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UNITED STATES GEOLOGICAL SURVEY
J. W. POWELL DIRECTOR

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KANAWHA VALLEY OF WEST VIRGINIA

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ABSTRACT FROM "MINERAL RESOURCES OF THE UNITED STATES, CALENDAR YEARS 1883 AND 1884"—ALBERT WILLIAMS, JR., CHIEF OF DIVISION OF MINING STATISTICS

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Kanawha coal has come into some prominence within the last few years, and the object of these notes is simply to record the conditions under which the business is now carried on, without professing to bring forward anything new.

General description of the district.—The Kanawha coal field is a general term, including all the coal seams opened on the Kanawha and New rivers with their tributaries, and may be regarded as covering the newly developed Flat Top district; but it is generally limited to that part of the field having for an outlet the navigable waters of the Kanawha, or the line of the Chesapeake and Ohio railway, which descends the valley of the Greenbrier to the New river, and follows that stream till it joins the Gauley at Kanawha falls, where the united streams take the name of Kanawha.

The New River valley is a narrow cleft in the mountains, and is frequently compared with the western cañons; but the Kanawha valley gradually widens, and affords bottoms suitable for farming. The New river is a succession of pools and rapids, but the Kanawha in ordinary stages of water is navigable for light-draught steamers to Cannelton, within 10 miles of the falls. The railroad follows the valley to Scary, where it leaves the Kanawha and takes a more direct course to the Ohio, which it strikes at Huntington, near the mouth of the Guyandotte river.

The general geological structure of the country is very regular, and the topography of the region allows the employment of very simple methods of handling and shipping the coal, but there is a great variety in the character of the coal mined from the different seams, and in the method of treatment. Up to the present time mining operations have been limited to the lands immediately adjoining the river and to a few tracts within 5 or 10 miles, reached by short lines of railroad specially constructed for their development. Coal was also shipped for many years from the Peytona cannel mines, on Coal river, depending on a system of locks and dams for slack-water navigation to the Kanawha. The Peytona mines are now abandoned, and the locks and dams are out of repair. The natural features of the country are such that the way is open for additional lines of railroad through many side valleys, opening up a greatly increased area.

The mountains rise 500 to 1,200 feet above the river level, and contain so much coal in sight, cropping out in nearly horizontal strata, that there has been no inducement to make any thorough search by boring for coal below the river level. The bore holes made have been mostly for salt wells, and the reports of coal struck in them are not to be relied on. The general and regular dip of the coal indicates what may be hoped for on boring in parts of the country where any of the coal seams have passed below the river level, but experience in working the seams above water level shows that they all have their local basins of maximum thickness, and that coal, which is valuable and apparently regular in one place, becomes so pinched or changed in character within a few miles as to be quite worthless, so that geology alone will hardly warrant any large expenditure for the working of the lower seams after they have passed out of sight.

The general dip of the Kanawha coal field is to the northwest, and on approaching from the east along the line of the Chesapeake and Ohio railway the first coal met is at Quinnimont, where it appears high up on the mountain. This is geologically one of the lower coals of the New river series, which are worked at frequent intervals from Quinnimont to Hawk's Nest bridge for 30 miles, and then disappear below the river; while the next higher or middle coals of the Kanawha series come into prominence for the next 40 miles, disappearing in turn near Charleston, to be succeeded by the third series, which is worked at Raymond City.

The Kanawha has been called the special field for small capitalists. This is still true in many places, but as competition increases and the margin of profit becomes less it is necessary to extend operations and to work with a larger capital. There is nothing of special novelty in the machinery and appliances or in the plan of underground working here, but as there are slight differences in different districts, and the methods are gradually changing, it may be of interest to put on record the present system.

At present the whole coal field is suffering from the overestimates which have been made by its explorers in times past. Geologists and mining engineers who have been familiar with the more irregular structure of other regions seem to have been deceived here, and to have relied too much on the regularity of the formation. In some cases they have no doubt duplicated the seams, and in others they have been content with finding the outcrops of known seams, and then have taken the measurements of coal and reports of quality from points where these seams have their fullest development, trusting to the known regularity of the formation to confirm their report, and ignoring the fact that each seam has its area of special value, either in the matter of thickness, or quality, or both.

