coal that can pass. This arrangement is similar to the box chute but works in an opposite manner. The coal passes under the pan and operates the gate in the chute; it is then fed on to a movable chute, the end of which is close to the sloping bottom of the pocket. When discharged from the end, the material runs down the bottom of the pocket. As the pocket fills, the coal pushes back the traveling chute to offset the friction in the traveling chute. Tests have shown that this type of chute reduced breakage in the pockets 5 per cent.

Renewal of chute linings is an important item in the cost of breaker operation. For years nothing but blue annealed sheet iron was

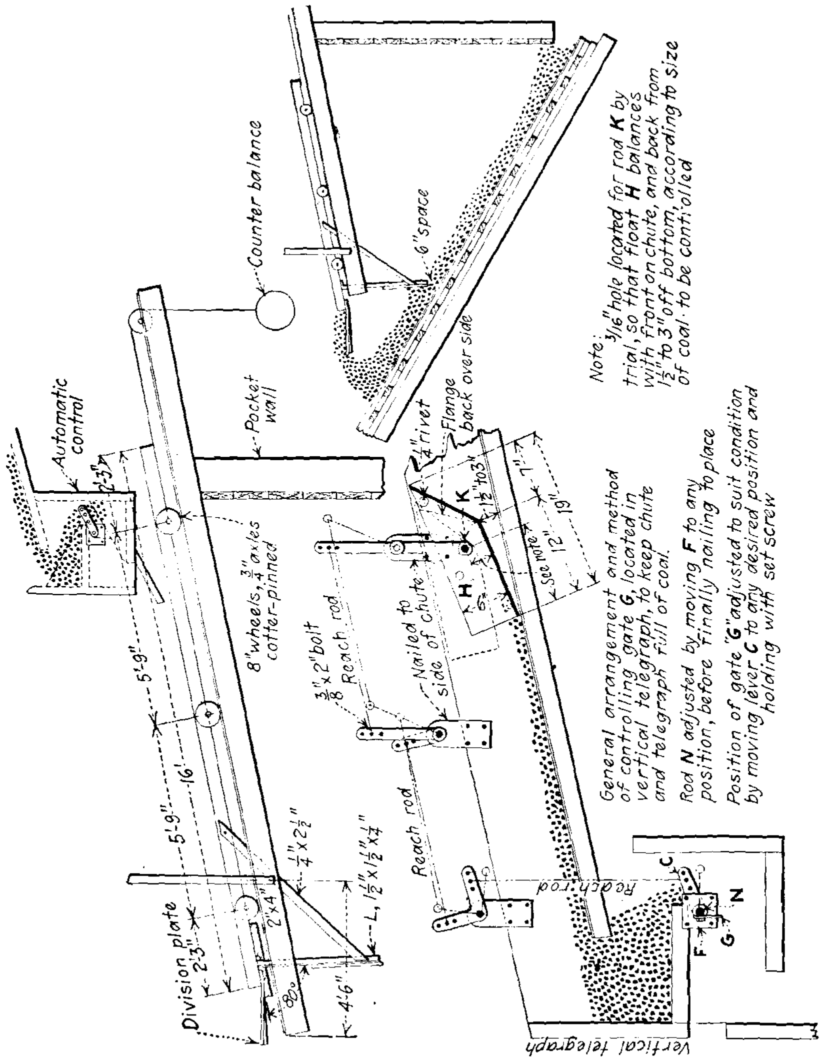


FIG. 21.—WHITE CHUTE FOR SENDING COAL TO POCKETS AND CONTROL TO REDUCE BREAKAGE. THIS CONTROL CAN BE USED ON ALL CHUTES IN BREAKER.

used; as the acid water soon corroded this a sheet seldom lasted more than three or four months. A number of companies using the old type of chute are lining them with galvanized sheet iron; this resists the action of the acid in the water and also permits the coal to slide on a smaller angle.

Vitrified-clay pipe makes an excellent lining for coal chutes and appears to resist wear indefinitely. Some chutes so fitted that have been in active service for more than 3 years show only slight signs of wear. Great care must be taken in the lining installation to see that the ends of the pieces of pipe exactly match, as otherwise they will wear out more rapidly than when set properly. Glass has been tried by some companies but is too brittle. Monel metal also has been used in a few places and to a slight extent.

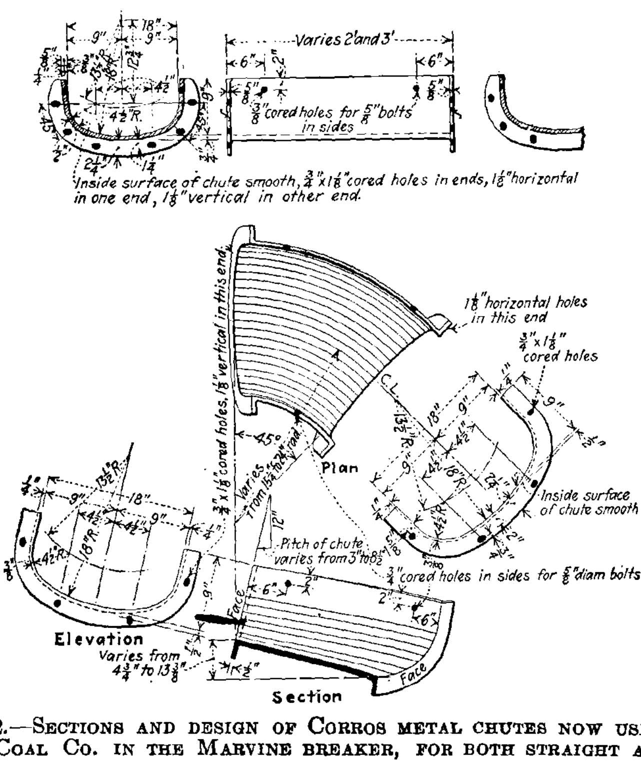


FIG. 22.—SECTIONS AND DESIGN OF CORROS METAL CHUTES NOW USED BY THE HUDSON COAL CO. IN THE MARVINE BREAKER, FOR BOTH STRAIGHT AND SPIRAL SECTIONS.

The Hudson Coal Co. has installed several chutes made of "Corros iron." The first trial of these chutes was made about 2 years ago, when a half-dozen sections were installed in the Loree breaker. A typical straight section of one of these chutes is shown in Fig. 22, as well as a typical curved, or spiral, section. This material is cast iron, containing approximately 12 per cent. of silicon. The properties claimed for it are immunity from corrosion by acid water, comparative freedom from oxidation, and extreme resistance to abrasion. The hardness of the metal is fully equal to that of chilled iron, being so great that it cannot be worked by ordinary machine tools.

The chutes installed at Loree breaker, Fig. 23, approximately 2 years ago, show no appreciable wear or deterioration, apart from the fact that the inner surfaces have become smoother and brightened by the passage of material. Installations made more recently have given similar

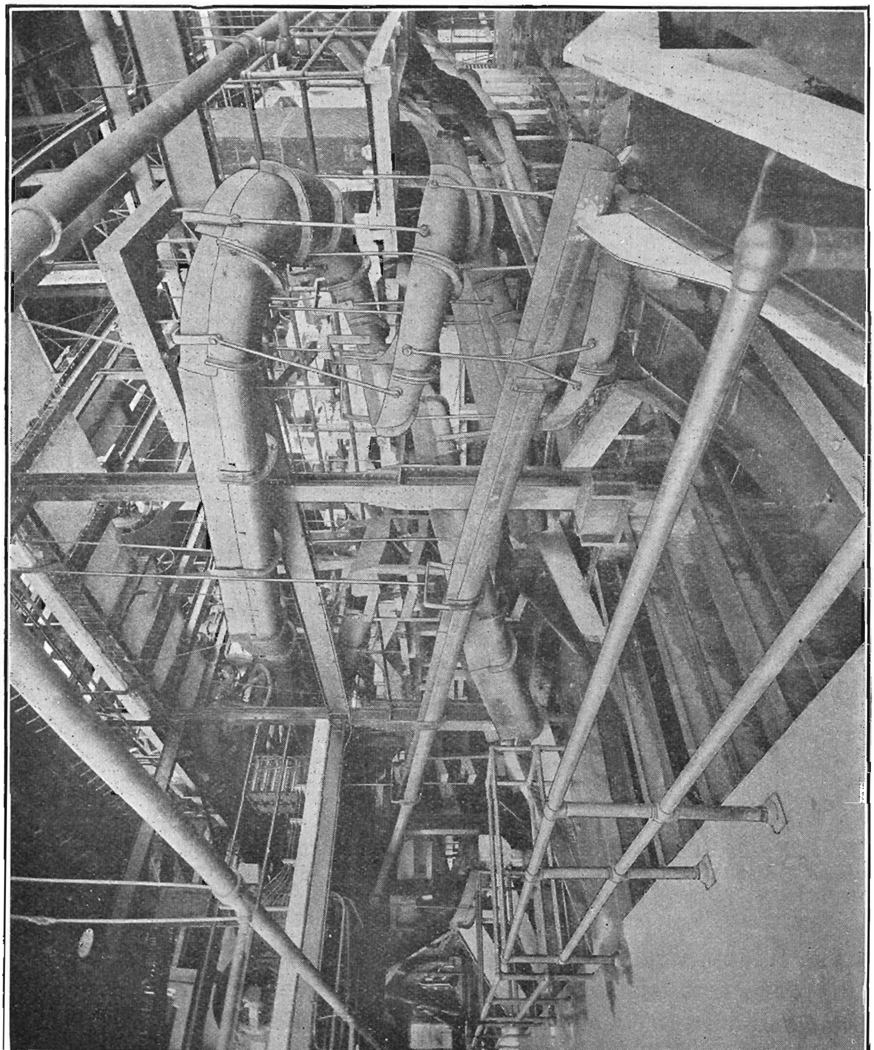


FIG. 23.—INTERIOR OF PART OF LOREE BREAKER OF HUDSON COAL CO., SHOWING A SPIRAL CHUTE MADE OF CORROS METAL

results. When these chutes are first installed, they have a rough cast finish on the inside, as no practicable method has been devised for making them smooth except that of using extreme care in facing the mold in which they are cast. As a consequence ordinary pitches are not quite sufficient to carry the material through them when they are first installed. After they have been in service several months, however, the inside surface becomes smooth and bright and the pitch required is only that ordinarily employed for sheet steel under good conditions. When installing these chutes, it is probably best to place them on such a pitch as is ordinarily required for the operation of smooth-iron or sheet-steel chutes, and line them with iron sheets. Then this lining should be removed, one sheet at a time from the bottom upwards, thus exposing, successively say each day, a new section of Corros iron to the wear of the material passing down the chute.

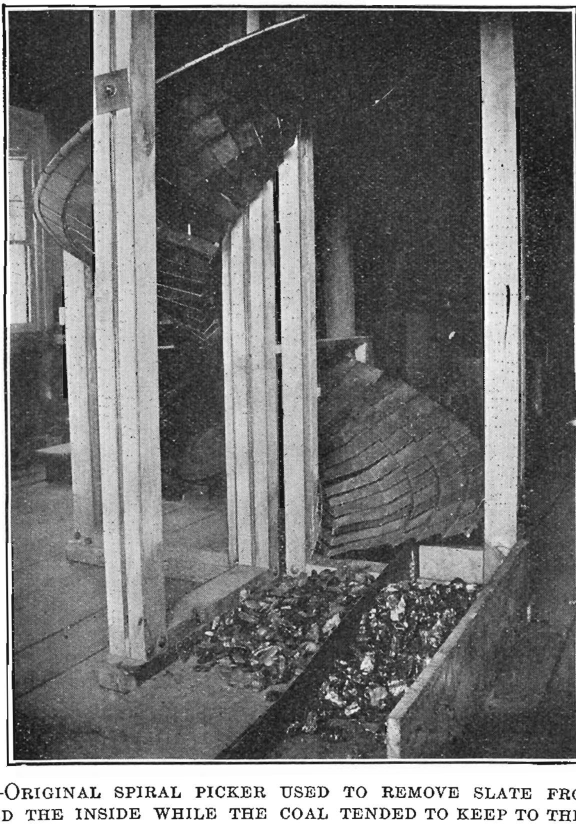


Fig. 24.—Original spiral picker used to remove slate from coal; the slate hugged the inside while the coal tended to keep to the outer edge. Designed as a chute for lowering coal, its value in separation was accidentally discovered.

The cost of Corros iron chutes depends largely on the nature of the casting, as the chief expense incurred is that of handling the metal in the foundry. Straight sections of 18-in. (46 cm.) chutes, 3 ft. (91 cm.) long, cost approximately $24 per linear foot. The ordinary breaker chute lined with sheet steel costs approximately $3 per foot. Just how long Corros iron chutes will last has not been determined, but none has as yet shown appreciable signs of wear. It has been demonstrated that in certain locations Corros iron has already outlasted at least ten renewals of No. 10 sheet-steel chute lining, and bids fair to last indefinitely. The erection of Corros iron chutes requires care, as they are necessarily made in flanged sections of definite size; moreover, this metal is rather brittle, being only about half as strong as ordinary cast iron, so that adequate supports must be provided.

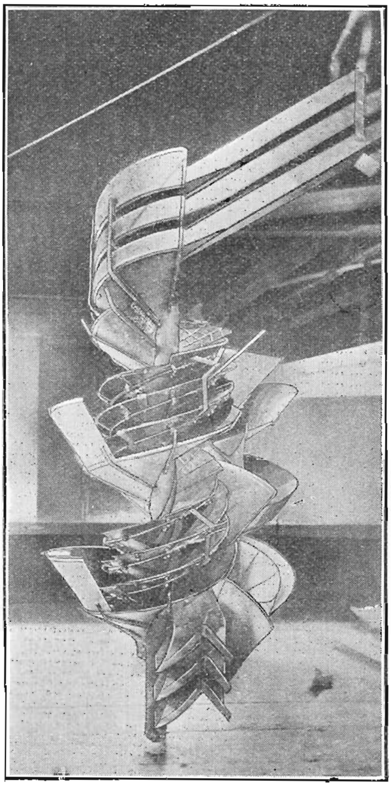


FIG. 25.—MODERN SPIRAL PICKER. THIS CAN BE REGULATED TO MEET ANY AND ALL CONDITIONS IN CHARACTER OF COAL TO BE CLEANED.

SPIRAL PICKERS

The anthracite spiral picker is the one picking device, aside from jigs, that is still in everyday use and shows no sign of disappearing. This contrivance separates the coal from the slate by centrifugal action. The mixed material is fed into the top of the picker and as it descends its velocity increases. As the coal rolls faster than the slate slides, it is thrown into the outside spiral, while slate keeps to the inner spirals and is discharged at the lower end. Fig. 24 shows the first spiral installed; it was built for experimental purposes in 1889. Fig. 25 shows the modern spiral, which is fully adjustable to any condition that may be encountered. In the latter illustration parts of the sides have been removed to show the inside arrangements.

Tests made last April on different sizes of coal gave the following average results:

	Coal, Per Cent.	Slate, Per Cent.
Material entering spiral	84.60	15.40
Coal leaving spiral	98.93	1.07
Slate leaving spiral	5.88	94.12

The total loss of coal in the slate amounted to 1 per cent. and the slate removed equaled 94 per cent. of that originally contained. Spirals have a capacity of from 8 to 12 tons per hour, depending on the size of the coal.

Fireproofing

The tendency is to build breakers of steel and concrete, thus reducing the fire hazard, though some companies are still building wooden structures. Although all the anthracite companies do not use the same methods of breaker construction, particularly in reference to fireproofing, their ideas are similar. The Hudson Coal Co. has given the following details of its practice at the Marvine breaker. In building new breakers, and adjacent structures, for the past several years this company has taken steps to render such buildings fireproof. The precautions taken to this end may be summarized briefly as follows:

In new breaker structures the framework has been built entirely of steel. As far as possible, the design has provided for complete accessibility to all main members for the purpose of frequent inspections and painting. For protection of the steel against corrosion by acid water, deterioration from rust, and the like, adequate painting with a suitable vehicle (asphalt and carbon chiefly) is relied upon exclusively.

The roofs and side walls, or sheathing, of these buildings have been made of asbestos-protected metal, attached to steel girts and purlins by means of the usual straps and clips. All window openings have been provided with steel sash, glazed with factory-ribbed wire glass, and fitted with top-hinged or pivoted ventilator sections. Practically all door openings have been provided with steel door frames and doors made up of a structural-steel framework covered with asbestos-protected metal.

All floors have been constructed of reinforced-concrete slabs, practically continuous over the entire floor area; these vary in thickness from 4 to 6 in. (10 to 15 cm.), in accordance with expected loads and character of service. In building these floors a self-furring lath, such as Hy-Rib or self-centering, has been laid directly on the floorbeams and fastened in place with suitable clips. The concrete has then been poured on top of this lath, without the use of wooden forms. The underside of the floor is back-plastered with a cement gun and hand floated to a suitable finish. In addition to the metal lath, small-diameter bars provide further rein-

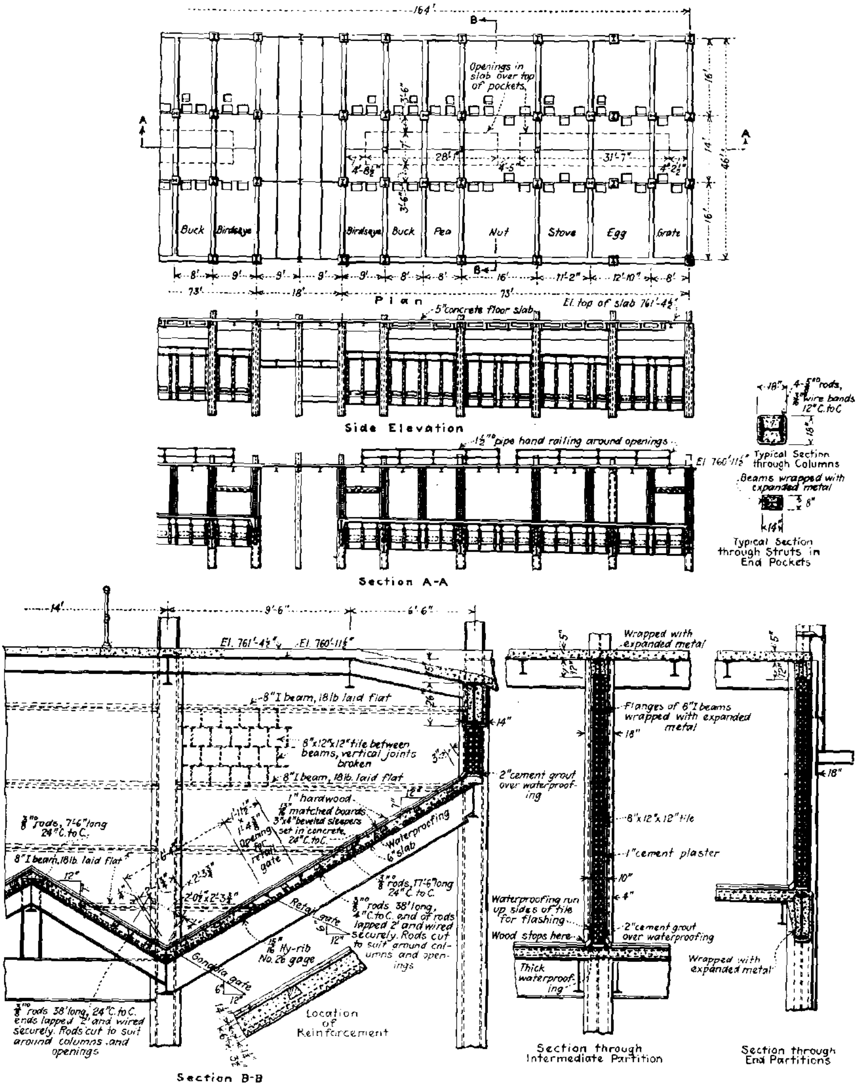


FIG. 26.—SECTION THROUGH POCKETS OF MARVINE BREAKER SHOWING METHOD OF CONSTRUCTION AND MANNER OF FIREPROOFING.

forcement, so that the possible, although unexpected, deterioration of the lath will not necessarily impair the structural strength of the completed floor.

All stairs have been built of structural-steel stringers without risers, and with 2-in. plank treads. The use of wooden stair treads is not thought to add any serious fire risk, and, except several special and expensive forms of treads, it is considered the safest and most satisfactory construction. Pipe hand railing has been used on stairs and throughout the entire structure, except where angle-iron handrails and supports have been thought more suitable.

All loading pockets in the breaker have been built on steel stringers, framing into the steelwork of the breaker. The pocket floor, side walls, and partitions have been constructed of reinforced concrete in practically the same manner as that followed in the erection of the floors, except that hollow tile has been used to some extent for partitions between pockets. This construction is illustrated in Fig. 26. These pockets have been waterproofed by liberally coating the inside surface with an asphalt mastic, and laying in it the wood lining necessary to protect the pocket floors and side walls from abrasion by the coal and the effects of acid water. The lip screens, chutes, hoppers, and troughs have been built entirely of cast iron and steel, the only wood entering into their construction being the gate levers.

