

ON A NEW MODE OF COKING IN OVENS, APPLIED TO THE STAFFORDSHIRE SLACK.

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Many varieties of Coke Ovens have from time to time been invented with a view to economise the cost of coking, which have met with variable success; and attempts have recently been made to perfect the adoption of flues underneath the floor of the ovens, which were tried so long ago as 1853 by Mr. Joseph Dunning and have since been attempted frequently but with only partial success. The subject of coking has a most important bearing upon railways especially; and if coke could be obtained at a cost approximating more nearly to the price of large coals than can possibly be the case under the ordinary system of coking whereby little more than a yield of 50 per cent. is obtained, the advisability of again reverting to coke in locomotives instead of coal would be considered, and would probably be judged expedient.

In the ordinary plan of coking, the oven in which the process is performed is a round chamber about 10 feet internal diameter, as shown in Fig. 7, Plate 22, the floor of which slopes gently from the back to the front; the oven is covered in by a dome springing at about 4 feet from the floor and rising to about 8 feet at the highest point. At the centre of the dome the charging orifice is situated, which serves as a chimney in the simplest form of oven, and as the entrance into the general flue of a series of ovens where a separate chimney is employed. The coke is drawn out through the door in front of the oven, and in some instances the coals are also charged through the door. In such an oven, whether it be open-topped, or whether the gases and smoke instead of being allowed to escape immediately into the atmosphere are conveyed along a general flue to a suitable chimney, the process of coking is carried on from the top of

the coals only, travelling downwards until it reaches the floor of the ovens. But the coking could not be carried on without a considerable quantity of air being admitted during a certain period at least of the process; and the fact is that the coking is effected at the expense of the combustion of a certain percentage of the coke which the charge of coals ought to yield. Were not air admitted, the process would stop; and as it is, the ovens are subject to great irregularities from the uncertain draught in variable states of the atmosphere. This is evidenced by the fact that if the draught of an oven is interfered with the oven does not get "burnt off" as it ought to be, requiring perhaps a day longer to be completed or even more; and when the oven is drawn it will be found that the coke is accompanied with the objectionable appearance due to what are called "black ends" or partially coked coals. This great evil has been in a measure corrected by the adoption of a tall chimney to a series of ovens, but in that case arises another objection: in a long series of ovens it is difficult to make the influence of the chimney felt throughout; and consequently of the two systems the original one is still preferred in some instances.

In connecting a chimney to a series of ovens the arrangement found best is to place say 48 ovens in a double row of 24 each, back to back, with a central flue passing between the two rows into a chimney occupying a central position in the block of ovens. But even in such an arrangement, where the farthest oven is separated by only 11 intermediate ovens from the central chimney, it is found impossible to prevent the speedy burning off of the oven nearest the chimney and the tardy burning off of the farthest, the intermediate ovens varying in their regularity according to their distance. It is said the oven nearest the chimney is capable of being burnt off without intentional admission of air, which in the other ovens is usually allowed to enter by only partially closing the door; but the real fact is that the draught of the chimney exercising its greatest force on the nearest oven draws in a quantity of air, imperceptibly though not the less certainly, through the imperfect joints of the temporary door and of the external and internal masonry; and each oven only apparently requires more air as it recedes from the chimney. At the Gloucester railway station the writer believes it was attempted several years

ago to correct this evil by arranging a series of ordinary ovens in a circle around a central chimney, and no doubt the difficulty as regarded the draught was removed; but from some cause or other the whole system is now swept away. Such an arrangement however as that of a central chimney with the ovens arranged in a circle round it would evidently constitute a marked improvement so far as regularity of draught for each oven is concerned; but it is equally clear that with the ordinary construction of ovens as above described much ground would be sacrificed by such a plan.

The yield of ordinary coke ovens rarely exceeds 50 to 52 per cent. of the coal supplied. The experiments which have been made to bring about the adoption of flued ovens have pointed to the importance of making use of the waste heat from the ordinary coke ovens to assist in the process of coking. Indeed all flued ovens have one common object: to make the waste gases circulate in flues either beneath the floor of the oven, where they are ignited by suitable admission of air; or, as in one instance, around the top, sides, and floor of the oven. As may be supposed, the rapidity with which the coking is performed is greatly increased, and the non-admission of air to the contents of the oven is a source of great increase in the yield: but the wear and tear on this class of ovens is excessive. In one instance, where the waste gases are made completely to envelope the oven, the wear and tear amounts to no less than 6*d.* per ton of coke produced; and in a recent plan the writer understands the flues underneath the floors of the ovens are in a very short time so destroyed that the oven must be laid off for repairs, far too frequently to make the plan commercially successful.