Thickness of the beds.—It is usual to hear of 50 feet as the thickness of workable coal in seams of 3 feet or over, but unfortunately most of these sections are grossly exaggerated, and many of the seams which appear so well on paper prove on trial to contain impurities which render them worthless at the present time. Doubtless such sections may be proved in places, but among the mines now working a total section of 12 feet would be regarded as very favorable. The limit of workable thickness on the Kanawha is usually stated at 3 feet, but several seams are worked which average less, and probably 30 inches may be regarded as the minimum where there are special inducements afforded by the ease of mining or by the superior quality of the coal.

Ownership.—West Virginia coal lands are generally held in large grants, and often under conflicting titles. Many of the tracts to which a clear title could be found are so involved by mortgages that they can only be taken as a whole by large capitalists, and cannot be divided to suit the requirements of individual operators. The river bottoms and lower slopes are often held under different titles by small farmers who control the approach to the coal lands in their rear.

Character of the coal.—The New River coal is quite soft, with very indistinct faces; contains much mineral charcoal; has a low percentage of volatile matter, and is used principally for steam purposes and coke making. It is easily mined, and requires but little powder. It ranges from 30 inches to 5 feet in thickness, and requires less skill on the part of the miner, as it is taken, coarse and fine, just as it comes from the pick. The Kanawha coals are classed as splint, gas, and cannel.

Splint is used mostly for domestic fuel and high-grade steam coal. It is noted for its toughness and regularity of cleavage, allowing it to be prepared in an attractive shape for market. It withstands the handling and exposure of a stockyard much better than ordinary bituminous coal. It is rich in volatile matter and gives very good results as a gas coal, but not better than other softer and cheaper coals. Splint coal requires more skill and care in mining than the softer coals, as the miner is paid on the basis of the lump coal which passes over the screens.

Gas coal is softer coal, and can be mined more cheaply than the splint, while it gives as good results in the retorts. It is used almost entirely for gas making, and to a very limited extent for steam purposes.

Splint coal and the softer grades often form distinct bunches in the same seam, and, if possible, they are then mined and shipped separately.

Cannel coal is now being mined only at Cannelton and on Paint creek, and is used principally by the gas works as an enricher for other coals. It is of very irregular occurrence and limited in area.

Number of seams.—There is still some uncertainty as to the identity of the coal seams in different parts of the district, which will no doubt be cleared up by the publication of Professor White's examinations made during the summer of 1884, some results of which have been given on pages 91 to 97 of this volume. There are at least eleven distinct seams which are now being worked at one or more points, but there are very few properties that will show more than two of the number in workable condition, although the section at some points includes seven seams.

Royalty.—About half of the coal now being mined is from leased land, and the royalty is variously paid, either as a fixed annual charge without reference to the quantity mined, or as a payment directly proportioned to the output; or, lastly, as a minimum, giving the privilege of mining a fixed quantity, any coal mined in excess being accounted for in addition. The royalty is sometimes regulated by a sliding scale, to encourage a large production.

The royalty may be on the run of the mine, as the coal comes from the pick. This is common with the coking coal of New river. It may be on all coal passing over a screen of 1¼ to 1½-inch opening, disregarding the nut and slack. This is usual at the splint mines. It may be on coal passing over a five-eighths inch screen, disregarding only the slack. In general the rate of royalty approaches 10 cents per long ton.

System of mining.—The system of mining adopted on the Kanawha is almost exclusively that of room and pillar work. Long wall has been tried in a few instances, but most of the attempts have been failures, and the mines where it is now in progress have advanced so short a distance that no decided deduction can be made from them. Long-wall retreating has never been tried here on any large scale, and where long-wall advancing was attempted in the past the effort was made to keep the roof up by timbering. Naturally it resulted in failure. The local prejudice against this method is strong, but there are some coal seams here where it could undoubtedly be made a success. The difficulties in the way are drainage and irregular work. Very few of the coal seams can depend on natural drainage over any extensive area, owing to the slight dip and the number of local basins or swamps, so that as soon as the roof settles the mine is in danger of being flooded, and the water collects in so many scattered depressions that it cannot be removed economically.

The principle of long-wall work requires uninterrupted progress, so that the roof may settle regularly, and soon enough after the removal of the coal to prevent excessive pressure at the working face, allowing the miners to continue their work step by step under a new roof. Irregularity of work may prove a serious objection to this method of working. River shipments are liable to be interrupted by low water or ice, and the railroad car supply is sometimes cut off for a week at a time. There is danger that during such a stoppage the whole working face might be lost.