Pockets under shaking screens, in the rear of jigs, and the slush troughs under jigs, have been built of almost identically the same construction as the loading pockets of the breaker except that it has not been necessary to build them of equal strength. By the use of concrete floors, pockets, and slush troughs, a continuous monolithic covering is provided over the entire breaker area, level with the tops of the pockets, the only openings being those provided for access by stairs and elevators. This in itself affords obvious advantages from the standpoint of fire-protection, as well as from that of adequately heating the structure.

The use of wood in the newer structures has been confined to the jig tanks, pocket linings, and other points already noted. Heavy planking for the bottom and sides of flight conveyors has not been entirely eliminated, because of the impracticability of fastening the conveyor trough and side plates to any other structural material. In some instances, heavy plank flooring is still used as it has great strength in proportion to its weight and affords a better footing. Furthermore, it is able to withstand vibration and flexure without impairment. It is intended, however, to eliminate entirely the use of wood in this connection.

Fireproofing in connection with electric-motor drives in breakers need cover only the control equipment and the wiring to the motor, the motor proper needing no fireproofed inclosure. The policy followed has been to inclose each oil circuit-breaker in a fireproof cell with all such breakers and control equipment concentrated in one room, which is made entirely fireproof. The wiring to the motors is incased in a steel conduit for protection against abrasion, and to eliminate the possibility of short circuits between conductors.

The most pronounced step in the direction of securing a fireproof breaker structure is the elimination of all boards and light woodwork, it being a well-recognized fact that heavy timber and planking is ignited with extreme difficulty whereas boards and wood of light weight catch fire with ease.

Certain work has been undertaken in connection with the fireproofing of the older structures, with the idea of eliminating the greater and more obvious risks. The motors, together with their control apparatus, have been housed in small fireproof compartments that provide ample space for the attendant to work in, and for ventilation of the equipment, but preclude the possibility of spreading any fire that might possibly originate in the controlling apparatus, particularly the oil switches. Roofs of breaker buildings, particularly those exposed to sparks and embers from passing locomotives, have been re-covered with asbestos shingles or sheet-asbestos roofing. Practically all permanent additions and repairs to the adjacent structures have been roofed with asbestos material.

Chutes, hoppers, and other exposed woodwork have been fireproofed by applying metal lath, or in some cases chicken wire, and covering this with cement plaster applied either with the cement gun or by hand. Metal lath and gunite are to be preferred to chicken wire and hand plastering. In other instances, similar woodwork has been protected by sheets of light-gage steel (No. 24 or 26); this method yields effective and durable results.

Small frame buildings or portions of buildings housing important machinery have been effectively fireproofed by the application of metal lath and cement plaster inside and out, together with the use of asbestos shingles for roofing.

Air Washer

A device for the mechanical cleaning of coal that has recently made its appearance might be termed an air washer or concentrating table, Fig. 27. The basic principle of this machine is simple, and its operation is readily understood. Coal, screened to approximately uniform size, is fed to one corner of an oscillating or jigging table, the bed of which is full of small openings, through which air is forced by a fan built in the base of the machine. The bed is provided with riffles similar to those on an ordinary machine using water as a separating medium and is inclined, both longitudinaly and transversely, both slopes being adjustable within suitable limits. Air pressure, and the length and rapidity of stroke are also variable. When a sized mine product is fed to this machine, the slate or other impurities settle to the table surface, where they are guided by the riffles, the coal "floating" over the riffles unhindered. The result is that pure coal can be delivered to one point, slate without any coal admixture is delivered to another, while the balance of the material arranges itself between these two extremes in accord with its specific gravity. Products of almost any desired composition and almost endless variety may thus be secured.

One of the great advantages of this machine is that no moisture is added to the coal during treatment. If the coal is already wet from previous processes, such as crushing and screening, an appreciable percentage of such moisture would doubtless be carried away with the air blast. This is of particular advantage in cold weather when wet coal freezes readily after being loaded on to the railroad car.

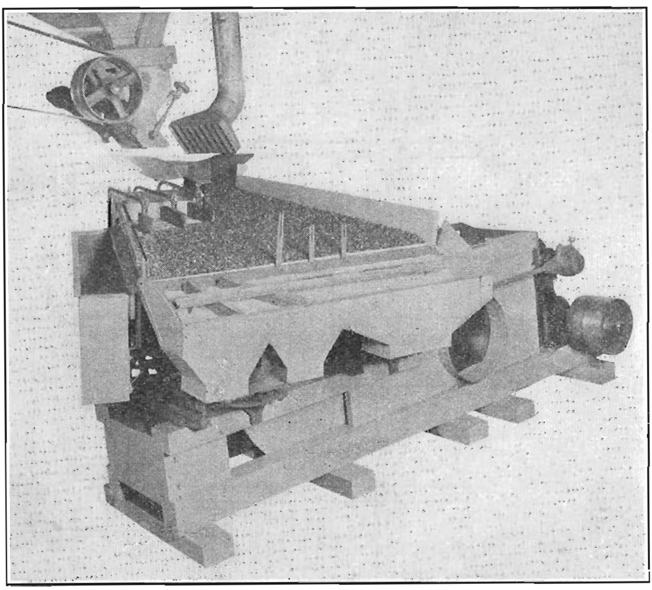


FIG. 27.—AIR TABLE FOR SEPARATION OF SLATE FROM COAL DESIGNED TO TAKE OFF ONLY COAL AND SLATE AND NO INTERMEDIATE PRODUCTS.

As at present built the capacity of this machine varies from about 3 to 10 tons per hour, the quantity that can be successfully handled depending on the size treated, being less with the smaller and more with the larger sizes. The power required to drive the machine is probably about that used in driving an ordinary concentrating table and supplying it with water.

Conklin Separator

The Hudson Coal Co. has recently developed an experimental plant for testing the operation of the Conklin method of separating coal from

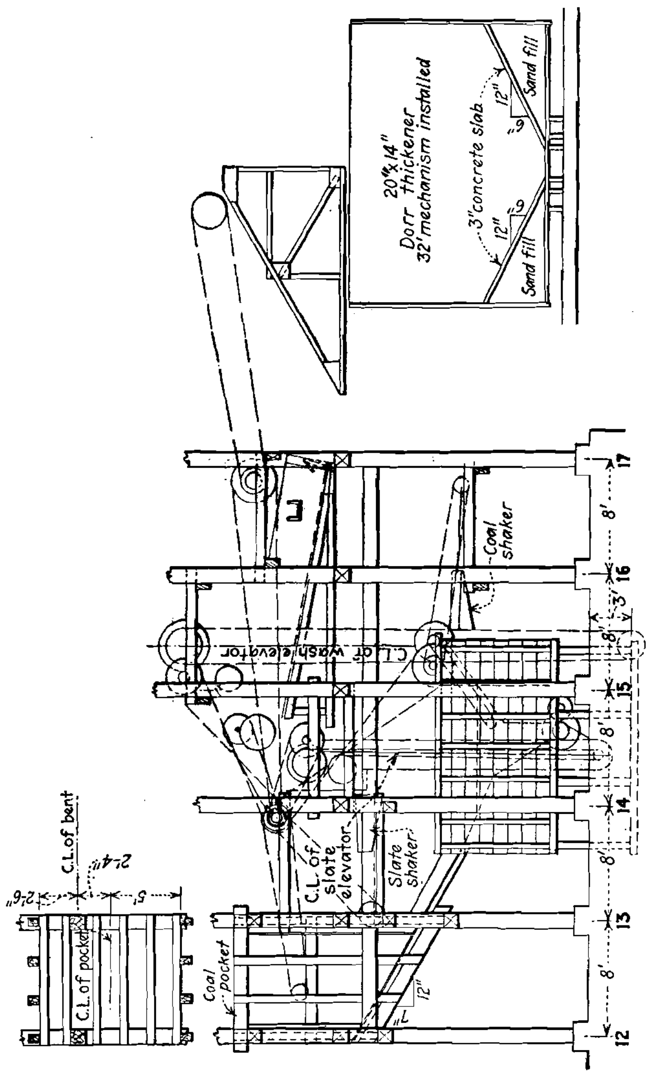


Fig. 28.—Elevation of Conklin separator.

its heavier impurities. This method, or process, is based on the principle of introducing a mixture of coal with its impurities into a fluid medium possessing a specific gravity somewhat greater than that of the coal, and somewhat less than that of the heavier impurities. The medium used is a pulp composed of magnetite dust passing a 200-mesh screen diluted in the proportion of approximately 44 to 1, and having a specific gravity of about 1.9. This fluid quality is sufficiently permanent to make the pulp a working medium that does not require agitation in order to preserve its property of high density. In fact, agitation of any kind is distinctly harmful to its operation, and is so far as possible eliminated from the process. At this density it is quite fluid and retains this quality to a large extent after 18 to 24 hr. of settlement.

The experimental installation consists of several elements, the first of which is the separator tank, filled with the pulp, into which the stream of impure coal is introduced. The actual separation takes place in this tank, the coal passing off on the surface of the pulp and the slate and other impurities sinking to the bottom and being removed by a screw conveyor and elevator. The removal of the coal is also assisted by a flight conveyor, which elevates it slightly above the overflow point of the tank. At the coal and slate discharges, a small shaking screen, having a very fine mesh, and a water spray are installed to remove any pulp that adheres to the coal and slate. Fig. 28 shows a side elevation of the apparatus.

The second element of the plant is a thickener tank, pump, and Dorr classifier, the function of which is the production of the pulp. The pulp washed off from the coal and slate as these materials emerge from the separator tank is lifted by means of a bucket elevator to a Dorr classifier, which removes the impurities and allows the diluted pulp to flow to a Dorr thickener. In this tank the pulp is restored to its proper degree of dilution, and is removed from the tank by a diaphragm pump which discharges it into the top of the slate elevator, thus completing the circuit.

The apparatus described has not, as yet, been placed in actual operation, but similar equipment, smaller in size, built by Mr. Conklin at Joplin, Mo., indicates that results may be expected approximately as follows: The machine will handle run-of-mine coal with the fines removed approximately as well as it will handle graded and sized material. By fines is here meant buckwheat and smaller, which, at present, it is not thought that the machine will be particularly proficient in handling. The capacity of the separator is expected to be approximately 7 tons per foot of width per hour. By "width" is meant the dimension of the stream at right angles to its direction of flow. With this capacity, separation is secured absolutely in accord with the specific gravity at which the pulp is maintained, so that by slight variations in the pulp density, the quality of the coal and slate can be controlled with a fine degree of nicety. By the use of magnetite-ore dust, it is expected that such specific gravities of the pulp can be secured that everything except the heaviest pure slate and rock can be supported on its surface.

Dorr Apparatus for Recovery of Anthracite Slush

The problem of most efficiently recovering anthracite slush in as dry a condition as possible has been given much attention, particularly by the Hudson Coal Co., which has found the Dorr hydroseparators and classifiers the most efficient agents for this purpose. An installation at the Loree breaker has given satisfactory results for almost two years. This installation consists of a Dorr hydroseparator 26 ft. in diameter and three Dorr duplex classifiers. The hydroseparator rejects the bulk of the water and the extremely fine solids and slime and gives a partly dewatered product; the classifiers eliminate the remaining fine solids and furnish a more completely dewatered product. The hydroseparator and classifiers also reduce the ash in the slush, as the fine solids and the slime rejected in the overflow are higher in ash than the original total slush.

The hydroseparator is a wooden tank with an overflow launder around its top and a discharge at the center of the bottom, to which are brought the settled solids by means of a rotating plow. The breaker slush, screened to remove all marketable coal, is fed into the top of this tank at the center. The larger particles of coal settle to the bottom and the extremely fine material is carried off in the overflow. The relative sizes of coal recovered and rejected are determined by the settling area of the tank and the amount of material fed to it. At the Loree breaker, the separation is made at 60-mesh, so that most of the plus 60-mesh solids are in the underflow and the minus 60-mesh solids in the overflow. At other installations 34-ft. tanks are planned; these will give a separation at approximately 100-mesh. Material finer than this, as a rule, has over 50 per cent. of ash so that its recovering and purification does not appear economic at the present time.

The underflow from the hydroseparator passes to three Dorr classifiers, each receiving approximately one-third of the total material by means of a three-opening distribution pipe. The classifier consists, essentially, of a settling box or tank in the form of an inclined trough open at the upper end and equipped with mechanically operated reciprocating rakes, which remove the coarse material as it settles to the bottom of the tank, the water and fine solids overflowing at the closed lower end. The solids recovered by the classifiers carry 35 to 40 per cent. of moisture, which soon drains, when stored in an open pile, to between 15 and 18 per cent. moisture.

A summary of the average results obtained in slush recovery by the Dorr apparatus at the Loree breaker is given below. When considering these results as to percentage recovery of solids, etc., it must be remembered that the plant was designed to save only the plus 60-mesh solids with a minimum of material finer than that size, so that the overall recovery of total solids is necessarily low inasmuch as over 50 per cent. of the total slush is finer than 60-mesh. With a plant designed for finer separation, provided with a larger tank and different classifier adjustment, recovery of practically all the slush solids can be made, but at the sacrifice of ash content in the finished product and with a resultant increase in moisture in the material recovered. It is not economical to recover all the solids, as the extremely fine material and slimes are relatively high in ash, compared to the coarser granular solids, and are also difficult to clean. The elimination of the slimes in the Dorr apparatus is therefore an important step in the effective recovery and utilization of anthracite fines.

A summary of the average results obtained from the Dorr plant at Loree, on anthracite slush, follows:

1. Total solids in slush fed to hydroseparator	49.8 short tons per hr.
2. Average size test on total solids in feed (cumulative):	
plus 60-mesh	44.50 per cent.
plus 100-mesh	57.60 per cent.
plus 200-mesh	72.10 per cent.
3. Average ash content of total solids in feed	32.9 per cent.
4. Total solids recovered by hydroseparator and classifier.	22.71 short tons per hr.
5. Average size test on solids recovered (cumulative):	
plus 60-mesh	89.00 per cent.
plus 100-mesh	97.00 per cent.
plus 200-mesh	99.50 per cent.
6. Average ash content of solids recovered	24.85 per cent.
7. Proportion of total solids recovered by hydroseparator and classifiers	45.60 per cent.
8. Proportion of total solids lost by hydroseparator	39.10 per cent.
9. Proportion of total solids lost by classifiers	15.30 per cent.
10. Proportion of plus 60-mesh solids recovered by plant	91.00 per cent.
11. Proportion of plus 100-mesh solids recovered by plant.	76.70 per cent.
12. Proportion of plus 200-mesh solids recovered by plant	62.90 per cent.
13. Proportion of total combustible recovered by plant	51.20 per cent.
14. Proportion of water eliminated by plant	98.40 per cent.

The plant at Loree at present capacity shows a direct operating cost of 5.3 cents per ton, covering labor, power, supplies and repairs, and a total operating cost of 14.3 cents per ton, including 8.8 cents per ton to cover interest, insurance, taxes, and depreciation at 20 per cent., on an investment of $17,500 for building and equipment. This cost covers delivery of finished product to a conveyor either for stocking or for loading on cars for shipment. The additional cost of operation for this conveyor will, of course, vary with local conditions.

Jigs

The most important apparatus for the cleaning and the washing of coal is the jig. Six important types are used in the anthracite fields though jigs of other types are used in a few places for particuliar purposes. The most important jigs now in use are the Reading, Lehigh Valley, Elmore, Wilmot-simplex, Tench or Delaware, and the James. Two jigs that are used to some extent are the Liberty, or German, and the Christ, which is used mainly for the treatment of the broken size. Only the six first named will be described here.

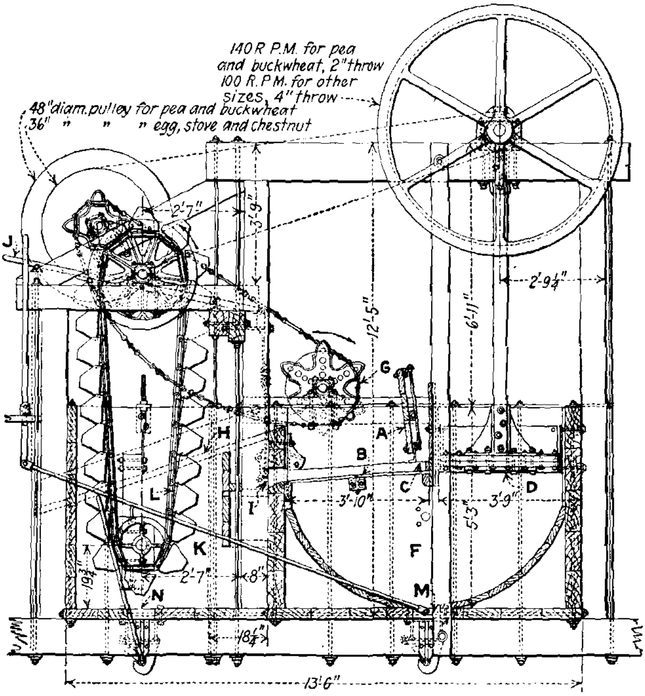


FIG. 29.—SECTION OF READING JIG, USED AT MOST COLLIERIES OF PHILADELPHIA & READING COAL AND IRON CO.

Reading Jig

The Reading jig is of the plunger type and is used mainly by the Philadelphia & Reading Coal and Iron Co. Fig. 29 shows a cross-section of this machine. The coal is fed to the machine in the rear of the baffle plate *A* and passes down behind this plate on to mesh plates *B* through the opening *C*. The water in the jig tub *F* is caused to rise and fall by the plunger *D*. As this water passes through the meshes of the mesh plates, it lifts and drops the coal. As the slate is heavier than the coal, it settles faster and quickly reaches the bottom, the coal remaining at the top. The cleaned coal is removed by the chain *G* to the clean-coal chute

H, whence it goes to the pockets. The slate gate I, operated by the lever J, is opened from time to time as the experience of the jig operator may dictate. The slate discharges through the slate gate into the chamber K from which it is removed by an elevator L, which raises and discharges it into the slate chute.

Fine coal broken down during the jigging process passes through the mesh plates into the jig tub, collecting at the bottom whence it is drawn off through the slush gate M. In a similar manner, the fine slate that settles in the slate chamber is flushed out by the gate N. When treating pea and buckwheat coals, the jig operates at 140 strokes per minute, the plunger stroke being 2 in. (5 cm.). For larger sizes, the speed is cut down to 100 strokes per minute, the length of stroke being 4 inches.

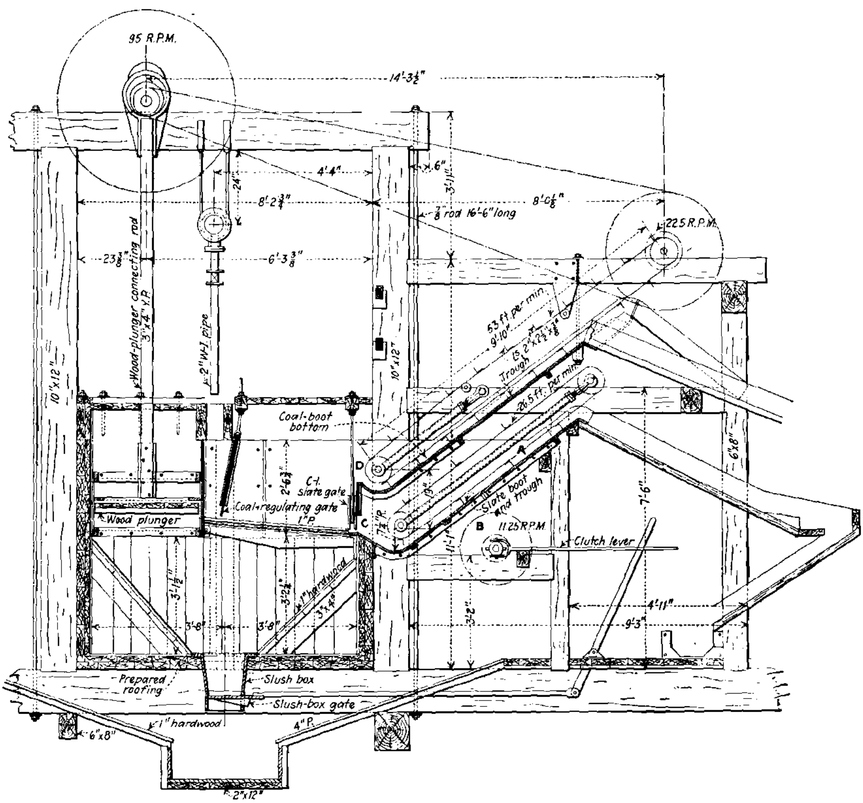


FIG. 30.—STANDARD JIG OF LEHIGH VALLEY COAL CO.

Lehigh Valley Jig

The Lehigh Valley jig is quite similar to the Reading. The coal is fed to the machine in the same manner and is treated in the same way but the slate discharge is regulated by the starting and stopping of the slate conveyor A, Fig. 30, by throwing a clutch B. This stoppage of the slate conveyor accomplishes the same purpose as the shutting of the slate gate on the Reading jig, for when the conveyor stops there is no escape for the slate and the bed of this material grows thicker on the mesh plates, whereas in the Reading jig it can continue to fall into the slate compartment.

This jig is really an overflow-type machine. No mechanical means is provided for removing the coal from the jigging chamber; it must flow off into the coal boot D, from which it is removed by a conveyor. The slush is removed from the bottom of the jig tub through an aperture that can be opened and closed at will.