The plan of coke oven forming the subject of the present paper, the invention of Mr. Henry Eaton of Bordeaux, is believed to fulfil the requirements of a good coke oven more completely than ovens on the ordinary plan or those having flues underneath the floor. About the middle of last year the writer, having to decide on the class of oven to be adopted at his Tursdale Colliery in the county of Durham, after a careful investigation into the merits of various plans determined to build an experimental block of 12 ovens on Mr. Eaton's plan at

the Woodside Iron Works, Dudley, with the intention not only of testing the value of the ovens for coking North country coal, but also of trying what could be done in coking the intractable slack of the Staffordshire Thick coal, the "fine" of which has hitherto been thrown away as waste in very large quantities. The success was so far complete that it was both decided to adopt this system at the Tursdale Colliery, where two blocks of 12 ovens each are now in operation on this plan and a third in progress: and a second block has also been erected at Woodside, which has been at work for two months.

The new ovens are shown in Plates 20, 21, and 22. Figs. 1 and 2, Plate 20, are a general elevation and plan of a single block of the ovens; Fig. 3, Plate 21, is a sectional plan to a larger scale, and Figs. 4 and 5, Plate 22, are longitudinal and transverse sections of the ovens.

The ovens, twelve in number, are arranged in the form of a circular block, as shown in Figs. 1 and 2, Plate 20, of 44 feet diameter, round a high chimney in the centre, which causes the draught to be equal upon all the ovens, so that the coking proceeds in all alike with equal regularity. Each oven A, Figs. 3 and 4, opens at the back by a flue into the regulator B, from which is a smaller flue leading into the chimney C. At its junction with the oven the size of the flue is about 18 inches square, reduced at the regulator B to 8 inches square, and at the foot of the chimney it is only 6 inches square. The regulator B is a rectangular chamber covered by a moveable plate perforated with holes for the admission of air to the gases disengaged in the process of coking. The square chimney C is divided at the base by diagonal partitions D, Fig. 3, rising a little above the flue levels, the effect of which is to distribute the draught of the chimney uniformly over the twelve ovens in four sets of three each. The flues do not enter the chimney at the same level, but the middle one in each set of three rises above the two on either side, and thus space is economised in the size of the chimney at the base. The top of the chimney is 3 feet square inside, but this is larger than necessary, and it need not exceed 2 feet 7 inches square. The chimney is lined with firebrick for 12 or 15 feet of its height

from the base, to protect the red brickwork from the intensity of the combustion which there takes place. It will thus be seen that the arrangement of a central chimney and its division at bottom by four partitions creates a most uniform draught in each oven of the block, and this uniformity is one of the most important elements to be secured in coking.

The chimney and ovens rest on a foundation E, Fig. 4, Plate 22, made up of cinders and dry rubbish free from any combustible ingredients, well rammed in to secure solidity, over which is laid about 9 inches of concrete. The whole block of ovens is contained by brick walls bound together by bolts and straps, the latter being wrought to the form of the door frames, which are thereby held in their places. Each oven is covered in by an arch, shown in the transverse section Fig. 5, every portion of which is an arc of the same circle. The turning of the arch has been found to be a matter of some difficulty, to ensure permanency; but has been satisfactorily accomplished in the following manner. To make a perfect skewback for this arch, the angle at which the arch beds on the partition walls of the ovens should vary at every point of the walls, on account of their diverging from one another, as they all radiate from the centre of the block. But it has been found best to adopt a medium angle throughout, and cut the last arch bricks on each side of the oven to bed properly to their place. The rest of the arch bricks are all bedded in planes parallel to a centre line through the middle of each oven; so that after starting from the skewbacks, as the lines of bedding planes lengthen and approach the centre, they leave a parallel strip the whole length of the oven and the arch is easily keyed in. This done, the centering being constructed in three convenient parts can be easily taken to pieces and removed through the mouth of the oven.