The dip of the coal on the Kanawha, though often irregular, is comparatively light, so that after the course of the main entry has once been determined, it is not usual to make any change, but to lay out the work at right angles.

At some of the New River mines the dip is heavy as well as irregular, so that the work cannot be laid out in advance, and the plan is necessarily changed from time to time to conform to the grade.

The location of the entries or gangways depends in general on the grade for hauling, the drainage of the mine, the ventilation, and on a convenient division of the land; but in most of the splint and gas coal mines an important consideration is to so lay off the work that the rooms, which are usually turned at right angles to the entries, may be driven squarely against the natural faces of the coal. In the harder splint coals it is almost impossible to induce miners to work rooms in any other direction, and such work is always injurious to the coal, shattering it more in blasting, and so lessening its market value.

The entries are usually driven 9 feet wide, and all gob is then removed. Sometimes they are 12 or 15 feet wide, with gob on one rib, and as an extreme case 30 feet wide. In this instance the coal is thin, and the roof slate, which is shot down for headroom, is all stowed at the side of the roadway.

Both the face entry and the butt entries are usually driven with parallel air courses, separated by a pillar of 20 to 40 feet, which is cut through for ventilation at intervals of 75 to 150 feet; but when the opening of the mine is not being rapidly pushed, the face entry is often ventilated by a parallel room driven ahead of the others. After opening out the mine by means of the first pair of butt entries, it is a common practice to drive the remaining butt entries single, allowing every third room to hole through for ventilation.

The rooms are opened from the entries with a width of 9 to 15 feet, and driven narrow for 18 to 30 feet, when they are widened to 20, 30, or even 45 feet. The usual width is 24 or 27 feet. The widest rooms are worked with two tracks, and have some of the advantages of long-wall work. The varying width depends on the character of the roof, the hardness of the coal, and the amount of gob for which stowage must be found. It is sometimes considered easier to keep the roof up in a wide room than in a narrow entry. The rooms are usually driven 300 feet long, but vary between 200 and 500 feet. When the pillars are to be drawn, the rooms are usually widened on one side only, and the room road is then laid along the rib, ready for use in drawing back the pillar; but in clean coal, free from gob, and especially in thin seams, it is often easier to relay the track after taking out the coal on a center road.

The pillars left between the rooms are usually 12 to 15 feet thick, but vary between 8 and 30 feet. The thinnest pillars are not drawn at all, or are merely thinned and broken through in places. The pillars of medium thickness are drawn back by a single room road, and those of 24 feet or over are either worked from the double room roads on each side, or else are split and worked by a special road. Room pillars are drawn back to within 40 or 60 feet of the entry, and the stumps are left to support the entry roof. The entry pillars and the room stumps are left till the entry is worked out, when they also are drawn.

Pillars are usually drawn as soon as the rooms in a limited section are finished, but some mine operators believe that the probably increased flow of water, when the roof is let down, more than counterbalances the value of the pillar coal. In such case the thin-room pillars are abandoned and the entry pillars are left till the mine is exhausted. In the hard splint mines, which make a specialty of lump coal for supplying stock yards, the pillar coal, after sustaining the pressure of the roof for a time, becomes brittle and will not bear handling. It then ceases to be merchantable coal.

So many of the Kanawha mines are high on the mountain that unusual facilities are offered for rear and side openings. In consequence of this the general plan is often more irregular, as the temptation is strong to avoid the expense of airways by pushing single entries through to the crop, on the plea that when that is once reached there will be sufficient ventilation.

Cutting the coal.—The undercut, as in other bituminous mines, is usually 3 or 4 feet deep, and is made in the coal immediately above the floor. In some cases a soft slate below the coal forms part of the cut, and rarely the work is done in a middle parting. Powder is used freely at most of the mines, but the block coal on Davis creek and the soft New river coals require very little. Wedges are only used incidentally for breaking down coal already shattered by powder. Black powder is used exclusively in blasting the coal, and high explosives are seldom used even in rock work. No attempt has been made to experiment with lime cartridges or other substitutes for powder.

Tools.—Most miners still use the ordinary coal drill, or jumper, but many of them, especially in the softer coals, employ the breast auger. A ratchet drill is much used on New river for drilling slate holes, and in the harder coals a limited use is made of the patent drills manufactured by Burk, Grimm, Howell, and others. The success of all these depends on careful handling, and they will be slow in displacing the jumper. Power drills, driven by compressed air, have never been introduced.