The accompanying table shows the results obtained from the use of these jigs in both the upper and the lower coal fields. These results are interesting not only from the point of view of the performance of the Lehigh Valley jig but also because they contrast the conditions encountered in the upper and the lower coal fields.

Size of Coal	Coal Before Jigging, Per Cent. of			Coal After Jigging, Per Cent. of			Slate After Jigging, Per Cent. of	
	Coal	Slate	Bone	Coal	Slate	Bone	Coal	Slate
Upper Field								
Egg	81	14	5	97	1	2	1	99
Stove	80	16	4	94	2	4	1	99
Nut	80	15	5	94½	2½	3	½	99½
Pea	84	12	4	91	6	3	½	99½
Buckwheat	83	12	5	84	8	8	1	99
Lower Field								
Egg	69	28	3	97	1	2	2	98
Stove	70	27	3	94	3	3	3	97
Nut	74	22	4	93½	3½	3	2	98
Pea	76	20	4	90	7	3	4	96
Buckwheat	76	20	4	87	10	3	4	96

Elmore Jig

The Elmore jig, shown in Fig. 31, also causes the pulsation of the water by means of a plunger. The difference between this and the preceding jigs, however, lies in the method employed to discharge the slate and coal. The coal is withdrawn by means of a direct overflow instead of being assisted by drag-line conveyors or scrapers. The slate discharge is automatic and when set to provide for a certain amount of rock in the coal it requires no further attention. When the weight of the slate in the bed reaches a certain point, it acts against a lever which, in turn, allows the slate to discharge into a small slate pocket, from which it is removed by a drag-line conveyor discharging into a slate chute.

This type of jig requires about 700 gal. per min. of circulating water; 12 hp. are required to operate the jig and 18 hp. to drive the circulating

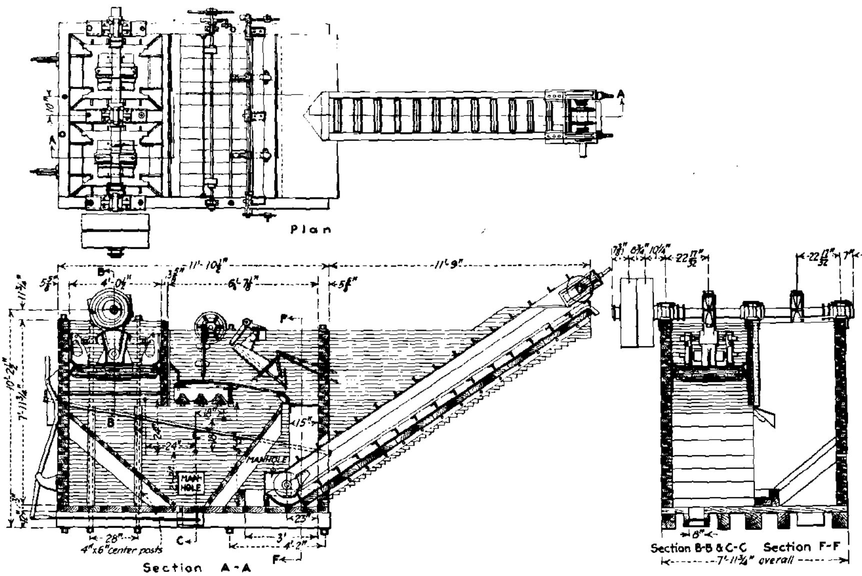


FIG. 31.—DETAILS OF ELMORE JIG.

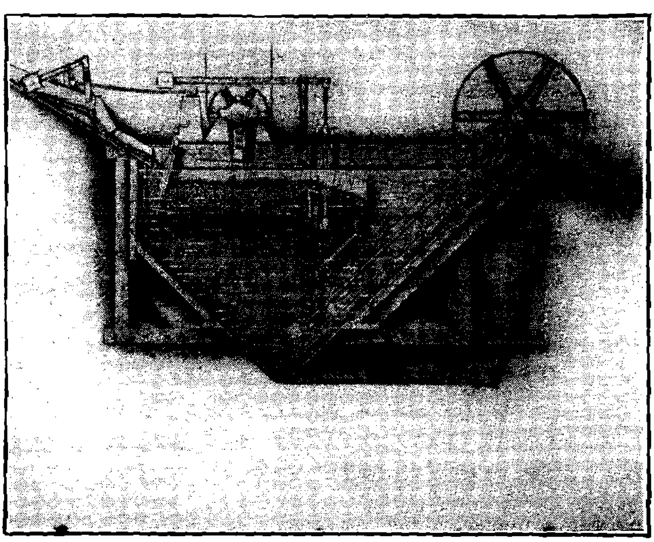


FIG. 32.—WILMOT-SIMPLEX JIG, WHICH IS OF THE PAN TYPE.

pump. It requires a floor space of 24 by 10 by 11 ft. (7.3 by 3 by 3.3 m.). Its capacity is as high as 50 tons per hour. It is in reality, however, a double unit having two jigging compartments and two plungers.

Wilmot-simplex Jig

In the Wilmot-simplex jig, shown in Fig. 32, no plunger is used. The pan containing the coal to be cleaned is moved up and down in the tank; as the water passes through the openings in the pan, it agitates the contents of the pan and the slate settles at the bottom. The coal and slate are both discharged, under water, into semi-pockets, conveyors dragging them out and emptying them into appropriate storage bins.

The jig works automatically, ceasing to run when it is supplied with insufficient coal for its operation. This regulation is accomplished by a pan in the feed chute. When the bed of the jig is properly filled, the coal backs up in this chute until the pan is weighted down, whereupon the jig commences operating. When sufficient coal to weigh down the pan is not present, the pan rises and the jig is shut off. Slush is removed from the jig tub in a manner similar to that already described.

As this jig is widely used throughout the anthracite field, tests made in various places will be of interest. At the Thomas colliery, trials were made on the jigging of a rock that contained a little coal. In the first test, the material going to the jig contained 80 per cent. of rock and 20 per cent. coal. The refuse coming from the jig showed only 0.3 per cent. coal, 0.5 per cent. bone, and 99.2 per cent. slate. In a second test, run on material of the same character and analysis, the same results were obtained in the refuse, the coal containing 10 per cent. slate and 16 per cent. bone. A third test on the same material, made a day later, showed 0.4 per cent. coal and 0.5 per cent. bone in the slate. On the following day, four more tests were run showing an average of 0.3 per cent. coal and 0.3 per cent. bone in the slate. Results secured in two tests on the coal showed that, in the first instance, 14 per cent. slate and 18 per cent. bone were present; in the second test, there was 10 per cent. slate and 12 per cent. bone in the coal. A fifth series of tests was made on the same material the following day, and the same results were obtained for the slate; the coal showed 10 per cent. slate and 10 per cent. bone

In the Enterprise Coal Co. tests on the type *D* simplex jig, using stove size containing 30 per cent. coal and 70 per cent. slate, and chestnut containing 50 per cent. coal and 50 per cent. slate, in the first test, and a mixture of 25 per cent. coal and 75 per cent. slate in the second test, the following results were obtained:

Stove slate contained ½ per cent. coal.
Chestnut slate contained ½ per cent. coal.
Stove coal contained 2 per cent. slate and 1½ per cent. bone.
Chestnut coal contained 3 per cent. slate and 3 per cent. bone.

At a Lehigh Valley Coal Co. colliery in the lower field, tests made on material that contained 50 per cent. coal, 44 per cent. slate, and 6 per cent. bone gave the following results: The coal contained 95¼ per cent. coal, 2¼ per cent. slate, and 2½ per cent. bone; and the refuse contained 3¾ per cent. coal and 96¼ per cent. slate.

Delaware, or Tench, Jig

The Delaware, or Tench, jig, an installation of which has been made by the Hudson Coal Co., is a modification of the Lehigh Valley jig. A lifting plunger takes the place of the coal conveyor and a conveyor line

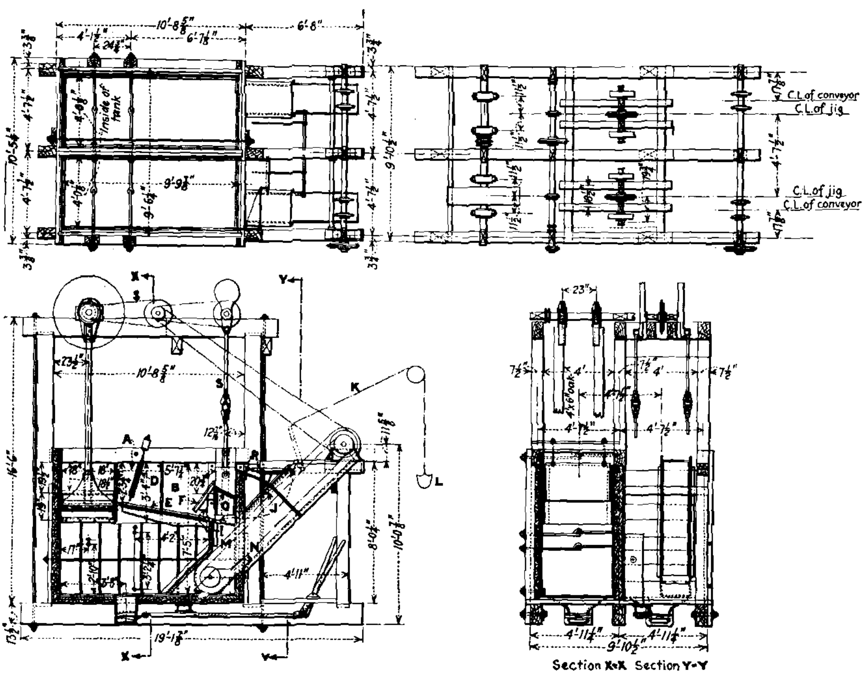


FIG. 33.—TENCH JIG OF HUDSON COAL CO.

somewhat similar to that used for slate removal on the Lehigh Valley jig is used for withdrawing the refuse. Fig. 33 shows various sections of the jig. The piston action and construction are the same as in the Lehigh Valley machine and the tub above the grate is similarly divided into two unequal parts *A* and *B*. The jig is automatic in all respects and there is no need of discharge floats or power-driven slate-discharge devices. The coal and slate are fed into the compartment *A* by a chute and pass underneath the feed-regulating gate *D* on to grate *E*, where they form a bed composed of coal and its impurities. The action of the piston effects a separation in the same manner as in any other piston type of jig.

As the bed of coal and slate forms upon the jig grate *E*, the slate comes into contact with the perforated guard *F*, which extends across the front of the jig and reaches to within 4 in. (10 cm.) of the jig grate *E*. Part of the slate passing under this guard *F* comes into contact with the slate gate *I* and exerts pressure against it. This gate is attached, by rods *J*, to a rope *K* passing over a pulley, from the end of which is sus-

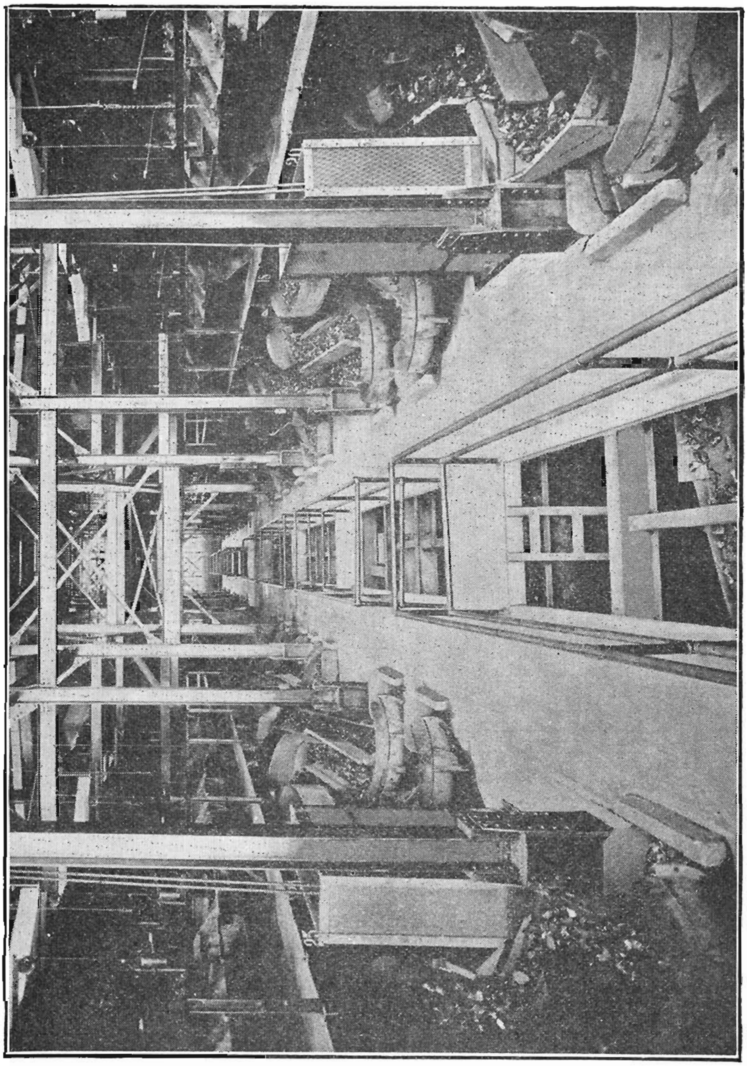


FIG. 34.—INTERIOR OF MARVINE BREAKER SHOWING JIG FLOOR.

pended a small bucket *L*; weights placed in this bucket control the amount of slate discharged from the jig. The weight to be used must be determined by experiment for the different sizes and grades of slate being jigged. When the pressure of the slate against the gate becomes greater than the force exerted by the weights in the bucket *L*, the gate opens.

The slate then passes into compartment *M*, from which it is removed by the conveyor line *N*. When the pressure against the gate *I* is decreased so that the force of gravity on the bucket *L* becomes greater than the slate pressure against it, the gate closes and retains the slate until such time as its pressure again exceeds that exerted by the weights in the bucket *L*.

As the coal on the top of the bed is floated off, it slides down over the top of the perforated guard *F* on to the lifting plunger *O*, which raises it to the top of the jig tub and out of the water. It then slides into the chute *R*, which leads to the coal pockets. The coal-lifting plunger *O* is operated by the mechanism *S*, being so regulated that one stroke of this lifting plunger is made for every four strokes of the jig piston.

The coal-lifting plunger and the slate control on the jig gates are the two distinctive details in the construction of this jig, but a feature that has proved highly beneficial in the removal of flat slate has been the increase in the height of the total jigging bed at the discharge end from 16 to 21 in. (40.6 to 53 cm.). Another advantage is the increase of the grate area, which is approximately 25 per cent. greater than the common size of Lehigh Valley jig.

The coal-lifting plunger *O* is made of cast iron, the side plates forming the end guides and the front and rear plates forming the side guides. Removable perforated plates bolted on to the slanting top surface let the water and fine material return to the jig tub; the perforations in these plates must be suited to the size of the coal being jigged. The back, or long, surface of the coal-lifting plunger also is equipped with perforated plates, which insures a free passage of the water between the main jig tub and the plunger compartment and lessens the splash of the water when the plunger makes its return stroke. It also forms a back plate to the plunger and prevents the coal in compartment *B* from falling under the plunger *O* into the tank below. The force of the water passing through its perforations holds back the coal.

When the plunger *O* is in its lowest position, its uppermost point falls slightly below the lower edge of the slanting surface of the inclined perforated guard *F*. The coal on the top of the bed in compartment *B*, because of the action of the jig piston, is thus thrown on to the top slanting surface of the coal-lifting plunger.

The slanting surface of the plunger *O* is inclined toward the front of the jig at an angle of about 30°; this allows the coal to slide off into chute *R* when the plunger is at the highest point of its movement. As soon as the coal on the plunger extends above chute *R* sufficiently to let it seek its angle of repose, it enters this chute so that when the plunger has reached its full stroke, little or no coal remains on its surface.

The advantages of this jig are: (1) Automatic slate discharge, (2) only one small conveyor line, (3) slight repairs, (4) all water remains in the jig, (5) little coal is broken, (6) less space is required for a given capacity, (7) cleaner separation is secured, (8) less water is required than in the overflow type of jig. This jig is now in successful operation on all sizes of coal from broken or grate to No. 1 buckwheat, inclusive. The following is a test on stove coal treated in this jig. Every ten minutes samples were taken of the feed, clean coal, and slate.

MATERIAL ENTERING JIG FROM TWENTY-FOUR SAMPLES, AGGREGATING 259.25 LB.

Size of Material	Size, Per Cent.	Coal, Per Cent.	Bone, Per Cent.	Slate, Per Cent.
Stove	93.3	68.9	2.2	28.9
Nut	6.2	81.3		18.7
Pea	0.2	100.0		
Smaller	0.3			

MATERIAL LEAVING COAL END OF JIG FROM TWENTY-FOUR SAMPLES AGGREGATING 239 LB.

Size of Material	Size, Per Cent.	Coal, Per Cent.	Bone, Per Cent.	Slate, Per Cent.
Stove	90.6	96.5	1.4	2.1
Nut	9.1	100.0		
Pea	0.2	100.0		
Smaller	0.1			

MATERIAL LEAVING THE SLATE END OF JIG FROM TWENTY-FOUR SAMPLES AGGREGATING 264.25 LB.

Size of Material	Size, Per Cent.	Coal, Per Cent.	Bone, Per Cent.	Slate, Per Cent.
Stove	88.6	1.4	0.8	97.8
Nut	9.4	3.0		97.0
Pea	1.4	33.7		66.7
Smaller	0.6			

The pea and smaller sizes coming from the slate end are screened out before they reach the main slate conveyor, and are sent through the breaker again.

BREAKAGE DURING TEST

	Per Cent.
Stove size entering the jig	93.3
Stove size leaving the jig	89.6
Breakage due to the jig	3.7

This breakage includes chestnut, pea, and smaller sizes.

James Jig

The James jig is of the single-compartment, balanced type, using the cup-and-gate method of refuse discharge. The screen is provided with 1/4-in. (6 mm.) circular perforations and carries a bed of 3/8-in. iron punchings.

Fig. 35 is a cross-sectional view. The device consists of a stationary jig chamber, supported in a large wooden tank, on top of which is placed the operating mechanism. From the bell cranks, 1 and 2, the pulsator A is suspended by rods working clear of the sides of the jig chamber. This pulsator has the shape of two inverted pyramids, on

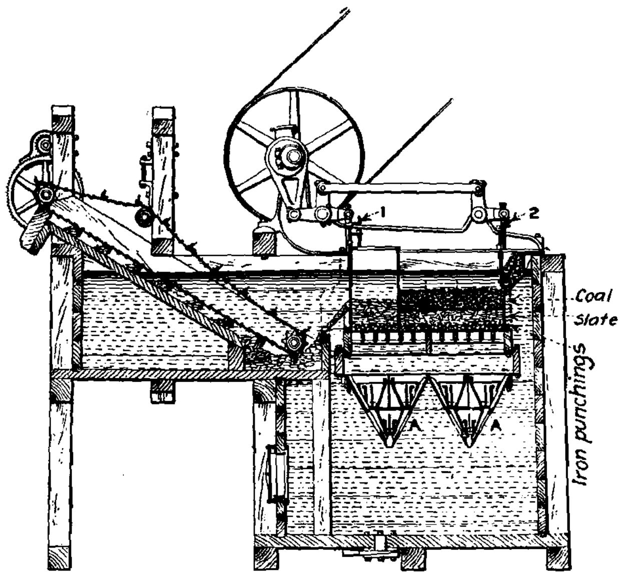


FIG. 35.—SECTION OF JAMES JIG.

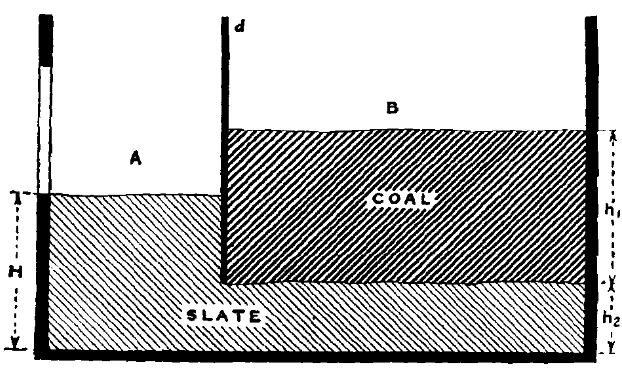


FIG. 36.—DIAGRAM SHOWING METHOD OF REMOVAL OF SLATE FROM JAMES JIG.

each face of which are placed three valves, making twenty-four in all, having an aggregate area equal to that of the screen. These valves are so designed that they open on the downward and close on the upward stroke of the pulsator, thus causing the flow or pulsation of water through the jig to take place in one direction; this reduces suction to a minimum.

Coal is fed to the jig by a chute leading in on the right, and after separation it overflows through an opening on each side of the chamber, as shown by dotted lines. It is discharged by drag lines, not shown. The slate discharges on the left side of the jig chamber and feeds the drag line illustrated.