The charging of the ovens, where one kind of coal alone is used, is done by wagons holding about 10 cwt. of coal each, which run upon a circular railway F, Fig. 4, Plate 22, on the top of the ovens. When the charging is completed, the moveable hopper G is removed, and the hole in the roof of the oven closed by a large slab and luted all round to make it air-tight. Where a mixture of coal is needed it is usually more convenient to fill at the mouth of the ovens. The

plan, Fig. 2, Plate 20, shows half the block of ovens with the railway for charging through the roof of the ovens, and half without the charging orifices in the roof. The progress of the coking can at all times be inspected through a sight hole in the top of the door of each oven, which is closed by a small fireclay plug. When completed the coke is withdrawn very easily from the ovens, as the partition walls are radial and diverging from each other. For watering the coke previous to drawing, a water main H, shown in section in Fig. 4, encircles the block of ovens, having suitable standards fitted with india-rubber hose pipes; at the end of the hose is attached a long gas tube which is put in through the mouth of the oven and moved about to direct the water over the surface of the coke. For facility of handling the tube and working the tools used in drawing the coke, a small portable crane I, Fig. 1, is provided, easily shifted by a couple of men, having a double hook roller, shown in Fig. 6, Plate 22, over which the tools move easily.

The mode of working these ovens is in the first place to dry them off in the usual way, which takes four to six days from the first lighting of the fires. When sufficiently heated, the ovens Nos. 1-4-7-10 are cleared of ashes and charged on the first day, the heat being purposely kept up in the rest of the ovens till they are in their turn charged. On the second day the ovens Nos. 2-5-8-11 are charged, and on the third Nos. 3-6-9-12. By this plan of charging the heat of Nos. 12 and 2 is assisting to impart heat through the partition walls to No. 1 between them; the same takes place with Nos. 4-7-10, each between a pair of warm ovens. For 24 hours therefore Nos. 1-4-7-10 have the advantage of adjacent heat, by which time they have acquired sufficient temperature to permit of the drawing and charging of the one set of adjacent ovens Nos. 2-5-8-11 on the second day without injury. Indeed the first ovens have acquired a sufficient degree of temperature to assist in starting the operation of coking in the ovens charged on the second day. The same remarks apply to the charging of ovens on the third day, those of the first and second day both now assisting to start the coking process in Nos. 3-6-9-12 charged on the third day. For 24 hours the ovens charged on the first and second day are now reacting upon one another, whilst those

charged on the third day are being urged forward to a degree which will enable them on the fourth day to permit of the drawing and recharging of Nos. 1-4-7-10.

In applying the new plan of ovens to the coking of the fine slack of the Staffordshire Thick coal, it is mixed either with bituminous slack from South Wales or with a smaller portion of pitch, in order to impart the necessary caking quality, the want of which has rendered the Staffordshire slack incapable of conversion into coke by any plans previously tried. In either case the requisite binding property is now obtained, and the coke is produced in lumps of large size and excellent quality, and is found of particular value in the blast furnace. With a mixture of 45 per cent. of Staffordshire slack and 55 per cent. of bituminous Welsh slack, the yield regularly obtained in the first block of ovens at Woodside, which is only 42 feet diameter, has amounted to from 55 to 60 per cent. of coke. With a mixture of 75 per cent. of Staffordshire slack and 25 per cent. of pitch, the yield has been from 50 to 53 per cent. of coke. The fluctuations in the yield arise from the variations in the quality of slack obtained from different places, some requiring more bitumen to bind it together. Where the binding is not perfect, considerable waste ensues in drawing the coke. To correct this has been the object of some recent experiments, in which a mixture of 44 per cent. of Staffordshire slack with 44 per cent. of Welsh slack and 12 per cent. of pitch has been used, resulting in a regular yield of from 60 to 65 per cent. of coke. Specimens of coke are exhibited to illustrate the respective binding power of the different mixtures described. The best yields however, as may be supposed, are obtained from coals which contain a sufficient proportion of bitumen to secure binding without admixture: such as the bituminous or caking coals of Durham, Newcastle, and South Wales, from which results of 67½ to 70 per cent. yield of coke are uniformly obtained in these ovens. These results have been obtained from coals supplied from the Brithdir Colliery in South Wales, Pease's West Colliery in Durham, and the TurSDale Colliery in Durham.