Machine mining has been tried to a limited extent, but not under favorable circumstances. Both the Lechner and the Harrison machines have been used; the latter at two different mines. Much difficulty was found in keeping up the repairs of the Lechner machines, and when work was suspended and the mine changed hands they were abandoned. The Harrison machines are very effective and require very little repair. Of the two plants introduced here one was removed to Ohio, where it is reported to be doing good work; the other is still at work, and consists of three Harrison machines and an Ingersoll compressor. These machines are being used where it was found very difficult to get any hand labor on account of the hardness of the mining. They are now undercutting in a lower bench, consisting of tough, spongy coal, lying below the usual mining streak. This gives an excessive amount of waste material to handle and makes impossible any true comparison of efficiency. The test of the machines is very severe, as the coal does not fly freely from the pick, which often hangs and remains fixed in the cut. The only difficulties with the Harrison machines have been the breaking of the shank of the pick, usually at the key slot, and the splitting of the forked end of the pick. The former difficulty is being remedied in later machines by enlarging the shank; the splitting of the point is often due to improper forging under a heavy drop hammer, and can usually be checked by a small drill hole heading off the crack.

When labor is abundant and wages are low there seems to be no economy in machine mining, but at other times there are marked advantages, notably in the greater regularity and control of the work, and in its concentration.

Bank wagons.—Whenever it is possible the rehandling of coal is now generally avoided, and the same wagon loaded by the miner is taken to the final shipping point; but when the tramway is very long the wear and tear of the small cars counterbalance the loss and expense of rehandling. The same is true on long and steep gravity planes, especially at mines working thin seams, limiting the size of the cars. When the coal is used wholly or in part for coking the item of loss by breakage disappears, so that on New river the general plan is to use a stock bin at the head of the plane, and to reload the coal into larger cars, known as "monitors," holding from two to four tons.

At most mines the Pittsburgh pattern is followed, and the cars are made without any timber frame, the planks being simply bolted to heavy iron straps. The dimensions are nearly everywhere different, depending greatly on the prejudice of the individual operator so far as regards gauge, diameter of wheels, length and flare of sides, but the height is generally controlled by the thickness of the seam. A fixed axle and loose wheels are generally used.(*a*) This avoids the need of a solid frame, brings the body of the car lower, and is at the same time cheaper. The waste of oil is much greater in lubricating the loose wheels, but this is now being remedied by several patterns of self-oiling box wheels, which carry a supply of oil two to four weeks in regular service, and seem likely to supplant the old patterns. Chilled wheels are generally used, ranging from 10 to 18 inches in diameter. Curved spokes with rounded edges are preferred, to facilitate spragging. Wrought spokes have been tried, but are not regarded with favor.

The use of brakes depends entirely on the grade of the track. When this is generally light no brake is used, but the driver rides on the front bumper of his car and holds it back by pressing with one hand against the mule's rump, using one or more sprags for occasional hills. On steeper grades the driver rides on the hind bumper of the loaded car, which he controls by a brake acting on the wheels of one or both

a See Dr. Chance's opinion on loose and fixed wheels in anthracite mines, page 119.

sides. More attention is now paid to the use of thick solid bumpers, thus avoiding many accidents, besides increasing the durability of the cars.

The capacity of the mine cars varies from 800 pounds to 2½ long tons, but cars of the latter capacity are built with a timber bed-frame, and use wheels fixed on their axles. Cars of the Pittsburgh pattern are rarely built to carry more than 1 long ton.

Mine tracks.—The room roads are usually laid with oak rails, 2 by 3 inches, or 3 by 4 inches; but when the coal is thin, and the cars must be pushed by hand, T iron rails are taking the place of wooden rails in the rooms. Box ties have been generally abandoned, and the wooden rails are now spiked to the ties. Strap-iron on wood is rarely used. Entry roads are laid with iron rails of from 8 to 24 pounds per yard, according to the size of the car employed, the rails in most common use being 12 and 16-pound.

The gauge varies from 2 feet 6 inches to 4 feet 8½ inches. Where there is ample height a gauge of 3 feet 4 inches or 3 feet 6 inches is commonly taken, but in low seams the gauge is increased, and the cars are very much flared, to obtain large capacity with a limited height.