Fig. 36 shows that the jig chamber is divided by the baffle *d* into two parts *A* and *B*; this baffle clears the top of the screen by a distance equal to the thickness of the bed desired. Water pulsates through the bottom screen in both compartments *A* and *B*. The coal and slate are fed into the right end of the chamber *B*. When compartment *B* has a certain height, or head, of slate h_2 and coal h_1, the water level being the same in both compartments (*A* and *B*), the sum of the weights of these heads must be equal to the weight head of the slate in compartment *A* at any given instant. If a means of discharging the coal in compartment *B* and the slate in compartment *A* is provided, each upward pulsation of water will cause coal to overflow in *B* and slate in *A*, when and so long as $W_2H = w_1h_1 + w_2h_2$, where w_1 and w_2 are the specific gravities of coal and slate, respectively.

The height of the two discharge gates, of course, takes into consideration the average specific gravity of the materials to be separated. A numerical example will show this action. Assume the specific gravity of the slate to be 3 and of the coal 1.5, and that the bottom of the baffle *d* is set 3 in. (7.6 cm.) above the screen, the coal discharge gate being set 15 in. (38 cm.) from the screen.

The head due to the slate is 3 in. $\times$ 3 $=$ 9 units.

The head due to the coal is (15$-$3) in. $\times$ 1.5 $=$ 18 units.

Total head $=$ 18 $+$ 9 $=$ 27 units.

This figure divided by 3, the specific gravity of slate, gives the height of the slate discharge *H* above the screen, or 27 $\div$ 3 $=$ 9 in.

The height of the coal overflow is fixed, whereas that of the slate can be varied to suit the material treated. Setting the slate overflow, or gate, too low will cause a rich refuse, and placing it too high will cause slate to come over with the coal

In Fig. 35 the division plate *d* is shown at the left of the jig chamber. The crank handle to the left controls the height of the slate overflow, and the rate of feed to the jig is regulated by the handle to the right, operating a gate on the feed chute. The coal overflow is on both sides of the chamber; it is represented by dotted lines.

The following advantages result from this type of construction: (1) Low water consumption; (2) automatic operation, for no "tapping" is necessary; (3) operation and efficiency independent of the refuse content of the coal, up to the maximum rate at which the jig will discharge refuse; (4) practical elimination of suction; (5) equally efficient operation with anthracite from ½ in. (12.7 mm.) to 1/16 in. (1.6 mm.); (6)

consistent results in anthracite operation; the ash content of the coal overflow has not varied more than 1 to 2 per cent. during 10 months of operation.

Tests on the James jig at the plant of the Locust Mountain Coal Co. gave the following results:

13.3 Tons of Feed per Hour

Feed	Coal, Per Cent.	Slate, Per Cent.	Ash, Per Cent.
Feed	78.5	21.5	20.13
Slate as discharged	8.0	92.0	
Coal as discharged	90.5	9.5	13.0

14 Tons of Feed per Hour

Feed	Coal, Per Cent.	Slate, Per Cent.	Ash, Per Cent.
Feed	80.5	19.5	20.35
Slate as discharged	7.5	92.5	
Coal as discharged	91.5	9.0	13.50

19.3 Tons of Feed per Hour

Feed	Coal, Per Cent.	Slate, Per Cent.	Ash, Per Cent.
Feed	72.5	27.5	24.00
Slate as discharged	4.0	96.0	
Coal as discharged	83.0	17.0	17.13

Chance Sand-flotation Process

Any two lump substances of different specific gravities may be effectively separated by introduction into a liquid, the specific gravity of which lies between their specific gravities. All the particles heavier than the liquid will sink while those lighter will float. H. M. Chance procures any desired specific gravity of the separating liquid by the addition of fine sand to water; this sand is kept in suspension by agitation. For the separation of coal from slate and bone, ocean-beach sand has been used in sizes ranging from 20 to 30-mesh down to 100 to 200 mesh and even finer. Specific gravities of from 1.20 to 1.75 may be maintained for any period.

The inverted-cone type of washer has been used in the most recent of these experiments, the washed coal and refuse both being removed from the apparatus without the use of complex devices or conveyors. A slow-moving rotary stirrer within the cone will keep the sand agitated and prevent its forming into banks on the walls. This fine granular material virtually forms a stratum of quicksand in the lower half of the cone which the stirrer maintains at a uniform density. As the flow of water is reduced to a minimum, a high fluid density is maintained. The cleaned coal is usually discharged through an overflow weir along with the water, but in some cases it is removed with a conveyor or a raking wheel. The coal is discharged on to a stationary screen, where the sand particles that adhere are rinsed off and the coal recovered. In treating the finer sizes, a shaker screen will probably be more efficient.

In washing anthracite, it has been found possible to produce washed coal carrying no free slate and only such a proportion of bone coal as is desirable in the finished product; also, to produce refuse with no free coal of the average ash content of the washed coal. Occasionally, pieces of what appear to be pure coal are found in the refuse but these are invariably found to be exceedingly heavy.

If the average specific gravity of the coal to be washed is 1.5 and the average density of the ash is such as to produce an increase in density of 0.01 per cent. for each per cent. of ash content, a specific gravity of the fluid of 1.6 will produce washed coal, no piece of which can contain more than 10 per cent. of ash. The coal that floats is a high-grade product. The material that sinks can be passed to a second washer, in which the fluid mass is maintained at a specific gravity slightly higher than the first and graded into middlings and tailings. The middlings will contain most of the bone, which can be crushed so as to separate the coal and the rock; it then can be returned to the first washer for cleaning. Pyrite can be separated from the tailings by a third washer and sold as a byproduct.

Retreatment of the tailings from the first washer will be of greater economic value in the case of an efficient cleaning process than with the usual processes. One fact that militates against the production of high-grade washed coal by ordinary methods is the presence of laminated slate and bony coal. In the center of the jig, such material will often have a falling velocity practically equal to that of the large pieces of clean coal and will, therefore, be discharged with the washed product. With the Chance process, no difficulty has been found in maintaining such a fluid density that no individual piece of coal is discharged that contains more than 3 per cent. of pyritic sulfur.

The first commercial installation will be located in the Pennsylvania anthracite district. Equipment is now being designed for the plant, which will be used for the cleaning of practically unsized coal. It has been found entirely possible to concentrate anthracite averaging 20-mesh, and experimental work has been done on coal of smaller dimensions. It is possible to treat an unsized product carrying a large percentage of fine coal, because the fines are discharged with the supernatant wash water at the top of the fluid mass. When extremely small sizes of coal are treated, it is not practicable to screen out all of the fine sand that is removed from the apparatus with the washed coal; consequently hydraulic classification will be used for separating the very fine coal from the sand that is withdrawn with it.

Highly satisfactory results have been obtained in treating No. 1 buckwheat, rice, and barley coals. It has been possible to reduce the impurity so that practically only the inherent ash remains. As a commercial proposition, however, this would result in too great a rejection of bony coal and hence in too low a recovery. As a result, the following percentages have usually been found to represent the best practice.

	Feed, Per Cent.	Washed Coal, Per Cent.	Reject, Per Cent
Ash	38.00	11.22	83.58
Total weight	100.00	63.00	37.00

Little sand is lost in the operation. When rice coal has traveled less than 1 ft. (305 mm.) over a ⅛-in. (3.6 mm.) mesh screen, the washed coal contains less than 0.6 per cent. of residual sand. A further travel of 1 ft., with the addition of fresh water, reduces this final sand content to approximately 0.1 per cent. or 2 lb. per ton of coal. The sand is washed from the coal by the agitation water after it is discharged over the weir at the top of the cone. It is possible to use this water several times, by employing a screen built in a number of steps, the sand washed out in one portion being given an opportunity to settle before the water is used in the next.

Concentrating Tables

After investigating five methods of cleaning anthracite slush, either on a commercial scale or in the laboratory, the Hudson Coal Co. has obtained the best results with the Deister-Overstrom, diagonal-deck No. 7 coal-washing table. The concentrating table, Fig. 37, has found wide application for years in the metal-mining industry and later for washing bituminous coal. It has only recently invaded the anthracite field, but about 150 of these tables are already in operation or are being constructed for use in cleaning various sizes of anthracite from No. 1 buckwheat down to slush.

The Hudson Coal Co. has made a long series of experiments on anthracite slush at the Loree breaker, Fig. 38, in conjunction with the Dorr slush-recovery plant. The results were highly satisfactory as to ash and sulfur reduction by the washing process, but a table will effectively clean only 3 to 4 tons of slush per hour; though of the larger sizes, up to No. 1 buckwheat, as much as 10 to 12 tons per hour can be handled. With slush, the fineness of the particles precludes the treatment of more than 4 tons, which means that a comparatively large installation (eight tables) is required to treat the slush from the company's largest collieries.

The various operations are as follows: Raw coal, mixed with about twice its weight of water, is delivered to the table through the feed box at the upper corner at the head-motion end of the deck. Water-distributing boards placed along the same side of the deck as the feed box allow a nice adjustment in the distribution of water over the deck surface. The table is placed in a horizontal position and is practically level longitudinally, or along the line of its reciprocation. A slight side inclination at right angles to this line, adjustable to meet changing conditions, permits the clean coal to be washed over the long edge of the table into a trough or launder. Simultaneously the action of the head motion in reciprocating the deck approximately 275 times per minute with a length

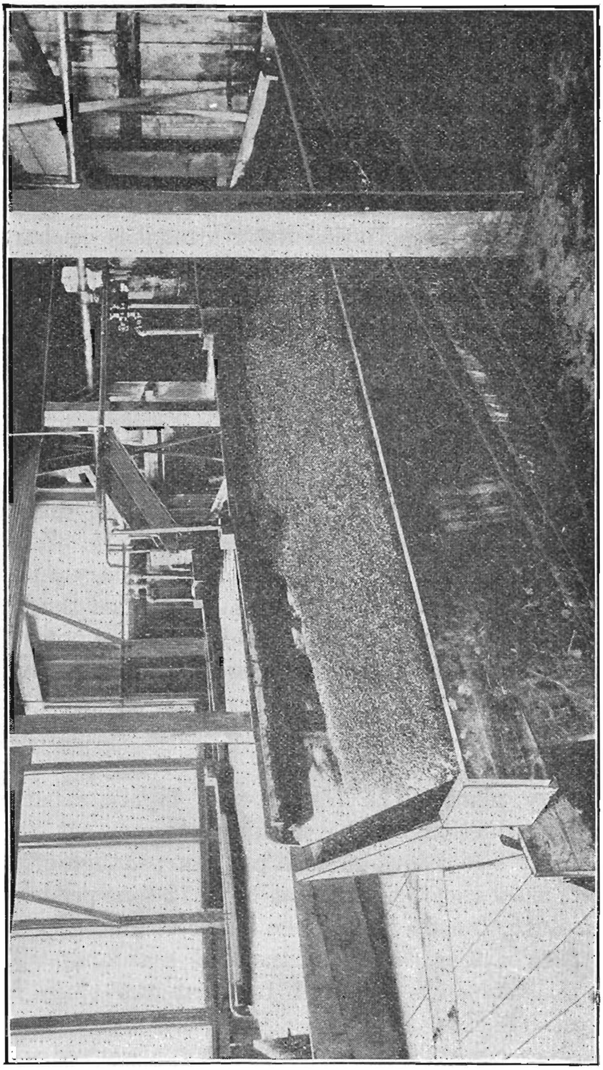


FIG. 37.—TWO DEISTER TABLES FOR PREPARATION OF RICE COAL IN A BREAKER OF PHILADELPHIA & READING COAL AND IRON CO.

of stroke of about ¾ in. (19 mm.), drives the pyrite and refuse, which stratifies next to the surface of the table deck, over the short edge, or refuse end, of the table, where it is caught in launders and conveyed to the refuse heap. The wooden riffles on the surface of the table deck aid in collecting and guiding the refuse to its proper point of discharge

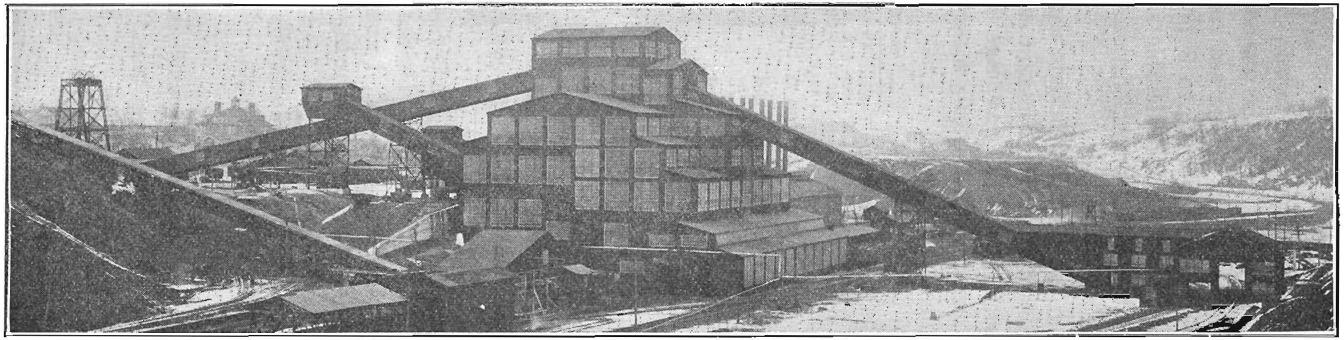


Fig. 38.—Loree breaker of Hudson Coal Co. In small building at end of conveyor line in left foreground Dorr separator is housed.

and also prevent the finer particles of waste matter from washing over with the clean coal.

Using this table on anthracite slush, the Hudson Coal Co. has obtained an average ash content of 13 per cent. in the washed product when the crude coal averaged 28 per cent. ash. This ash content in the washed coal can be reduced still further, to from 7 to 8 per cent. if required, by extreme care in tabling and at a considerable sacrifice of capacity. Typical average results obtained in the operation of this table are as follows:

The material treated on table was anthracite slush [through 3/64-in. (1.2 mm.) round opening] recovered from breaker slush by Dorr hydroseparator and classifiers, with the following average size as determined by test: On 60-mesh, 88 per cent.; on 100-mesh, 8 per cent.; on 200-mesh, 3 per cent.; through 200-mesh, 1 per cent.

				Distribution and Yields			
	Short Tons Per Hour	Ash, Per Cent.	Sulfur, Per Cent.	Total Solids, Per Cent.	Combustible, Per Cent.	Ash, Per Cent.	Sulfur, Per Cent.
Feed	3.41	28.0	1.71	100.0	100.0	100.0	100.0
Washed coal	2.43	13.0	0.79	71.3	86.1	33.2	32.8
Slate, etc	0.93	65.0	1.91	27.2	13.2	63.2	33.2
Pyrites	0.05	70.0	42.00	1.5	0.7	3.6	36.8

Reduction of ash, 53.51 per cent.; reduction of sulfur, 53.8 per cent.

The best data at hand indicate that 4c. per ton will cover labor and power expense of tabling and that probably the total cost per ton, including fixed charges, depreciation, repairs, etc., will not exceed 10c. per ton in a fair-sized installation, which is one of about eight tables. In this calculation, power is charged at 1.5c. per kw.-hr. and labor at 50c. per hour.

At one of the breakers belonging to the Madeira-Hill & Co. interests, a mixture of rice and barley was washed on Deister-Overstrom concentrating tables for 10 days, the float-and-sink being used to determine the quantity of slate in the washed coal. During the period that the tests were made on the concentrators, 3,600 tons of rice and barley coal were shipped. Samples were taken at intervals of 20 min. and then mixed and quartered to form the final sample. The results were as follows:

Coal Discharged from Concentrator

	Coal, Per Cent.	Slate, Per Cent.
Rice over 3/16-in. mesh	87.5	12.5
Barley over 3/32-in. mesh	87.0	13.0
Barley over 1/16-in. mesh	87.5	12.5

Slate Discharged from Concentrator

Proportion of slate	90.75
Proportion of coal	9.25

The material fed to the concentrator contained 30 to 35 per cent. ash. The following is an analysis of the product from the concentrator:

Coal Discharged from Concentrator

	Rice Over 3⁄16-in.	Barley Over 3⁄32-in.	Barley Over 1⁄16-in.
Fixed carbon, per cent	75.93	79.85	80.11
Ash, per cent	19.48	15.20	14.62
Heat value (dry basis), B.t.u	12,172	12,573	12,663

Slate Discharged form Concentrator

Fixed carbon, per cent	22.69
Ash, per cent	70.20
Heat value (dry basis) B. t. u	3,636

Water Used for Wet Preparation

An abundance of water must be supplied for the wet preparation of coal. Where coal is prepared, in general, by dry methods, water is used for the preparation of the finer sizes. The average quantity of water used in the Wyoming Valley per ton of daily output, in preparation by wet methods, is 1,035 gal. (3.9 li.) per min. Thus, if a breaker has an output of 1,000 tons per day it will require 1.035 gal. of water per minute. A combination wet-and-dry method requires 0.634 gal. (2.4 li.) per min. per ton of daily output. The dry method requires only 0.626 gal. per minute.

In the Lehigh region, the wet method of preparation requires 1.428 gal. per min. of water per ton of daily output, and the combination wet-and-dry method of preparation requires 0.692 gal. per min. per ton of output per day. In the lower field, the wet method requires 1.542 gal. per ton of daily output and the wet-and-dry combination method requires 1.23 gal. per ton of output per day. The amount of water required depends on mining conditions. The steep-pitching measures produce a coal that demands more water in its cleaning than does the flat-measure coal produced in the Wyoming Valley field.

Not only is much water necessary, but its quality is important. Ordinary mine water is much too high in sulfur to be employed, as it will corrode the lining of the chutes excessively. Consequently, the coal companies endeavor to obtain either pure water or such as is contaminated with as little sulfuric acid as possible. One company treats its water with quicklime to counteract the sulfur, thus reducing the acidity and prolonging the life of its chutes; it requires about 2 to 4 lb. of lime to counteract the sulfur in 1,000 gal. of water, under average conditions.

Force Employed at Preparation Plants

The following figures show the number of tons prepared per man employed in preparation and the relationship between the number of employees in the preparation plants and those engaged in other portions of the operations:

Wyoming Valley Field

	Preparation Method Employed		
	Dry	Wet-and-dry	Wet
Number of collieries reporting	14	22	30
Tons of coal produced	5,674,010	10,845,542	17,120,602
Tons of coal prepared per man employed on preparation	7,020	6,420	7,120
Percentage relation of preparation men to outside employees	38.7	34.4	34.3
Percentage relation of outside employees to total employees	20.8	24.1	22.2
Percentage relation of outside employees to inside employees	24.8	31.6	28.6

Lehigh Field

Number of collieries reporting	5	4
Tons of coal produced	2,241,783	1,597,216
Tons of coal prepared per man employed in preparation	4,930	6,000
Percentage relation of preparation men to outside employees	27.9	25.6
Percentage relation of outside employees to total employees	38.6	36.4
Percentage relation of outside employees to inside employees	68.0	57.2

Southern Field

Number of collieries reporting	7	64
Tons of coal produced	2,655,615	20,352,232
Tons of coal prepared per man employed in preparation	5,290	5,730
Percentage relation of preparation men to outside employees	33.5	26.0
Percentage relation of outside employees to total employees	31.2	34.0
Percentage relation of outside employees to inside employees	44.7	50.9

These figures show that more coal is produced per man in wet methods of preparation than in the combination wet-and-dry; this is to be expected for the wet-and-dry method practically means two breakers in one, and a greater force of men will necessarily be required in such a case. The figures also show that in the Wyoming field almost as much coal is produced by the dry method as by the wet method. If the figures here presented are taken without analysis, it will appear that no great saving in men per ton prepared is attained by the use of wet-preparation methods. It should be stated, however, that in the few collieries where dry methods are being used, a large proportion of the coal is coming from virgin territory and consequently has but little rock mixed with it, so that the force of men required to eliminate the rock is correspondingly reduced. The tonnage produced per man in the upper field is greater than in the Lehigh or lower regions; this is because of the mining conditions prevailing in the lower fields, reference to which has already been made.

Leading Anthracite Breakers

The preparator, commonly known as the breaker, will be discussed, to show how the features mentioned are assembled to obtain the best results. The breakers described show the practice in practically the entire anthracite field. Two of these breakers are in the Scranton region, one is in the Wilkes-Barre, one in Nanticoke, one in Hazelton, one near Mahanoy City, one near Lykens, and one in the Panther Creek Valley.

Marvine Breaker, Hudson Coal Co.

In 1920, construction was started on a 5000-ton steel breaker at the Marvine colliery, of the Hudson Coal Co., in order to concentrate in one breaker the preparation of material that was being handled in two old structures wherein the dry method of preparation was in use. Besides, the old Marvine breaker was unable to handle the tonnage that the mines could produce.

The Manville breaker, one of the two eliminated by this concentration, is situated about 1 mi. from the Marvine. The coal is now dumped in this old plant and run through a pair of rolls, which crushes it to steamboat size, then by chutes it is delivered into railroad cars that convey the coal to the new Marvine breaker, where it is dumped into a conveyor line.

The Marvine has two hoisting shafts 2000 ft. (609.6 m.) apart, but one of these was used only to hoist the coal from the lower to an intermediate level, where it was sent to the main shaft up which it was hoisted into the breaker. As the new breaker can handle the output from both shafts, the output is practically doubled.

One interesting feature of this new breaker is that the coal from one of the shafts is carried to the breaker over the main line of the Delaware & Hudson R. R. and across the Lackawanna river; two belt-conveyor lines, approximately 1100 ft. (335 m.) in length, Fig. 39, transport it in this latter portion of the journey.