Hauling.—In thin seams the loaded cars are pushed by the miners themselves, or by special laborers, to the room mouth, where the entry roof is shot down or the bottom taken up, giving sufficient height for a horse or mule. Whenever the coal is as much as 4 feet thick, or that height can be cheaply gotten by a little cutting in the floor or roof, small mules are used to haul directly from the miner. In general, mules are preferred to horses, though the latter are cheaper.

No use is made of inside gravity planes, and there are very few mines in the district where there is sufficient grade. No attempt has yet been made to introduce underground haulage by any of the modifications of the endless rope.

Small locomotives are used at many of the mines for service on outside tramroads, but very few mines in the Kanawha region are so arranged or ventilated as to allow their introduction for inside work, and Hawk's Nest is the only place where one is in use.

Drainage.—Most of the Kanawha mines are so situated that the bulk of the water is disposed of by natural drainage, either through the main entry or by a secondary opening on some side ravine, but still the drainage is often an annoying and expensive matter, not so much on account of the quantity of water as because it collects in scattered basins, from which it must be hauled in water boxes at great expense, and to the injury of the roadway. A few small steam pumps are in use, generally so near the bank mouth that the exhaust steam can be led out in pipes. Siphon pipes are used at many of the mines, and are generally started by means of a common hand pump. No use is made of compressed air, and at present only two steam jets are in operation.

Firedamp.—It is generally said that no firedamp is found in mines working above water level, and it has often been asserted that fire-damp is unknown on the Kanawha.

With the exception of some mines on Campbell's creek, which are a few feet below the bed of the stream and are operated by short engine slopes, all the Kanawha and New River mines are above water level, and many of them so high up on the mountain as to have openings on the side valleys of the branch streams. It is true that no serious explosions have ever occurred here, but gas has in several instances accumulated in quantities sufficient to cause slight explosions, scorching the men who have fired it; and cases have also been reported in which the gas escaping from drill holes in an entry has been fired and has continued burning for some time.

The deep depression of the river bed and of the lateral valleys has doubtless aided the escape of gas, and made the present workings safer, but as mining is continued and the openings are extended farther from the outcrop, the probability increases that gas will be found in serious quantities. As yet there are no indications of any amount of firedamp which will not be rendered harmless by even ordinary ventilation, or which will require the substitution of fans for furnaces.

Most of the mines are so damp that the much-disputed question of coal dust, as related to explosions, may be left out of account, but a few of the mines on New river, which are dry and dusty, present features very similar to those of the Pocahontas mine, though on a smaller scale.

Ventilation.—Till quite recently no general attention has been paid to ventilation on the Kanawha. This has been due to the general absence of firedamp and to the possibility of frequent crop openings, as well as to the failure of both operators and miners to realize the importance of the matter. Now that the mines have been extended and pushed farther from the outcrop, the need of increased air is felt, and most of the mines are provided with ventilating furnaces.

The State inspection of mines only commenced in 1883, and it is too soon yet to note any marked results, but it will no doubt be beneficial in stimulating improvement and checking the grosser errors of ignorance and parsimony. Cases are known where in past years headings have been driven entirely too far beyond air, and then, to encourage the miners to persevere still farther, so-called air courses have been started that, when completed, would be of no assistance. The law as now framed is crude and one-sided, bearing principally on the mine owner and giving opportunity for abuse.

Many of the mines are still working by natural ventilation alone, and where they are so situated as to have openings both on the front and on the rear or side of the mountain very little trouble results, especially when the dip of the coal is considerable.

No use is made of ventilating fans, and at many mines there would be difficulty in getting water for steam power where it would be needed, though the power might be transmitted by wire rope from the valley below.

In two cases the attempt has been made to ventilate by compressed air exclusively. Both attempts failed and were soon abandoned. At one mine, where coal-cutting machinery is now employed, the compressed air has been used as an auxiliary to permit driving the headings a longer distance, and with very good results. The air is kept fresh in the immediate vicinity of the working machines, but the volume is too small for practical use in the general ventilation of the mine. It is sometimes stated that the use of compressed air has a bad effect on the slate roof of a coal mine, tending to produce falls, but experience does not seem to justify the assertion.

Gravity planes.—Most of the mines are connected by gravity planes or inclines with their loading works at the railroad or river. Both 4 rail and 3-rail planes are used, and in a few cases 8-rail planes with center tracks of narrow gauge for the safety truck or barney.