The new Marvine breaker is constructed of steel and prepares the coal by the wet method. The building is as nearly fireproof as it can be made. The only wooden construction is the jigs, the inside lining of the loading pockets, the treads of the stairs, the shaker sides, hangers, and arms, the

FIG. 39.—VIEW OF LONG CONVEYOR LINES THAT TRANSPORT COAL FROM HEAD HOUSES TO MARVINE BREAKER; THESE CONVEYOR LINES ARE 1100 FT. LONG.

slate-conveyor trough, and the troughs on the three main conveyor lines. The breaker is electrically operated throughout and controlled from a central switchboard. It is equipped with 44 Delaware, or Tench, piston-type jigs, and a complete plant for the treatment of the silt is installed nearby. The latter consists of Dorr thickeners and classifiers and Deister-Overstrom concentrating tables.

The coal is crushed on the ground level before it is taken into the breaker, so that the only crushing done is that of the grate, or broken, coal when no market can be found for this size. Crushing the coal on

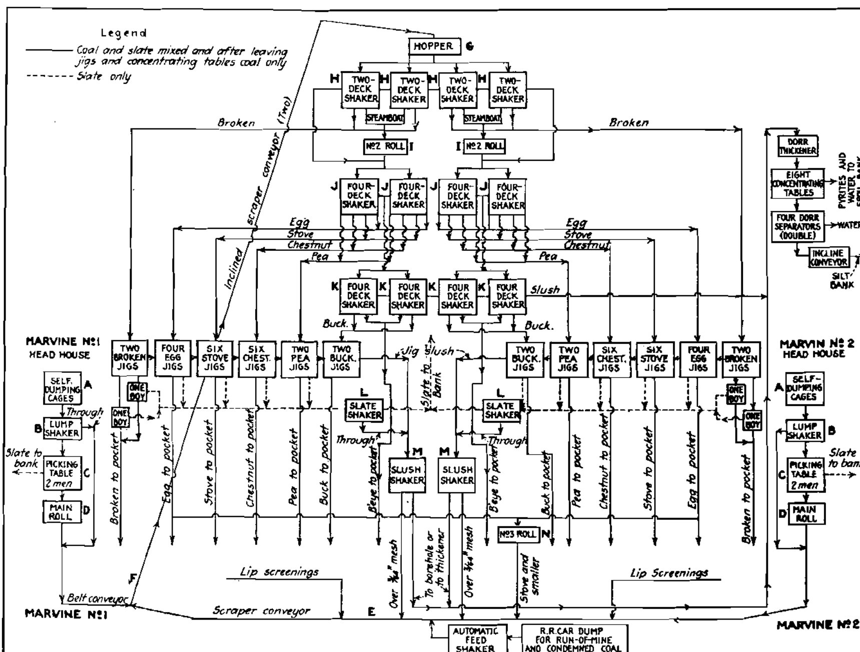


FIG. 40.—FLOW SHEET OF MARVINE BREAKER.

the ground level has the advantage of eliminating the heavy crushers and bull shakers at the top of the building, which cause severe stress on the structure, and permits a considerable reduction in the height of the structure. Another interesting detail is the complete elimination of coal-carrying elevators. Water is supplied to this breaker from the Lackawanna River by electrically driven pumps.

This breaker is constructed in two distinct units; that is, it is so built that either half of the breaker is a complete operating unit and can be shut down without interference with the running of the coal through the other half.

The following is a description of the flow of coal through the breaker and the method of preparation followed, Fig. 40.

The two head houses *A*, situated at the top of the two hoisting shafts, are identical in construction. Coal is hoisted from each shaft, which contains two hoisting compartments in which self-dumping cages operate. The coal is dumped into a chute, which delivers it to the lump shaker *B*. The lump-size coal passes from this shaker on to a gravity picking table *C*, where two men remove the rock, which is sent to the slate bank. The coal passes through the main rolls *D*, which crush it to steamboat size and smaller. The material passing through the lump shaker *B* is conveyed by chutes to a point under the rolls *D*, where it mixes with the material from the rolls.

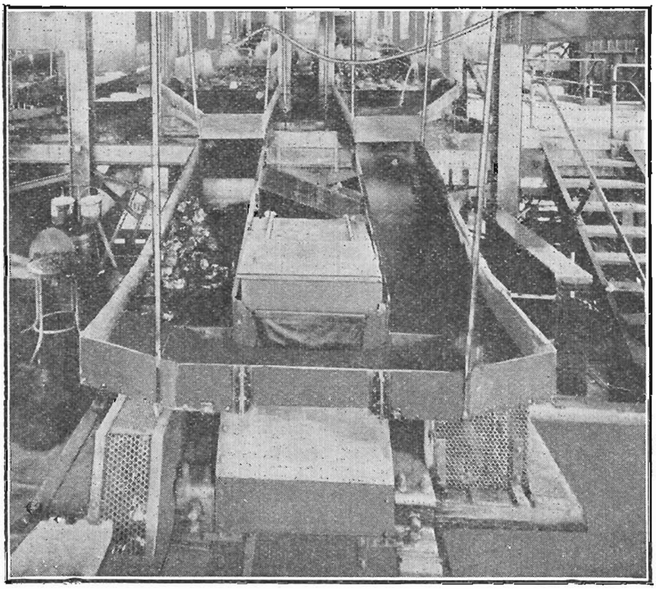


FIG. 41.—GRATE AND EGG SHAKERS IN MARVINE BREAKER.

From head house No. 1, the coal is transported by means of the two belt-conveyor lines for a distance of approximately 1100 ft. to the inclined scraper-conveyor lines *F*. The coal from head house No. 2 is moved by a scraper conveyor *E*, which travels directly underneath the center of the breaker. Into this is delivered, as it passes under the building, all material such as products of the rolls breaking egg coal, material from the slate shaker, that from the slush shaker, and from the lip screens. This conveyor also receives the material dumped from railroad cars, either run-of-mine, previously crushed to steamboat size, and condemned coal, both of which are fed to this conveyor by an automatic feed. This conveyor line delivers its material to the inclined scraper conveyors *F*, each of which is designed to handle the entire tonnage of this breaker. These conveyors deliver the material to a hopper *G* at the top of the building, thence the material passes to four double-deck shakers *H*, Fig. 41. The steamboat material passes from the deck of these shakers into the No. 2 rolls *I*, where it is crushed to egg and smaller. The material passing from the second deck of the shakers *H*, which is the broken, or grate, size, is sent either to the No. 2 rolls *I*, where it is crushed to egg and smaller, or, when a market exists for this size, it goes to two jigs on each side of the breaker from which the coal product, after passing a picker boy, goes to the loading pocket, and the slate product, after passing a picker boy, goes to the slate bank. Experience has shown that it is necessary to employ one boy on the slate and one on the coal discharged from each of the jigs in order properly to prepare this coal for the market and maintain the slate free from coal.

Material passing through the shakers *H*, being egg coal and smaller sizes, is mixed by chutes with the product of the No. 2 rolls *I*. This material then passes on to four sets of four-deck shakers *J*, which size the coal into egg, stove, nut, and pea. The egg coal, which comes from the top deck, goes to four jigs on each side of the breaker. Washed coal from these jigs goes directly to the loading pocket and the slate to the slate bank, both without any hand picking. In case egg coal is not in demand, this size after leaving the jigs may be passed to the egg-coal rolls *N* which break it down to stove and smaller sizes; the material from these rolls passes into the main intake conveyor underneath the breaker.

Stove coal, coming from the second deck of these shakers, goes to six jigs on each side of the breaker. The washed coal from each jig passes to the loading pocket and the slate to the slate bank, both without picking. Chestnut coal, from the third deck, goes to six jigs on each side of the breaker; as in the case of the other sizes, the washed coal goes to the loading pocket and the slate to the slate bank. Pea coal, from the fourth deck, goes to two jigs on each side of the breaker and, as before, the coal product of these machines goes directly to the loading pocket and the slate is sent to the slate bank.

Material passing through these shakers *J*, consisting of No. 1 buckwheat and smaller sizes, goes to the 4 four-deck shakers *K*, which make No. 1, No. 2, No. 3, and No. 4 buckwheat, the last three sizes being mixed and shipped as bird's-eye. No. 1 buckwheat comes from the upper deck and passes to two jigs on each side of the breaker; the washed coal from these machines goes to the loading pocket and the slate to the slate bank. No. 2 buckwheat, from off the second deck, No. 3 buckwheat, from the third deck, and No. 4 buckwheat, from the fourth deck, mix at the end of the shakers and the resulting bird's-eye is conducted, by chutes, to the loading pocket. The slush, or material which passes through all decks, is conducted to a separate building for further treatment.

All slate from the jigs pass over slate shakers *L* to reclaim the fine breakage. The material going over these shakers passes to the slate bank; that passing through them joins with the slushings from the jigs. This mixture then passes over the slush shakers *M*. The material passing over a 3⁄64-in. (1.2 mm.) mesh goes into the main conveyor line *E* underneath the breaker. The material going through these slush shakers passes to the plant for the treatment of the slush.

Lip screenings from all the loading pockets, Fig. 42, go to the main conveyor line *L* under the breaker. The slush-treatment plant, which

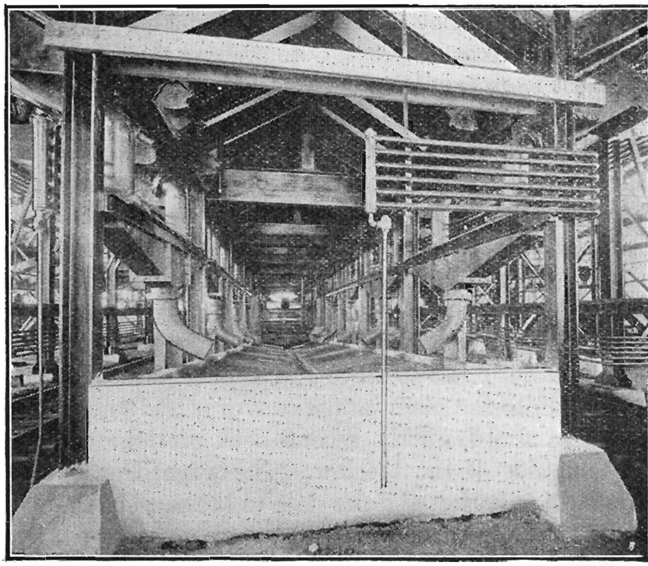


FIG. 42.—BOTTOM OF LOADING POCKETS OF MARVINE BREAKER.

receives all the slush from the breaker, consists of a Dorr thickener, in which the slush is settled out of the water; that which overflows contains only the smallest particles of the suspended solids. The thickened material from these machines is fed to eight concentrating tables and the coal from these passes to four Dorr separators where a large percentage of the water is removed. The coal is then conveyed to a stock pile or a loading pocket for shipment.

Pyrite from the concentrating tables may be recovered or discarded as desired. The water from the Dorr thickener and separator passes out of the plant.

No. 1 Breaker, Pennsylvania Coal Co.

At No. 1 colliery of the Pennsylvania Coal Co. at Dunmore, just outside of the city of Scranton, a new breaker is being constructed. This also is a steel and concrete structure; several details, however, vary greatly from those in the Marvine breaker. Fig. 43 is a flow sheet of this breaker. When the coal leaves the conveyor, it will be dumped into a chute leading to the three-deck main shakers 4 in the top of the breaker. The lump coal, which includes the steamboat, will pass to a picking chute 5 and the grate, broken, and egg will go Elmore jigs 6 and 7. The rock from these jigs is to be hand-picked to remove the coal and bone, the

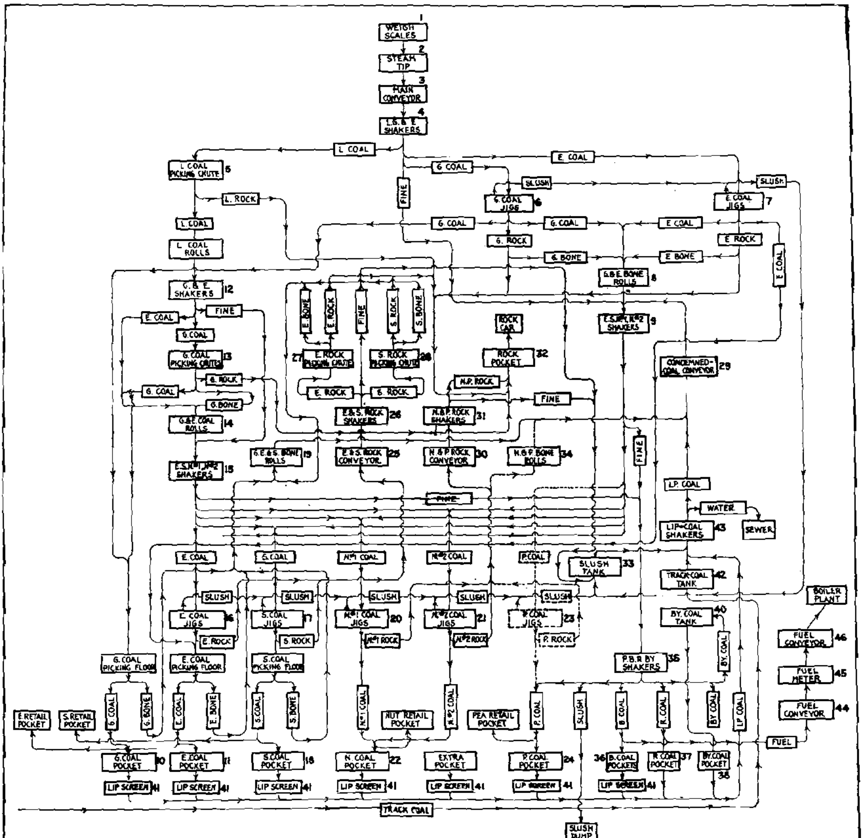


FIG. 43.—FLOW SHEET OF NO. 1 BREAKER OF PENNSYLVANIA COAL CO.

latter being sent to the bone rolls 8, from which the material will pass to a shaker 9, which makes egg, stove, and two sizes of chestnut coal. The coal from the jigs will then pass to the picking floor, where the bone left in the coal will be removed. The cleaned product goes to the pockets 10 and 11.

Cleaned lump coal from the picking chute 5 will go through the rolls, thence to a set of broken or grate-and-egg shakers 12. Grate coal will pass to a picking chute 13 and then unite with the egg coal and pass through rolls 14. Thence it will go to another set of shakers 15 on

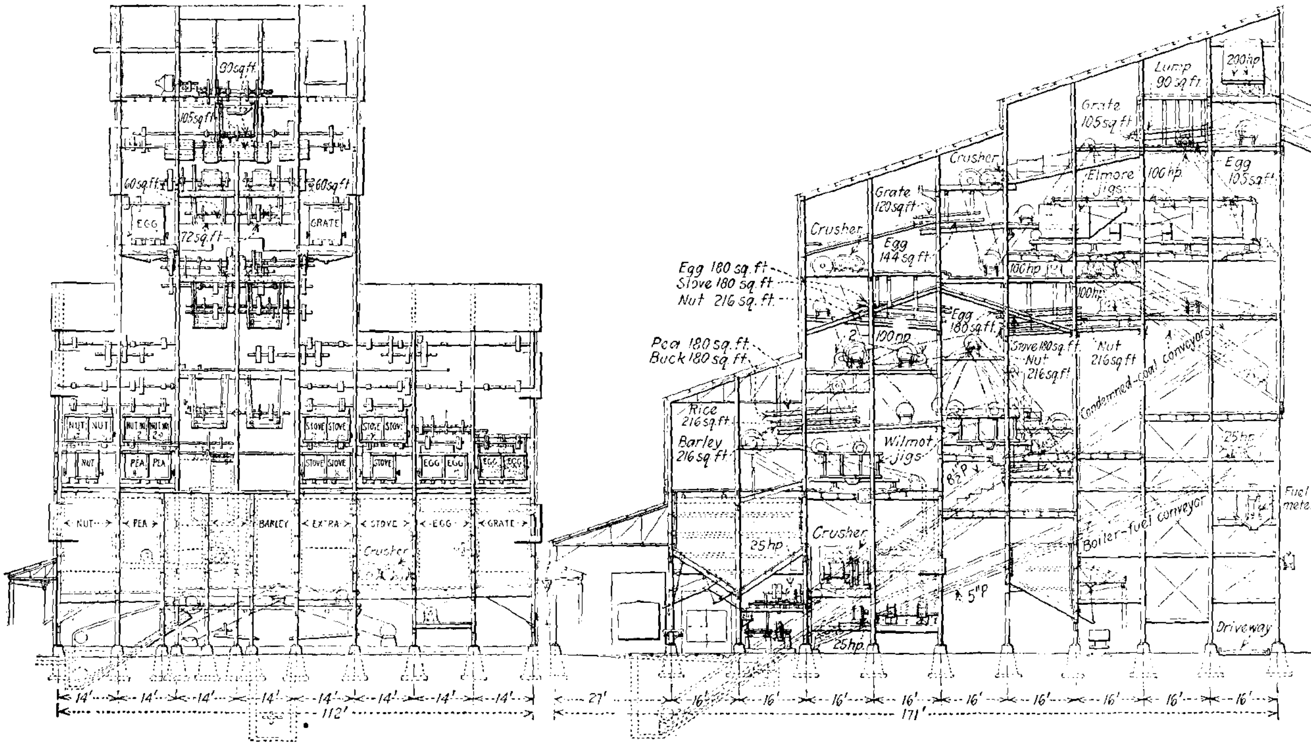


FIG. 44.—FRONT AND SIDE ELEVATIONS OF NEW NO. 1 BREAKER OF PENNSYLVANIA COAL CO. THIS SHOWS AREAS OF SCREENS AND HORSEPOWER NECESSARY TO OPERATE BREAKER.

which egg, stove, and two sizes of chestnut coal are made. The egg, stove, and nut from shakers will go to Wilmot jigs. After cleaning, coal from the egg jigs 16 and the stove jigs 17 is to be hand-picked, the product going to the proper pockets 11 and 18. Bone coal recovered in hand-picking the grate, egg, and stove coals will unite and go through rolls 19, the crushed product of which will be carried by the condemned-coal conveyor 29 to shaker 9.

Cleaned coals from jigs 20 and 21, which will treat the two nut sizes, unite and go to the nut pocket 22. Shaker 9 is so arranged that the bottom deck can be changed to produce pea coal; in that case this size will pass to the pea jigs 23 the cleaned product of which will go to the pocket 24.

Rock from the egg and stove jigs 16 and 17 unites and is to be taken by the egg-and-stove rock conveyor 25 to the egg-and-stove rock shakers 26. Here it is to be separated, after which the bone will be hand-picked (27 and 28) from the rock and sent to the grate-egg-and-stove bone rolls 19, thence to the condemned-coal conveyor 29. The rock from the nut and pea jigs 20, 21, and 23, will unite and go to the nut-and-pea rock conveyor 30, thence to a shaker 31 where the fines are to be removed. The rock will go to the rock pocket 32 and the fine to the slush tank 33. Instead, however, of sending this rock from the nut and pea jigs to the rock conveyor 30 it can be sent to the nut-and-pea rolls 34 from which the resulting product is sent to the condemned-coal conveyor 29.

All the fine coal from shakers 9 and 15 unites and passes to shaker 35; here pea, No. 1 buckwheat, rice, barley, and slush are separated. The sized coals will not be further treated but will pass directly to their respective pockets 37 and 38, the slush going to the slush dump 39. The barley coal can be sent from the shaker 35 to the barley tank 40 instead of to the pocket. From this tank it passes to the pocket 38. All the slush from the Elmore jigs near the top of the breaker and from the Wilmot jigs will pass to the slush tank 33.

In loading railroad cars, an appreciable amount of coal is spilled around the tracks. At many breakers, this is lost. At this breaker a concrete floor has been placed all around the car tracks and suitable drains made so that it will be possible to flush this whole area with water, thus washing the coal into drains that will conduct it to the track-coal tank 42. All the lip-screen coal 41 will be taken to a shaker 43 on which it is to be joined by the track-tank coal. Here the water will be separated from it. The coal is then to be delivered to the condemned-coal conveyor by which it is to be taken back into the breaker for retreatment.

The buckwheat, rice, and barley sizes, instead of going to their respective pockets after being screened on shaker 35, can be sent to a fuel conveyor 44, which will deliver its material to the fuel meter 45, after which it is taken by another conveyor 46 to the boiler plant.

Fig. 44 shows the position of the machinery, also the screen area and the horse power of the motors necessary to drive the various pieces of equipment. This breaker has, what is to all purposes, an individual electric drive. One motor seldom actuates more than one, or at the most two, pieces of machinery at a time. A total of 875 hp. is required to drive all the machinery.

Franklin Breaker, Lehigh Valley Coal Co.

The two breakers just described use the wet type of treatment; the Franklin breaker of the Lehigh Valley Coal Co., located near Wilkes-Barre, Pa., employs both wet and dry methods. Its drive system also is different, a single power unit being used to actuate the machinery.

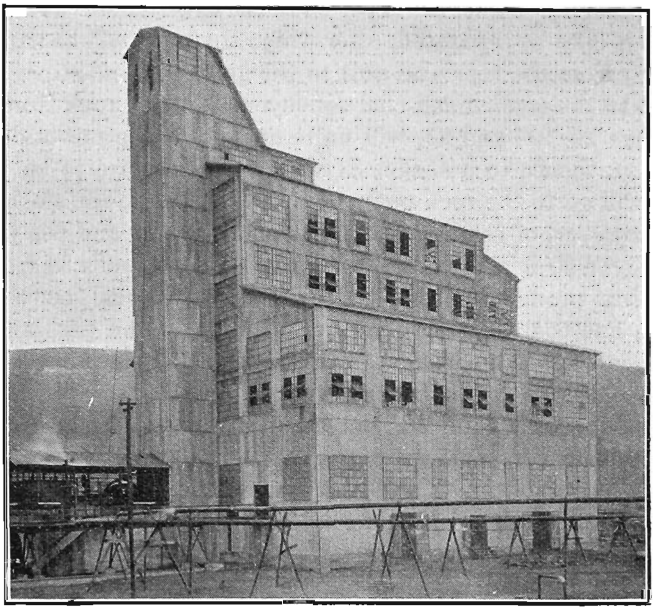


FIG. 45.—EXTERIOR OF FRANKLIN BREAKER OF LEHIGH VALLEY COAL CO. AT WILKES-BARRE, PA.; STEEL FRAME AND CONCRETE FLOORS, TOGETHER WITH SHEET-IRON SIDING, MAKE BREAKER PRACTICALLY FIREPROOF.

Another marked change is that the coal pockets, instead of being placed above the loading tracks, the coal being drawn off by gravity, are placed at right angles to the tracks and level with or below them. A belt conveyor between the two rows of pockets transports the coal to the railroad cars.

With this arrangement the height of the breaker is reduced, less labor is required in loading the cars, the cost of the construction of the breaker is lessened, and its foundations need not be so heavy, for the weight of the pockets and of the coal in them is removed from the breaker foundation.

The general layout of the pockets at a simiarly equipped breaker is shown in Fig. 53. All rock separated in the Franklin breaker is pulverized and returned to the mine for silting purposes.

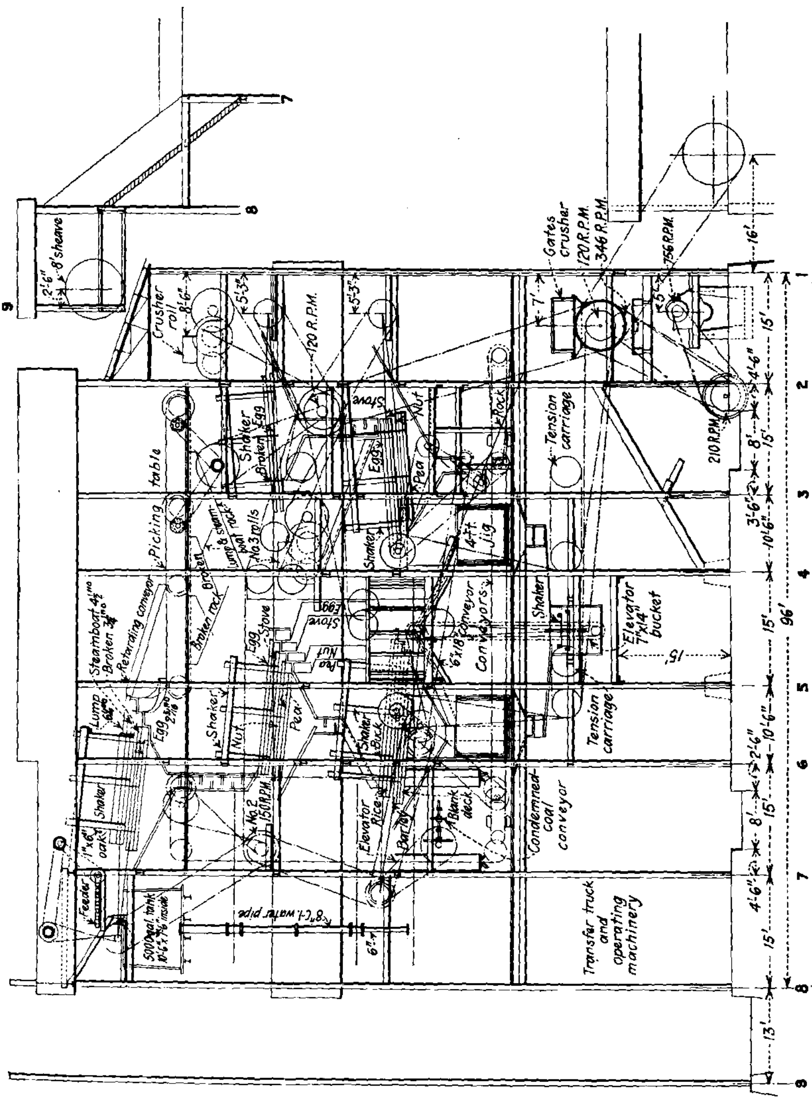


FIG. 46.—ARRANGEMENT OF MACHINERY IN FRANKLIN BREAKER OF LEHIGH VALLEY COAL CO.; LOADING POCKETS ARE SIMILAR TO THOSE SHOWN IN FIG. 53.

The breaker is built of steel and covered with sheet iron; it is well provided with windows, as shown in Fig. 45; Fig. 46 is an elevation and Fig. 47 a flow sheet of the breaker.

The mine cars are hoisted to the top of the breaker and the coal dumped into a hopper, from which it is fed by a reciprocating feeder on to the four-deck shakers. Lump coal, taken off the top deck, is hand-picked to remove the rock. Steamboat coal, taken off the second deck, is likewise hand-picked, the cleaned coal uniting with the cleaned lump. Both sizes then pass through a set of No. 1 rolls on to a set of four-deck shakers. From the top deck, broken, or grate, coal is taken. This size can be sent either to its pocket or to a set of breaking rolls, from which the coal passes to another shaker. From the top deck of this, egg is

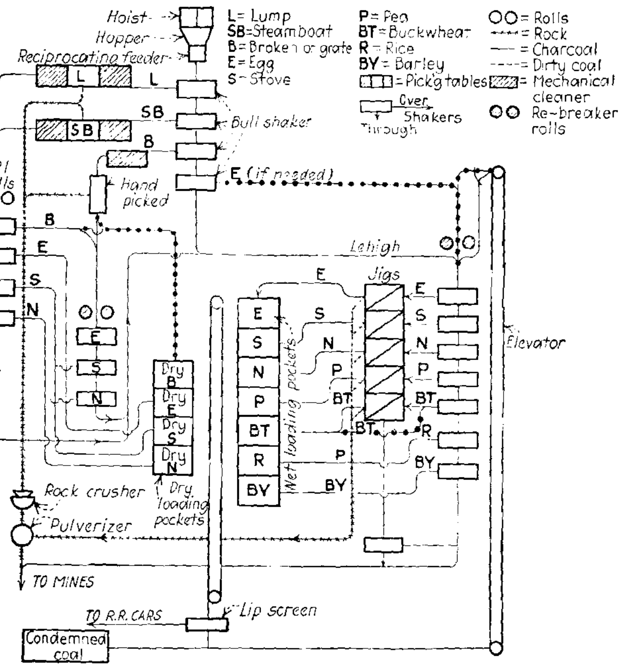


FIG. 47.—FLOW SHEET OF FRANKLIN BREAKER.

taken; this unites with the egg from the second deck of the shaker fed from the No. 1 rolls and passes to the egg pocket. Stove coal, taken from the second deck of the broken-coal shaker, unites with the same size from the third deck of the shaker fed from the No. 1 rolls. Nut of two sizes from the third and fourth decks of the two shakers, respectively, unite in the same way and pass to the appropriate pocket. This constitutes the dry-coal side of the breaker, no water being used up to this point. From the third deck of the bull shaker, broken coal is taken; this goes through a set of mechanical pickers and is also hand-picked to remove the slate. The cleaned broken coal goes either to its pocket or through the re-breaking rolls.

The dirty coal passes through the bottom deck of the bull shaker and is wet. If it is desired to break down the egg coal, another deck is employed on the bull shaker, the egg coal being separated at this point and sent to re-breaking rolls. If on the other hand it is not desired to re-crush this size, this deck is not used and the coal from the bull shaker unites with that from the shaker that is fed from the No. 1 rolls and with that from the shaker that is fed from the broken re-breaking rolls. The coal from these three sources passes to a set of fine-coal screens, on which egg, stove, chestnut, pea, No. 1 buckwheat, rice, and barley are made. This coal is sent to reserve pockets, from which it is fed into the jigs.

Lehigh Valley jigs are used to prepared egg, stove, chestnut, pea, and No. 1 buckwheat. The rice and the barley sizes go to their respective pockets without jigging. Slush or culm is sent to the mines for silting purposes. The rock from the two picking tables at the top of the breaker is sent to a Gates rock crusher, after which it unites with the rock from the jigs and is pulverized so that it may be sent into the mine as flushing material.

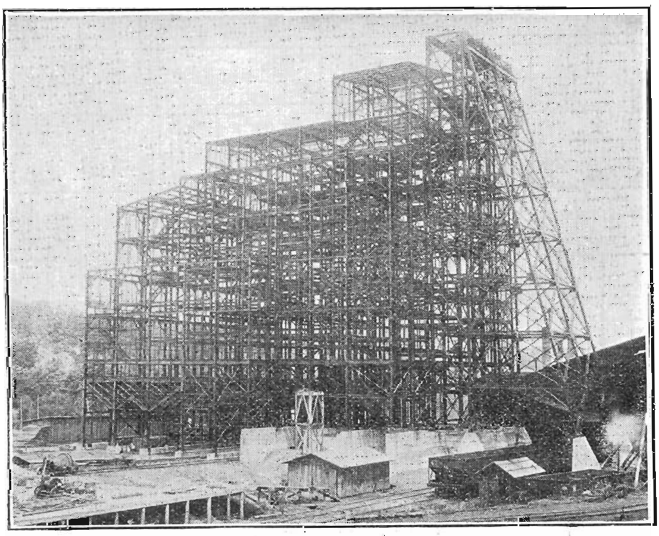


FIG. 48.—WANAMIE BREAKER OF LEHIGH & WILKES-BARRE COAL CO. UNDER CONSTRUCTION.

Wanamie Breaker, Lehigh and Wilkes-Barre Coal Co.

In the Wanamie breaker, Fig. 48, may be found methods not adopted in any of the breakers already described. All sizes above egg are prepared dry; egg and smaller sizes are prepared wet. The first difference noticeable in this breaker is the grizzly used to remove the lump coal from the run-of-mine. The second variation is the use of anthracite spiral pickers for the primary removal of slate from the stove and egg coals. The building is of steel construction and is as near fireproof as possible.

On the flow sheet, Fig. 49, are presented the results of a run of 200 mine cars in 1 hr. and the amount of coal that passed through each process. Slate was not taken into account. As the breaker is double, the

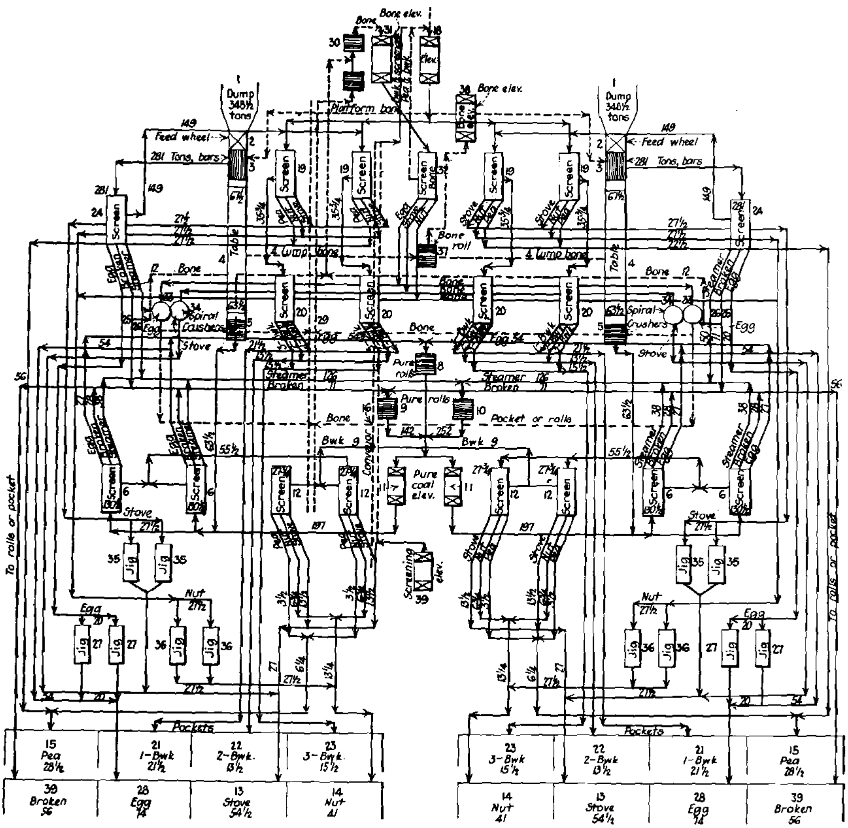


FIG. 49.—FLOW SHEET OF WANAMIE BREAKER; THE TWO HALVES OF THIS BREAKER ARE EXACT DUPLICATES.

method of preparation of the coal is duplicated on the two sides, but the cleaning of the bone is not a double operation. The flow sheet may be easily compared with the elevation of the breaker shown in Fig. 50.

Coal is discharged into chutes from the mine cars, which are hoisted to the top of the building; thence it is fed by a rotary feeder 2 on to grizzlies 3. Sizes smaller than lump pass through the bars, the lump coal passing over on to picking tables 4, where the rock is removed. In the test shown, 67½ tons of material passed over the table and 63½ tons of coal were sent to the rolls, showing that 4 tons of worthless material was removed. This was duplicated, of course, on the other table.

After passing the rolls 5, the crushed coal goes to two sets of shaker screens on each side of the breaker, where the egg, broken, and steamboat sizes are removed. The steamboat and the broken, as well as the egg coal if it is so desired, go through the re-breaking rolls (8, 9, and 10) and then are returned by the elevator 11 to the same set of screens for resizing.

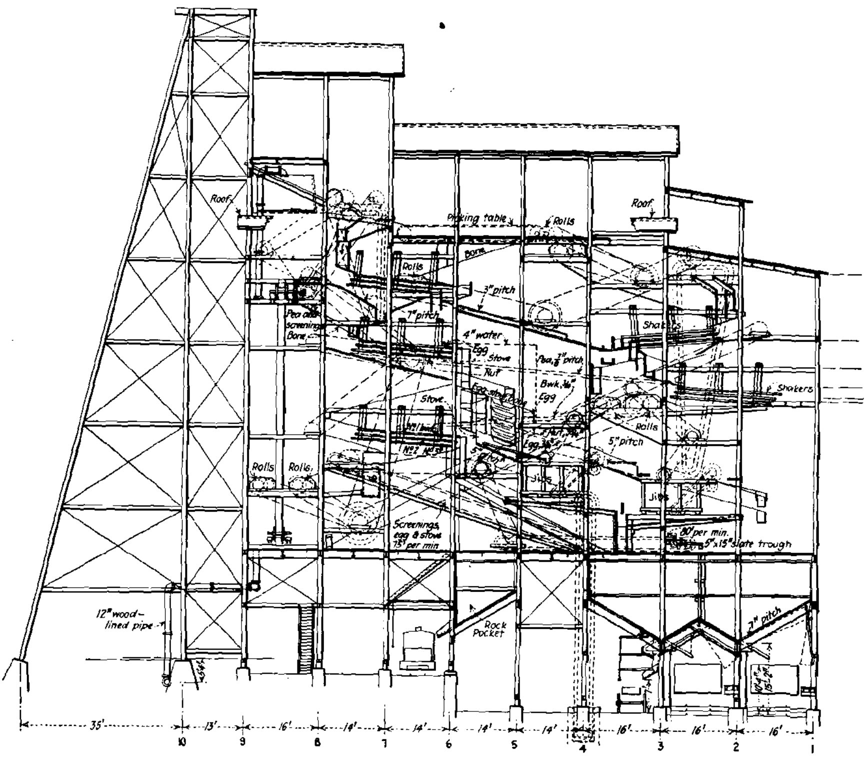


FIG. 50.—ELEVATION OF WANAMIE BREAKER SHOWING ARRANGEMENT OF MACHINERY.

Egg and smaller, if it is not broken down, passes to another set of screens where stove, chestnut and pea are made, these sizes going directly to their respective pockets 13, 14, and 15. The finer sizes, which go through the lower deck of these last shakers, are taken by a conveyor 16 to an elevator 18 and raised to another set of shakers 19, on which any remaining pea, stove, or chestnut sizes are removed. The fine coal goes to another set of shakers 20, on which No. 1 buckwheat, No. 2, or rice, and No. 3, or barley, are made. These sizes then go to their proper pockets, 21, 22, 23, without further treatment.

The fine coal that passed through the bar screens at the head of the breaker goes to sets of shakers 24 where steamboat, broken, and egg coals are separated. The first two of these sizes are hand-picked (25, 26), the cleaned product going to the re-breaking rolls (9 and 10), already mentioned. The process followed in the subsequent treatment of these sizes is the same as has been described. Egg coal, from the set of shakers last mentioned, passes to the egg jigs 27 and the cleaned product goes to the egg pocket 28.

Bony coal separated on the broken and steamboat picking tables 25 and 26, is sent, by conveyor 29, to the bone rolls 30, from which it goes to the bone elevator 31, which delivers it to the bone shaker 32, where egg, stove, and chestnut grades are separated. The egg and stove coals from this shaker pass to anthracite spiral pickers 33, 34, whence the clean egg coal goes to the egg pocket 28 while the bony coal passes to the bony conveyor 29 and is delivered to the bony rolls 30 for recrushing and subsequent re-treatment. The same process is followed in the treatment of the coal and bony from the stove spirals 34. Stove, chestnut, and pea coals made on the shakers 19 pass to the stove and nut jigs 35, 36, the pea size going to its pocket 15. Cleaned sizes from the jigs likewise pass to their respective pockets 13, 14. Fine coal passing through these shakers goes on to another set of screens 20 and is separated into No. 1 buckwheat, rice, and barley. These are not further treated but go to their respective pockets 21, 22, and 23.

Bone coal removed by hand from the picking table 4 passes to a bone roll 37, thence to a bone elevator 38 by which it is discharged on to the bars 3 at head of breaker. The condemned-coal elevator 39 takes the coal to conveyor 16, which discharges it into an elevator 18 which takes it to shaker for retreatment. In case there is a demand for broken coal, instead of sending this size, as made on shaker 6, to the rolls to be rebroken, it can be sent direct to the broken pocket 39.

Lattimer Breaker, Pardee Brothers & Co., Inc.

The conditions under which coal is produced to a large extent determine the methods that must be followed in its preparation. In the Lattimer breaker, of Pardee Brothers & Co., Inc., near Hazelton, a condition is encountered that is somewhat different from that ordinarily found. Large strippings are located at this operation so that the coal is apt to be of large size, as it is loaded into the mine cars by steam shovels.

Fig. 51 is the flow sheet of this breaker. The coal is dumped into a pocket at the top of the building and is passed by an automatic feeder to the bull shakers. The large lump coal going over the top of this shaker passes to a picking table, where both the rock and the large lumps coming from the strippings are removed. Steamboat coal from the bull shaker passes to a picking table, after which the clean steamboat unites with the clean large lumps from the first table and passes through a set of rolls. It then runs on to a set of shaker screens on which broken, egg, stove, chestnut, pea, and No. 1 buckwheat grades are separated. As this coal is already clean, it passes directly to the proper pockets. Should it be desired to re-break the broken coal, it can be elevated and sent back through the rolls to be crushed to finer sizes instead of being chuted directly to its pocket.

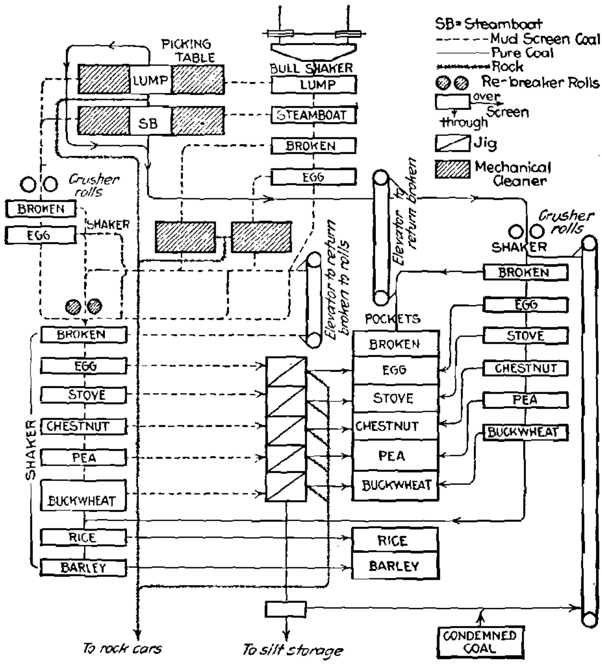


FIG. 51.—FLOW SHEET OF LATTIMER BREAKER OF PARDEE BROS. & CO., INC.