The rails are laid either on string timbers or on ties, but the latter are apt to slip and cause the rails to kink where the plane is steep, so that if they cannot be held in place by frequent drift bolts, where outcropping ledges are crossed, light string pieces are sometimes used below the ties to steady them, and blocks are fitted between to brace them apart, the whole being bolted together; this, of course, is only effectual where there is a secure anchorage at the foot of the plane.

Many of the planes are too steep for using a barney to advantage, but where it can be used there is a considerable gain in time, labor, and safety.

Drums and check wheels.—The ordinary drum is from 3 feet to 12 feet in diameter, according to the size of rope and length of plane. The lagging is usually of soft wood. The larger drums are built with wooden segments, and arms secured to cast flanges on an iron shaft. The smaller drums are made with cast-iron spiders. The brake band is often a complete circle, but on large drums is generally halved, and the ends opposite the lever secured as a safeguard in case of breakage, when half the band would still act. The brake is placed either at the middle or at one end of the drum; the former is preferred.

Drums are generally placed overhead, but where a barney is used they are sunk below the level of the tracks.

In order that both ropes may lead from the same level, two drums are sometimes used, connected by cog gearing, to work in opposite directions. They do not meet with favor, on the ground of increased cost, greater space required, and liability to accident.

On ordinary drums two ropes are required, winding and unwinding the length of the plane, but by the use of friction sheaves only a single rope is needed. These are cast sheaves filled between their flanges with end-wood blocks to receive the rope, which takes a sufficient number of turns to prevent slipping. They work in pairs, revolving horizontally, and are controlled either by a single brake or by one on each sheave. There is economy in the space required and in the length of rope used, but the wear of the rope is heavy from the number of bends, apart from the size of the sheaves, which are usually limited in diameter to the distance between the track centers. In case the rope breaks, both cars are likely to be destroyed, and when there is any unequal wear of the end-wood blocks filling the sheaves, their action is liable to become that of an eccentric, bringing an excessive strain on the shafts and rope.

Scales and screens.—The arrangement of scales and screens differs widely for the different classes of coal. On New river the coal is all paid for as run of mine, and is weighed before dumping. It is then either shipped without screening, or if there are coke ovens to be supplied it is passed over screens of varying width of opening, according to the proportion of small coal needed at the time for coking.

At the splint and gas coal mines the miners are paid on the basis of lump coal, and the coal is not weighed till it has been screened. Gas coal is dumped over one-half-inch to five-eighths-inch screens, and the harder splint over screens of 1¼-inch to 2-inch. The coal passing through this coarse screen is again divided into nut and slack by a finer screen of one-half-inch to three-quarters-inch.

Rolled iron screen bars of tapering section are generally used, but improved steel screens with thinner bars are being introduced at new works. No use is made of drum screens.

Coal is estimated at the mines either by the long ton of 2,240 pounds, or by the weighed bushel of 80 pounds. Formerly the gauged bushel of 2,688 cubic inches was used, but scales have now been introduced at nearly every mine, and prove much more satisfactory.

Stock bins and loading arrangements.—Stock bins were formerly used in loading splint coal on the railroad, and they served to equalize the work when the supply of cars was irregular, but the loss from breakage of coal and the extra expense of handling were so great that they have all been abandoned. Now the coal falls from the screen directly into the railroad car, and is there weighed by means of track scales, or else is weighed in a section of the loading chute, known as the weigh basket, and suspended from a scale platform at the landing floor. The outer end of the weigh basket is often suspended from a counterweighted drum, resting on the scale platform and controlled by a brake. The object is to lessen the force of the coal as it comes from the screen, and then to discharge it easily from the weigh basket into the car. Where the tipple is high, the weigh basket may be suspended from two drums and lowered bodily, as described for river tipples.

On New river, where the fine coal is coked, breakage is no objection, and large stock bins are used to advantage. At some of the coke works long sheet-iron pipes have been introduced, through which the coal is dumped, striking a cast-iron block below for the express purpose of breaking it fine. This takes the place of a mechanical crusher.

The Kanawha river is subject to heavy floods and very rapid changes of level. Loading of river barges is carried on from low-water to about a 15-foot stage, when work is usually suspended. The river is liable at any time to rise 25 feet, and in extreme floods 40 feet.