Coal passing over the picking tables in the head of the breaker is united and goes to a set of rolls, thence on to a set of shakers from which the broken and egg coals go to a set of re-breaking rolls to be broken to finer sizes. Should it not be desired to break the egg coal to smaller sizes, this grade is bypassed around the rolls to another set of shakers. The coal that comes through the rolls likewise passes to the same set of shakers, where it is joined by other coal.

On the third deck of the bull shaker, broken coal is removed and on fourth deck egg coal is taken off. These coals both pass to a set of mechanical pickers where some of the rock is removed. The coal from these pickers unites with that mentioned above, as does the coal of similar size that passes through the bull shakers. All the coal is thus re-united, except the clean material removed from the original picking tables. This coal is now sized. The broken coal taken off the top deck of the shaker is elevated to the rolls to be re-crushed. The egg, stove, chestnut, pea, and No. 1 buckwheat pass to the jigs for preparation, thence to their respective pockets.

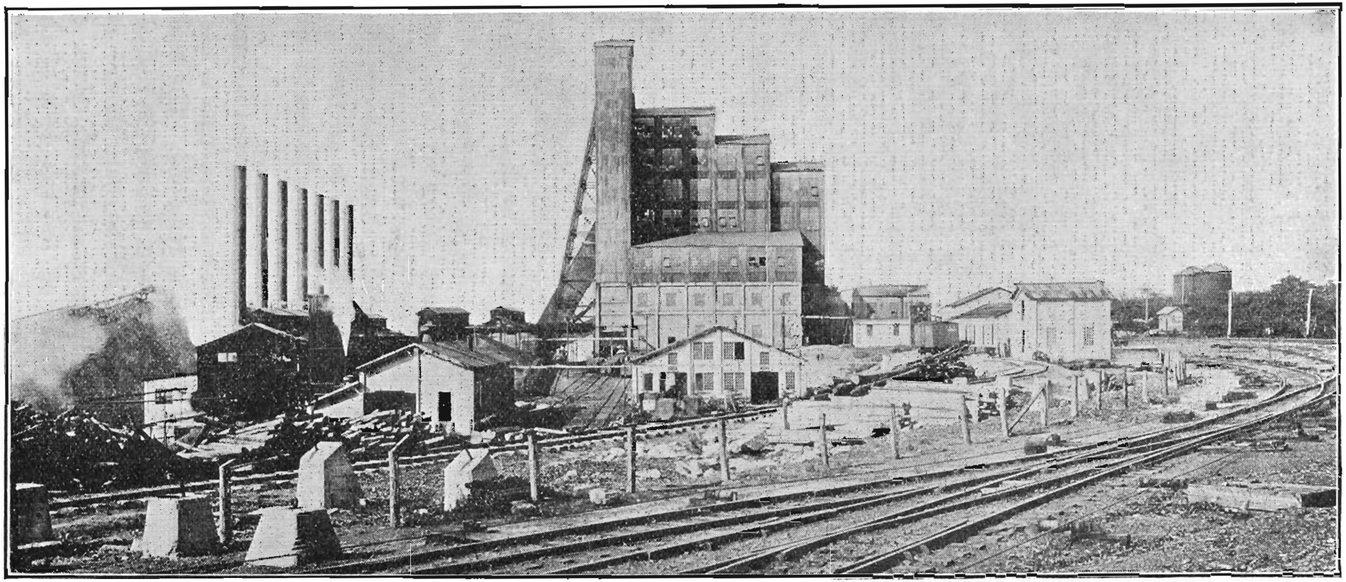


FIG. 52.—VIEW OF BUCK MOUNTAIN COLLIERY OF LEHIGH VALLEY COAL CO., ALSO SHOWING BREAKER.

Coal finer than No. 1 buckwheat, passing through the bottom deck of the clean-coal shakers, unites with the coal of similar size from the mud screen and passes over a shaker, which separates the rice from the barley. These grades are then ready to pass to their respective pockets.

All rock from the picking tables, mechanical separators, and jigs goes to the rock pocket, whence it is transported by rock cars to the dump. The silt from the jigs and from the bottom deck of the shakers goes to the silt storage pile.

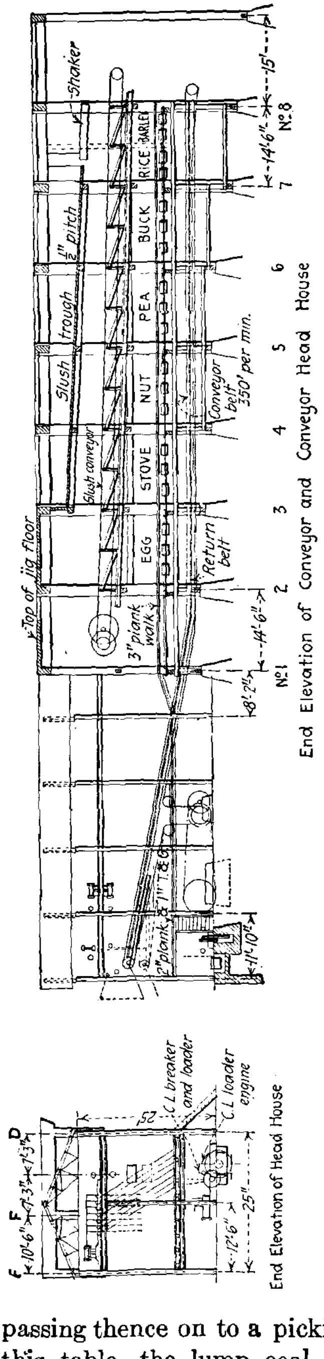


FIG. 53.—ARRANGEMENTS FOR LOADING COAL AT BUCK MOUNTAIN BREAKER.

Buck Mountain Breaker, Lehigh Valley Coal Co.

The construction of the Buck Mountain breaker, Fig. 52, is similar to that of the Franklin, owned by the same company. The same arrangement of loading pockets is used; the layout is shown in Fig. 53. A belt conveyor carries the coal from the pockets to a chute at a sufficient height above the tops of the railroad cars that the coal will slide into the cars by gravity.

This breaker lies in the southern middle field where the mining conditions differ from any hereinbefore discribed; as a result, the method of preparation is different also. The coal in this field lies in steep-pitching measures that are quite wet; in fact when a car of coal comes from the mine it looks more like a car of mud than one of coal.

The flow sheet, Fig. 54, shows that the coal is hoisted to the top of the breaker, in the mine cars, and is then dumped into a hopper, from which it is fed on to the bull shakers by a manually operated gate. On the upper deck of this screen, the lump coal is separated passing thence on to a picking table where the rock is removed. From this table, the lump coal passes to a set of crushing rolls, where it is broken down. The resulting cleaned coal is then passed over a shaker, the broken coal going to a set of re-break rolls, thence into a hopper. Egg coal from the same shaker either goes directly to the same hopper or passes to the rolls.

Broken coal from the second deck of the bull shaker is crushed to egg and smaller and then passes to the hopper above mentioned. Egg coal from the third deck of the bull shaker goes either to the broken

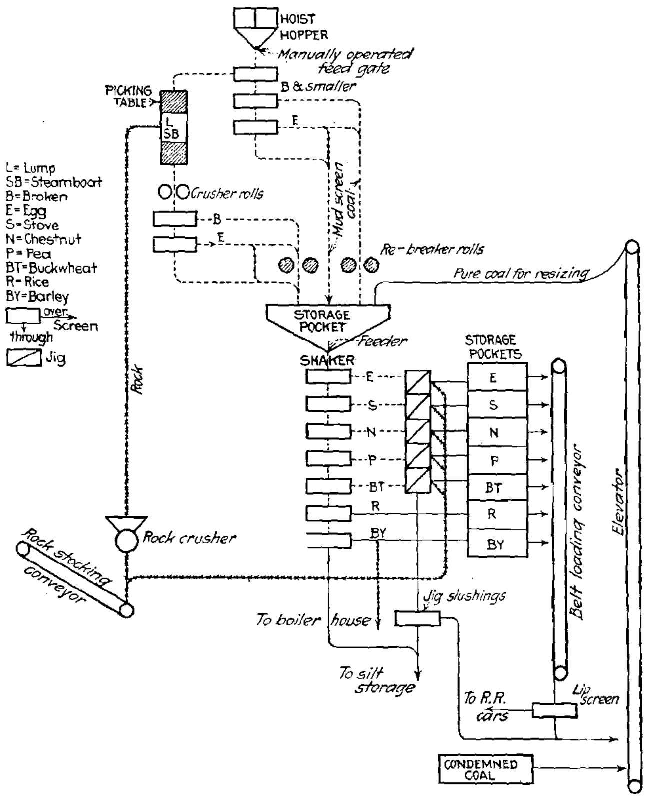


Fig. 54.—Flow sheet of Buck Mountain breaker.

rolls or directly to this same hopper. Thus all of the coal is re-united and broken down to egg size after the large rock has been removed from it. From the hopper, the coal is delivered by a feeder to a set of shaker screens by which it is sized into egg, stove, chestnut, pea, No. 1 buckwheat, rice, and barley. The first five sizes are sent to jigs and cleaned of their rock, the cleaned coal going to its proper pocket. The last two sizes are sent to their pockets without further treatment, except that the barley may be sent to the boiler house to be used as fuel. The jig slushings and the material passing through the lip screen now go to another shaker, from which the large-size material goes to the condemned-coal elevator, while the fine slush goes to the silt storage.

All the large rock is sent to a Gates crusher, by which it is broken down in size. It is then joined by that from the jigs and taken by a rock-stacking conveyor to a waste bank.

Brookside Breaker, Philadelphia & Reading Coal and Iron Co.

The Brookside breaker of the Philadelphia & Reading Coal and Iron Co., near Tower City, in the southern coal field, embodies features different from any hitherto described. In the first place, it is constructed of wood. As shown in Fig. 55, it is what might be called a hillside breaker; that is, in its construction, advantage has been taken of the natural contour of the ground. This permits a great saving in material. Fig. 56 is the flow sheet.

The preparation of the fine sizes is more careful than in most of the breakers hitherto described. In the mining of coal in steep-pitching measures, practically all the material produced in the mine, whether rock or coal, is brought to the surface. In this case, the mine cars, regardless of the material with which they are loaded, are brought to the breaker head. Two dumps are provided, one for rock and one for coal cars. The rock cars are discharged into the rock chute, which delivers to a rock shaker 1. The coal cars are discharged into a chute 2, from which the coal goes to the bull shaker 3. Here the lump is taken off the top deck and goes to a picking platform 4, which is of the gravity type, where the pure lump coal is separated from the bone and rock. Rock from this platform unites with that from the rock-picking platform under the rock shaker 1 and the coal recovered from that platform unites with the bone from the picking platform 4.

The pure lump coal from picking table 4 passes to a set of No. 1 rolls 5 and is crushed to steamboat and smaller. It then goes to a shaker 6, where the steamboat is taken off the deck, the finer material passing through. The pure steamboat then goes to a set of No. 3½ rolls 7 and is crushed to broken and smaller. The coal from these rolls unites with that passing through the steamboat shaker 6 and goes on to the broken shaker 8; here the broken coal is separated, going to the broken pocket. If, however, sufficient demand for this coal does not exist, it passes through a set of No. 3 rolls 9 and then unites with the coal from shaker 8 and passes to shaker 10, where the egg is removed and sent to its pocket; if it is desired to break this coal still further it passes through a set of No. 4 rolls 11 and the coal then unites with the fine coal from shaker 10 and passes to shaker 12, on which stove, chestnut, pea, and No. 1 buckwheat are made, each size going to its proper pocket.

Coal that passes through the lump-coal shaker 3, goes to the main hopper 13 thence to a shaker 14. From the top deck of this shaker, the steamboat coal is taken, passing to a picking table 15 from which the pure coal goes to a set of rolls 7. The rock from the picking table 15 goes to the rock pocket. From the lower deck of the same shaker, broken coal is taken. This goes to a picking chute 16, from which the pure coal

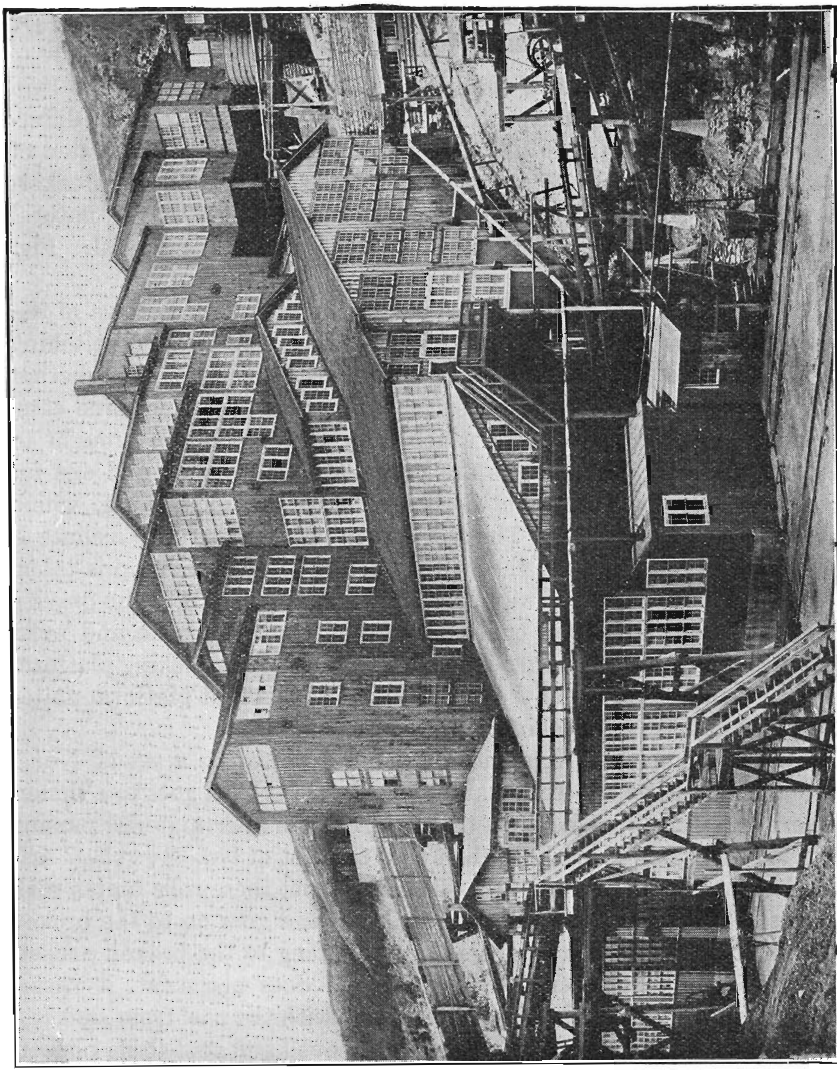


FIG. 55.—Brookside breaker of Philadelphia & Reading Coal & Iron Co.

either goes to the pocket or to the rolls 9. The bone coal from both the steamboat and the broken picking chutes goes to a set of No. 3 rolls 17, and thence to the main elevator.

Fine coal passing through shaker 14 goes to another set of shakers 18, from the top deck of which egg coal is taken. This passes to an egg

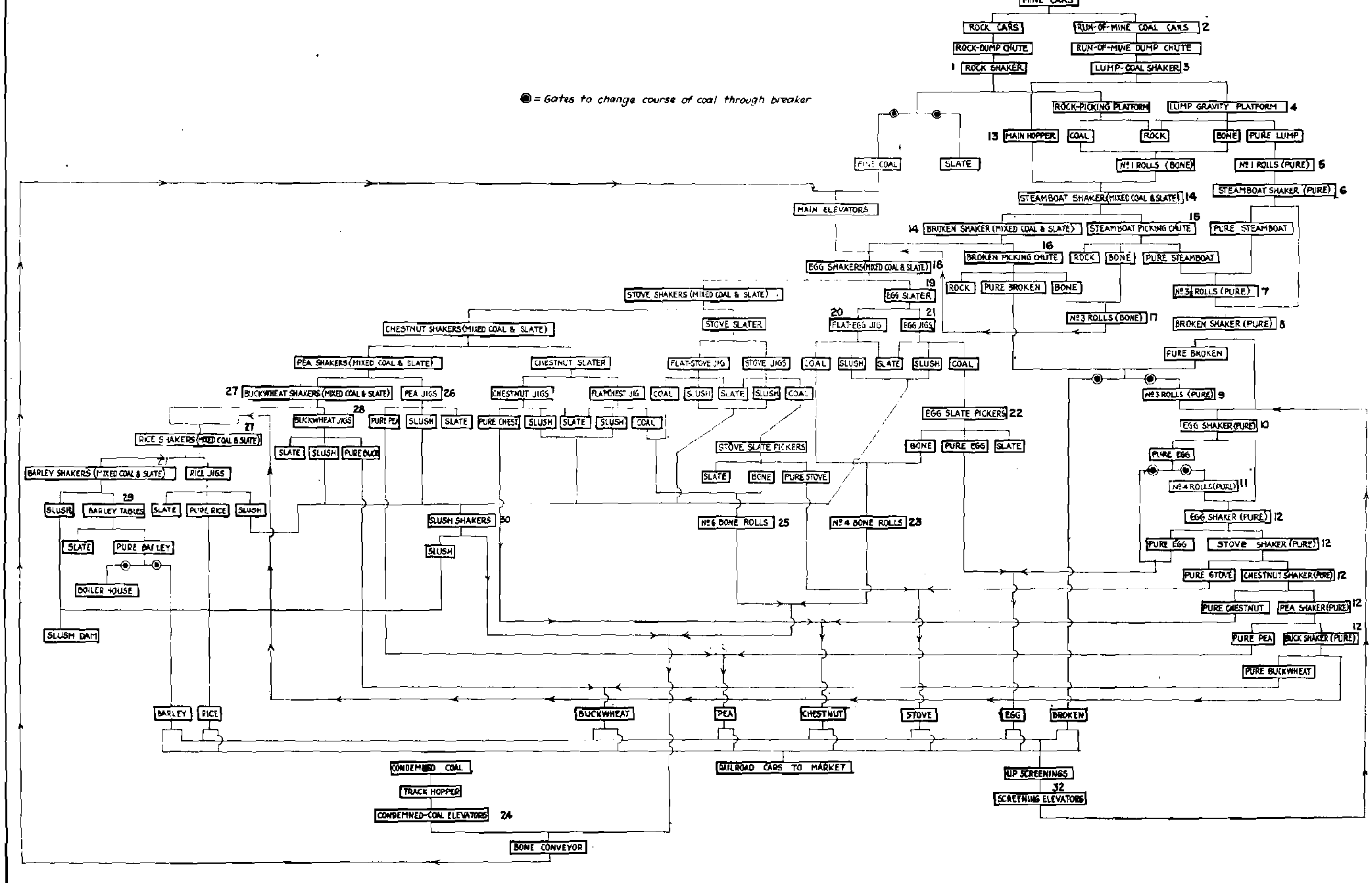


FIG. 56.—FLOW SHEET OF BROOKSIDE BREAKER.

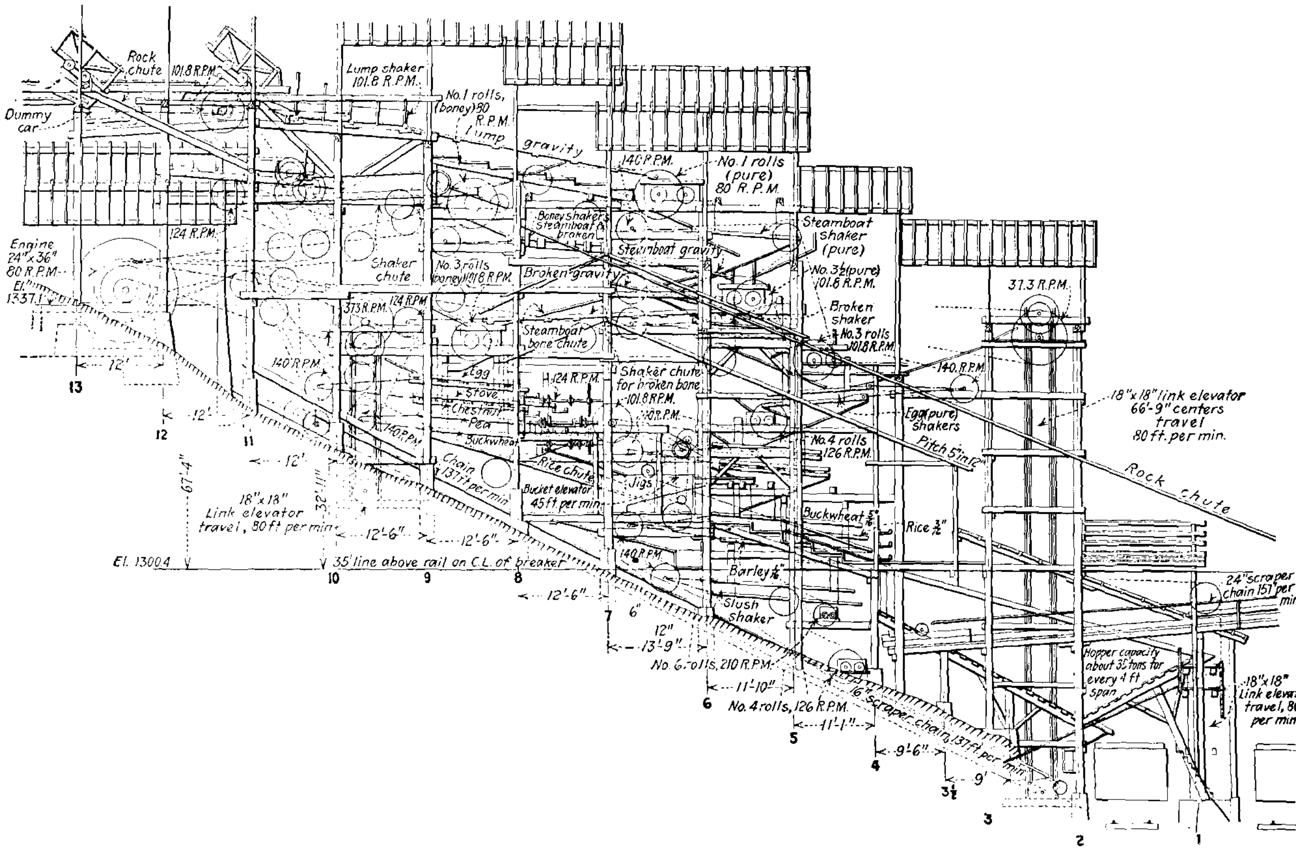


FIG. 57.—SIDE ELEVATION OF THE BROOKSIDE BREAKER.

slater 19, which separates this size into flat and round pieces. These then go to separate jigs 20, 21. The cleaned coal is picked at 22 to remove any slate that may remain, and the resulting product goes to the egg pocket. Bone from jig 20 and that which is picked after treatment from jig 21 goes to a set of No. 4 bone rolls 23, thence to the condemned-coal elevator 24.