Formerly the incline track was extended into the river and secured to a timber crib filled with rock at extreme low-water level. A movable carriage or slide was used, forming a horizontal extension of the incline, and provided with outriggers or timbers, projecting over the barges into which the coal was dumped. These slides were very heavy, and required frequent moving to adjust them to the varying stages of the river. They are now replaced by high tipples or dumping platforms, built on solid cribs or on piles, and rising 40 to 75 feet above low water. The coal is usually screened at the river, and the slack and nut are led by chutes to their respective barges. The lump coal at the best tipples drops from the screen into the weigh basket, which is suspended at the center by wire ropes leading to a brake drum, and connected with counterweights. The brake drum, with the weigh basket, counterweights, guide arms, stop ropes, and all their connections, are carried on a scale platform. After the coal is weighed the basket is lowered, and may be dumped by means of stop chains from either end; or, if provided with center hinges the stop chains may all be tightened alike, when the basket will open in the center and drop the coal. The object of this is to deposit the coal regularly and lightly, so as to avoid straining the barge, and to make the leveling of the coal easier.

If the coal has been transferred from the mine wagons to larger cars, and already weighed before reaching the river, it is either handled by a drop basket similar to the weigh basket, or else the loaded car, resting on a movable section of the track, is lowered into the barge and there dumped.

When coal shipped in barges is to be sold on the market, it is carefully leveled for gauging, as river sales are not made by weight, but by the measured bushel of 2,688 cubic inches.

The work of improving the Kanawha river is now being carried on by the general Government, and slack-water navigation has already been secured for 18 miles by one permanent and two movable dams. The two dams now under construction will extend the system 15 miles. The river is very rapid in time of flood, and breakwaters are built to protect the tipples and barges against floating drift and ice. Heavy ice is sometimes formed, and much damage has been done at times by gorges. It is hoped that the fixed dams on the upper part of the Kanawha will be a help in the future by holding back the ice for a time, and then breaking it as it passes over.

Barges.—The barges used for river loading are of the Pittsburgh pattern, but are generally made with lower sides. They are 130 feet long by 25 feet wide, costing $1,000 to $1,200 each, and having a capacity of 10,000 bushels of coal when drawing 5 feet. Skeleton barges are also used of the same size and similar in construction, except that their sides are of framework covered with plank, in place of being built of solid timber.

The principal river market for Kanawha coal is Cincinnati, but some is taken as far as Louisville, and a few of the large 20,000-bushel flat-boats have been loaded for the New Orleans trade as an experiment.

Stern-wheel tow-boats are used exclusively, and they can handle from two to twelve barges on the Kanawha, according to the stage of water, but increase the size of their tows on the Ohio, taking twenty or more barges.

Washing and crushing machinery.—Coal-washing machinery has not been used in the district, and the only crusher is one at Hawk's Nest Coke Works, unless the arrangement of rapid discharge through an iron pipe can be called a crusher.

Coke making.(*a*)—The New River slack coal is suited for direct coking, and the coke made at those mines has met with much favor in market. The splint slack does not coke so well, and in nearly all cases is mixed with slate and bone coal or "nigger head;" but as most of the splint mines are within the limits of river navigation, the slack finds a market as a cheap fuel for steamboats and for factories. The slack from the gas coal mines has not been coked with success, but after washing would no doubt make a very good coke. At present these mines are above the limit of river navigation, and the distance by rail to any large manufacturing district is so great that the market is limited and their slack is often a source of expense.

Coke is successfully made at Eagle and at Hawk's Nest from coals belonging to the middle series, and experiments show that there are several seams which, locally at least, will make very good coke.

Beehive ovens of the ordinary pattern are the only ones used except at Hawk's Nest, where a block of eighty Soldenhof ovens has been built. They are a modification of the Belgian oven, designed to quicken the coking process by the combustion of gas in the cellular walls and underlying flues of the ovens. The coke is discharged by a steam ram at the conclusion of the process, and is quenched by the use of water on the yard instead of in the oven.

The location of the Hawk's Nest ovens was a very expensive one, and the firebrick used in their construction proved inferior. The many repairs required on starting the ovens were a great injury to the character of the coke in a process requiring regular work, and as these repairs have been continued up to the present, it is impossible to make a fair comparison between the two systems.

The Soldenhof ovens give a coke with shorter fiber and generally less luster than the beehive ovens. They are more compact and require less labor, but their first cost is very heavy, and they require more repairs. They have not yet proved to possess any advantage over the beehive ovens.

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a See also pages 207–213.