Exactly the same processes take place in the treatment of the stove coal from the second deck of shaker 18, except that a set of No. 6 rolls 25 is used to crush the bone. Chestnut from the shaker above mentioned is treated like the stove coal and the bone goes to the same set of No. 6 rolls 25.

The pea coal does not pass through a slater but goes directly to the pea jig 26, from which the cleaned coal passes directly to its pocket. On shaker 27, No. 1 buckwheat, rice, and barley coal are made. The buckwheat passes to the buckwheat jigs 28, the cleaned coal going to its pocket. Rice is likewise jigged. At this point the rice and barley coals from the pure side of the breaker join together and are sized on this deck of the shaker 27.

The barley coal is treated on Deister tables 29, after which pure barley is sent to the boiler house or to the market, as the case may be. The slush, which settles into the jig tub, is passed over a slush shaker 30 and the larger sizes removed and sent to the condemed-coal conveyor. The fine slush unites with that passing through the barley deck of shaker 27 and is sent to the slush dam. Lip screenings are taken by lip-screening elevators 32 to the clean egg shaker 10 for resizing.

As stated before, there are really two sides to this breaker—the pure-coal side and the bony-coal side. On both sides the treatment is wet. On the pure-coal side, the material receives no other treatment than the necessary breaking down and the sizing. Material sent to the bony-coal side, however, receives throughout a somewhat more elaborate treatment. In the first place, the coal, before it is jigged, is sized into flat and round particles, which simplifies the jigging. All sizes from egg down to rice are jigged, the barley coal being treated on Deister tables.

Rahn Breaker, the Lehigh Coal and Navigation Co.

This is the newest breaker of the Lehigh Coal and Navigation Co., and therefore embodies its latest ideas. A feature that differentiates it from other breakers is that the large rock is separated in what is known as a rock house and the coal that is taken into the breaker by the drag-line conveyor is comparatively clean.

Another feature is the breaker drive. Electric motors are used as the motive power but instead of installing motors to drive one or two pieces of machinery, only five motors are used in the whole building. One of these drives the conveying machinery, one the pumps, one the shaker screens, one the rolls, and one the jigs. They are so disposed as to direction of drive that the vibration is reduced to a minimum. All the motors are controlled from a central switchboard. Another feature is the use of the cone separator for the finer material. Unfortunately this apparatus is only in the experimental stage and cannot be described.

The following is a description of the passage of the coal through the breaker; its progress can be followed readily on the flow sheet, Fig. 58. After being dumped, the coal passes over the bull shakers 2, on which

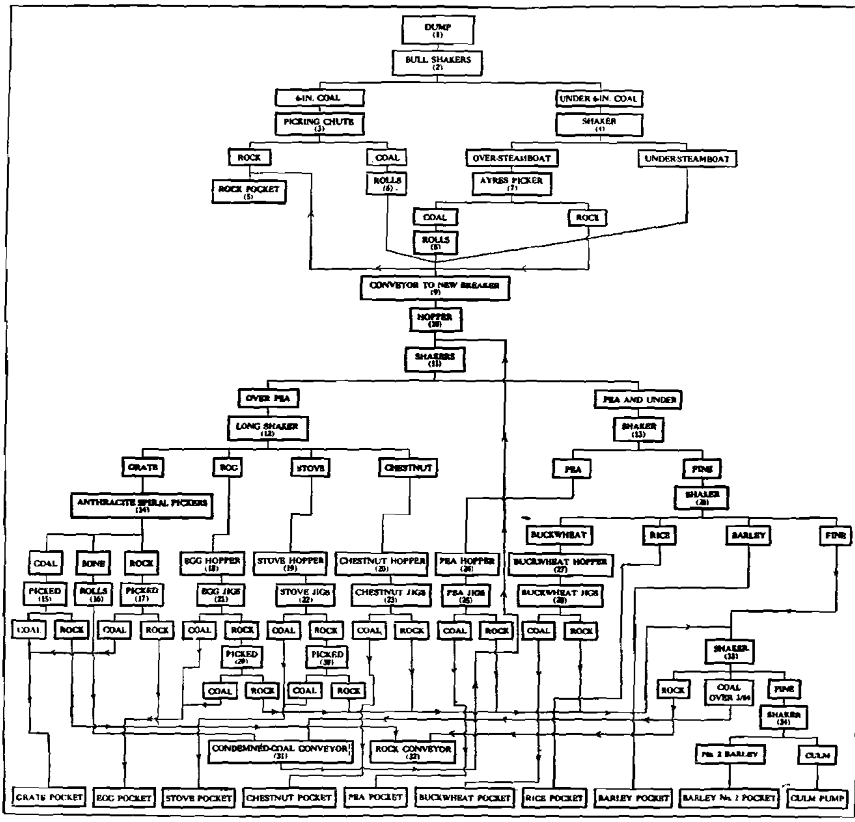


FIG. 58.—THE FLOW SHEET OF THE RAHN BREAKER.

two sizes are made; coal 6 in. (15 cm.) and larger passes over these shakers while that under 6 in. passes through them. The large coal then goes over a picking chute 3, where the rock is separated, being sent direct to the rock pocket 5, the coal passing through a set of rolls 6. Coal that passes through the bull shakers 2 goes over another set of shakers 4, on which two sizes are made—steamboat and larger, and coal smaller than steamboat. The larger size is picked on Ayres pickers and the coal is passed to a set of rolls 8, the rock being sent to the rock pocket 5. The size under steamboat coal from shaker 4 goes to the conveyor leading to the new breaker, as does the coal from the rolls 6 and 8, this conveyor delivers the coal into a hopper 10 at the top of the new breaker, from which it is delivered by three feeders to three sets of shaking screens 11. On these shakers only two separations are made—over pea and pea and under.

This over-pea size passes directly from the shakers 11 to the long shakers 12. As is rather unusual in the anthracite field, these long shakers have only one deck each but make four separations, namely, grate, egg, stove, and chestnut. These shakers are 30 ft. (9 m.) long; on the first 12 ft. (3.7 m.) chestnut passes through, on the next 9 ft. (2.7 m.) stove coal is separated, and on the last 9 ft. egg goes through and coal of grate size passes over. This grate coal then goes to three anthracite spiral pickers 14, on which the coal, bone, and slate are separated. The coal is then hand-picked and passes to the grate pocket, the rock going to the rock conveyor. The bone coal goes to a set of rolls 16 thence to the condemned-coal conveyor 31. The rock from the spiral pickers 14 is hand-picked and the coal recovered is sent to the grate pocket, the rock being sent to the rock conveyor.

Egg coal from the long shakers 12 passes to a hopper 18 directly behind the three egg jigs 21. These are of the double type, and the coal is fed to them uniformly from the hopper, this uniformity in feed aiding the jigs to prepare the coal more thoroughly.

The jigs are of the Elmore type and make 100 strokes per minute. The coal that leaves them goes to the egg pocket, but the rock is hand-picked, the coal saved being thrown into the coal chute and passing with the balance of the coal to the pocket, the rock going to a shaking screen 33. Its subsequent treatment will be described later.

The stove and chestnut are prepared in the same manner as the egg, except that after the chestnut coal passes through the jigs the rock from the jigs is not hand-picked. Three double jigs handle the stove coal and three more the chestnut.

From shaker 11, the pea coal and smaller sizes pass to another shaker 13, which makes only one separation—pea and coals finer. The pea coal passes to the pea hopper 24, thence to the pea jig 25, where it receives exactly the same treatment as the chestnut coal.

The fine coal from shaker 13 is passed to a shaker 26, which has three decks and prepares four sizes of coal—buckwheat, rice, barley, and fine. Buckwheat coal is jigged just as is the pea and chestnut and receives the same subsequent preparation. Rice coal does not receive any further treatment and goes directly to the rice pocket. The barley coal, like rice, passes on without treatment. The fine coal from shaker 26 passes to shaker 33 and is fed on to its second deck; the rock from the jigs 21, 22, 25, and 28, is treated on the upper deck of the shaker.

Oversized rock goes to the rock conveyor while the undersize and the coal passes to the second deck of the shaker. All the particles over $\frac{3}{64}$ in. (1.2 mm.) pass over this second deck to the condemned-coal conveyor, the finer particles passing through to another shaker 34, on which No. 2 barley is made. This size then goes to the No. 2 barley pocket, and the culm passes to the culm pump for delivery to the slush bank.

The coal delivered to the condemned-coal conveyor 31 is carried to the shaking screens 10 for treatment. The rock sent to the rock conveyor 32 is taken to the rock pocket and from that point hauled to the rock bank.

The breaker has a capacity of approximately 2,000 tons in 8 hr. The percentage of the different sizes of coal made, the amount of slate in the coal, and the percentage of the coal in the refuse slate are given in the accompanying table:

Size of Coal	Size Made, Per Cent.	Slate in Coal, Per Cent.	Coal in Slate Refuse, Per Cent.
Broken	3.8	...	2.0
Egg	7.8	2.0	2.0
Stove	9.7	3.5	2.8
Nut	17.2	5.0	3.1
Pea	10.6	8.0	3.5
Buckwheat	12.2	10.0	4.1
Rice	15.5		
Barley	20.2		
Barley No. 2	3.0	....	2.2

The domestic sizes of coal make 38.5 per cent. of the total produced and the fuel sizes amount to the large proportion of 61.5 per cent.

Three main and two minor drives are employed in this breaker. One of the main drives operates the machinery of the rock-separator house, another runs the jigs, and a third the shakers. A separate motor is used in each case, the jigs requiring a 400-hp. machine and the shakers one of 500 hp. Allis-Chalmers motors are used for both shaker and jig drives, being connected to the main shafts by 36-in. belts with pulleys on 50-ft. centers.

DISCUSSION

Sidney J. Jennings,* New York, N. Y.—We have been told by the newspapers and by some of the operators that anthracite is a luxury fuel. A visit to this district has convinced me that it is a very luxurious fuel. The operators here seem to have educated the housewives who are able to get anthracite to a degree of luxury that seems excessive. You can get a perfectly good fuel, even though it is a little bit smoky and dusty, for probably two-thirds of the cost of anthracite; but you cannot get the

* Consulting Engineer.

housewife to use that fuel if she can get the better one. Is it not, therefore, a part of the education in thrift not to prepare the anthracite to such an excessive degree of refinement? The sizing of the coal into so many sizes, as is now done, seems excessive.

The fact that the breakers work one shift adds, undoubtedly, to the capital expenditure and increases the cost of the fuel and puts it still further in the luxury class. I have roughly figured that the cost of the breakers, the model one that we have seen, is about $1.10 to $1.50 a ton of yearly capacity. Probably, by the addition of a storage bin at the breaker, which will receive coal on the day shift only, so that the breakers can be worked on three shifts, the capital expenditures can be reduced—certainly to about 60 or 75 cents a ton—by doubling or trebling the work any one breaker can do.

I suggested this to some of the anthracite operators, but they say that it is difficult to get men to work on the night shift. That problem has been faced by the workers in the mills for concentrating ores and has been solved, and I do not see why the anthracite breakers should be any more luxuriously looked after.

R. V. Norris,* Wilkes-Barre, Pa.—One point in connection with the seeming lack of energy in working day and night shifts, in many mines, is the development gangways. These are usually driven on two, and frequently on three, shifts and then they barely hold the 8-hr. output. It is a question of whether it is practicable to maintain development at a pace sufficient to work the chambers more than one shift and I think that is one of the underlying reasons why the coal mines throughout the world practically have developed on this basis.

Edwin Ludlow,* New York, N. Y.—This question has been carefully considered for we all realize the enormous capital expenditure in our breakers. The question of maintaining the breakers on a day shift, though, is one of labor, the costs of which are in excess of the interest on the capitalization. It has been found, in most of our experiments in trying to run two shifts (we never got to three), that it was cheaper to keep that breaker, at the time it was running, at a maximum output so that the hundred or more men employed in connection with it would be busy during that period of time.

One great difficulty is the fact that the contract miner is independent as to his hours and seldom works more than 4 or 5 hr. in any one shift. It takes therefore a large force of miners to keep the breakers going 8 hr. steadily. It requires three shifts on development in most mines having a large breaker, to keep that work far enough ahead. I doubt whether more than the one shift per day would be successful under present labor condi-

* Consulting Engineer.

tions. Most of us have had difficulty in maintaining the one shift to a mark above the minimum at which we know the breaker can be run economically. I doubt whether it would be practical at the present time to operate double shift. Our own experience has been that the greatest economy is to maintain the output of the breaker at its maximum on day shift.

C. T. Starr, Bethlehem, Pa.—How would Mr. Jennings limit the preparation, in sizes?

Sidney J. Jennings.—In the number of sizes.

H. G. Davis,* Wilkes-Barre, Pa.—The night shift question has been discussed for many years in the anthracite region. One of the coal companies, some years ago, tried to operate one of its breakers day and night in order to keep its mines in operation, having lost a breaker by fire, but the plan was not practicable.

English and German engineers who have visited the region invariably, on noting the tremendous outlay of capital connected with the development and operation of an anthracite mine, wonder why the breakers are not operated day and night so as to give a greater yield on the investment. This problem may yet be solved in a satisfactory manner since the machinery installed therein can be driven by separate electrical units.

I have at all times tried to eliminate the night shifts, for I have always thought that where men were employed on the night shift in order to get coal ready for the morning, somebody was not on his job. I have had no reason to change my mind up to this time. Of course, there are times when the development of a mine or a section justifies a night shift, when a number of chambers may be operated on the night shift in order to keep the transportation forces fully employed. In all cases, night shifts should be discouraged.

Our system of mining is entirely different from that in the bituminous field, and our method of preparing our product is much more complicated; but while I do not think that the breakers could be successfully kept in operation for the 24 hr., it may be possible, with the application of electrical units, to operate 16 hours.

Arthur Thacher, St. Louis, Mo.—Coming from the West, I am naturally in favor of night work. I know it is not carried on in the East, but in the West we find little difficulty with night operating. It seems a great economic waste to have all that capital expenditure working only a few hours. I recognize the fact that if the mines are operated for 24 hr. the storage of coal will be difficult. Coal is more bulky than ore. The question of bins is serious and if we cannot deliver the coal we might get into trouble.

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* Consulting Engineer.

It has been said that the mines cannot be worked on three shifts because of contract labor; in my opinion contract labor is wrong and we will never reach our greatest success until we return to day wages; though I know that does not agree with most of the conceptions of the present day. Contract labor is one of the troubles today in England and Australia. I will go further and say that the day-wage system is practically applicable to bringing out the best results. I have obtained the best results from day pay, and some of the most remarkable records have been made in that way.

I do not mean that we can at once drop our contract work—you are controlled by the people of the community, by the customs and traditions of the village. I have not dropped it myself and will probably use it all my life. But we should recognize that it is not the best way to obtain the best results and we should be slow about trying to increase it.

F. B. Nold, Lansford, Pa.—The author referred briefly to experiments being carried on; has any one here had experience in the separation of coal in the breaker or mine by air, chiefly a preliminary cleaning before the main separation is made?

R. V. Norris.—There was some separation done by air by the Lehigh Coal and Navigation Co. some years ago; that was shown by a report published in connection with the summer meeting of 1911.

Edwin Ludlow.—The present plan is entirely different from that, as I understand it. This system is used at three or four places in the bituminous field, where it is doing satisfactory work. The idea is to carry the fine coal over a shaking screen through which a current of air is passed upward. This air current keeps the coal in agitation on the top of the screen while the slate drops through. I do not know that it has been tested in the anthracite region, as it is comparatively new.

R. V. Norris.—One point in regard to the question of night shifts is that all anthracite is mined by the contract system; that is, the miner contracts to mine the coal. If you want to work in a double shift you must either provide a double number of chambers, or else you must, in some way, force partnership agreements, so that one partner may work on one shift all the time. Both of these are somewhat impracticable.

Dever C. Ashmead (author's reply to discussion).—It has been suggested that anthracite mines and breakers should be operated on the three-shift basis. Three conditions will be considered and reasons given why operation of anthracite mines under these conditions would not be feasible.

Condition 1.—Whole mine to be operated on a three-shift basis.

Condition 2.—Present operating force to be divided into three parts, each part to operate a portion of the mine. Thus the first shift might operate the Red Ash, the second the Baltimore, and the third the Hillman bed.

Condition 3.—Operate the mine in one shift, as at present, and the breaker in three shifts.

The first condition could not be attempted with hope of success for frequently when the mines are being developed on the three-shift basis it is difficult to keep the development so far in advance of the producing forces, which work one shift, as to provide the latter with working; it would be, not only difficult, but impossible to do so if the coal-mining forces were trebled. Further, the men would continually quarrel, each claiming that a succeeding shift in the breast was loading out, and getting paid for, coal dislodged by the preceding shift and not leaving the shift that followed an equal amount of coal to load out.

The introduction of the three-shift system would probably necessitate the introduction of contract work or partnership on a large scale. One man would take the contract for the chamber, or breast, and would then hire men to work it for the three shifts. For years the miners have been trying to have the contract system ended, and they would resent any readjustment that would increase the prevalence of the practice that they have unsparingly condemned.

In the second condition, the mine will be operated on three shifts without increasing the force of miners, the work being spread over three shifts instead of one and each place being worked by the same number of men as at present. This overcomes the difficulty of providing development and also gives possession of one place to a miner and his loader, eliminating disagreements. But it will cause the operator much trouble, for the miners in the anthracite region, as a whole, are not used to working except on the day shift, therefore to force two-thirds of the men to work other shifts would immediately cause unrest and strikes.

Furthermore, at many mines there is only one shaft, so that working three shifts would mean that a full force of shaft men would be required to handle the coal; in other words, the labor cost of hoisting would be trebled. Besides, the underground-haulage cost would be increased, the present arrangements underground being such that the coal often must be transported from one bed to another, and the same haulage system is practically used for a number of beds. Therefore this system would be kept in operation for all three shifts using practically a full working force for each 8-hr. period. Larger gangs of repairmen would have to be employed. The ordinary day force might be decreased but the number of repairmen who would have to be employed for the other two shifts would be great enough possibly to double the present forces. The whole cost of mining would be increased, and it is extremely doubtful if the saving resulting in the smaller amount of capital required would begin to pay for the increased cost of operation.

The third condition is likewise impracticable. If the mine worked only a third as long as the breaker, it would be necessary to provide storage for two-thirds of the coal produced. For instance, if a colliery produces 6,000 tons of coal a day, the breaker will have a capacity of 2,000 tons, therefore storage must be provided for 4,000 tons. The storage pockets must be of fireproof construction, and every facility for the quick handling of this coal must be provided. It is questionable therefore, whether the decreased cost of the breaker would pay for the construction of the storage pockets. In addition, while the 2,000-ton breaker will prepare only one-third as much coal as the 6,000-ton breaker, the cost will not be reduced in proportion; the saving in the cost of construction might be only from one-third to one-half. Also the coal must be taken out of storage so that breakage will be increased and a decrease in the prepared sizes will result in lowering the return on the coal.

The cost of supervision would be increased by three-shift operation and the coal would have to be inspected over a period three times as long as at present. The capacity of the breaker per shift would be greatly decreased, but the force operating it would not be reduced in proportion, as a 2,000-ton breaker would require the employment of more than one-third of the men demanded by one of 6,000-ton capacity. These last reasons apply, of course, whenever the breaker is run on three shifts whether the mine works steadily or only for 8 hours.

The margin of profit in the anthracite region is so small that it would be impossible to operate the coal mines at any increased cost. The introduction of any such systems would upset the whole labor situation, and the losses that would arise from a strike of a few months duration would exceed all profits that might come from such a change. In my opinion no profit would be derived from such a change; in fact, the introduction of such a system would increase the cost of operation.