In the first block of the new ovens at Woodside, which gave the yields of coke above stated from the Staffordshire slack, the partition walls between the ovens were built 9 inches thick. It is evident however that the thinner the partition walls the more perfect is the communication of heat between the ovens; and the writer found in the erection of the first block of ovens that 9 inches make too thick a wall. The consequence of this mistake was that the quantity of coke produced was not so great as expected, since it was absolutely necessary to assist the progress of the coking by a large admission of air. In France, where Mr. Eaton made his first experiments and where the new ovens have been in operation for several years, the partition walls were about $6\frac{1}{2}$ inches thick. At the Briton Ferry Iron Works in South Wales, where it was decided to adopt this plan of ovens from the success of those at Woodside when they had been at work only a few weeks, the partition walls were built only half a brick or $4\frac{1}{2}$ inches thick, and the results were more satisfactory than any that Mr. Eaton had obtained in France. This was to be attributed solely to the diminished thickness of the partition walls, and led the writer to test the point practically in the first block of ovens erected at Tursdale. In order to make a fair comparison, six ovens of the block were built with $4\frac{1}{2}$ inch partition walls, and six with 9 inch walls. The result was that in the same time $12\frac{1}{2}$ per cent. more coal could be coked in the ovens separated by only $4\frac{1}{2}$ inch walls than in those with 9 inch walls. The thickness of $4\frac{1}{2}$ inches is as little as can be safely used for the partition walls, and it was at first feared they might prove a little weak, being $8\frac{1}{2}$ feet long with an average height of $4\frac{1}{2}$ feet; but bound as they are on all edges they have proved to be thoroughly substantial, and it is intended to adopt this thickness in future. It has already been adopted with perfect safety in the two instances above mentioned, at Briton Ferry and at Tursdale.

The economy secured in the new plan of oven arises from the circumstance that the heat requisite to start and urge the oven forward is supplied chiefly by radiation from the partition walls; and in a few cases only, owing to peculiarity of coal, is it at all necessary to assist the progress of the oven by the admission of air. The

principle of the oven aimed at is the entire exclusion of air, in order to prevent entirely the waste that takes place by partial combustion of the coke in the ordinary process; and this object is attained with certain rich gaseous or bituminous coals. But when dealing with intractable material, air is still needed: from 2 to 3 square inches of air space given beneath the door are amply sufficient to meet the case of the mixture of 45 per cent. of Staffordshire slack and 55 per cent. of Welsh bituminous slack. Whatever air is given to any oven, it is of the greatest importance to introduce it at the commencement of the coking process and not at the end. When introduced during the first period of the operation, its effect is to mix with and burn the gases which are being disengaged in great abundance from the coals, doing the coke very little injury: whilst its introduction towards the end of the operation is productive of serious mischief, for when the gases are beginning to clear off the air is free to attack the surface of the coke, and does so. To this fact there is a remarkable and curious exception in the case of the manufacture of coke from a mixture of Staffordshire slack and pitch, which seems to be accounted for by the formation of a silicious film or crust over the entire surface of the coke, which most effectually shields it from the action of the air. In all cases however, after the gases have ceased to be evolved in quantity sufficient to fill the oven, the further admission of air is prejudicial to the finishing off of the charge, by cooling down both the coke and the oven which contains it. At this period of the operation therefore, as is found the case in the first block of ovens erected at Woodside, it is necessary entirely to exclude the ingress of air, in order to prevent the rapid loss of heat which the oven otherwise sustains. When the air is thus excluded the oven has acquired a sufficient heat to complete the expulsion of all the gases that remain to be evolved, which are seen to issue burning as small jets of flame from the cracks in the mass of the coke. The regulator B, Fig. 4, Plate 22, allows the admission of air beyond the oven through the perforated cast iron plate which covers it, forming a perfect smoke consumer.

The area of the flue opening from the regulator into the chimney is a matter of considerable importance, and admits of an efficient adjustment by simply inserting pieces of firebrick in the passage of the

flue. This is a particular convenience where from any exceptional cause the admission of a considerable quantity of air is needed, as already referred to in the case of the first block of ovens erected at Woodside. Here the simple reduction of the area of the flue from 49 to 30 square inches at its passage out of the regulator occasioned an increased yield of 5 to 6 per cent. of coke. For with the flue full open, the draught of the chimney drew in more air than was required when the greater part of the gas had been driven off, and a surface combustion of the coke ensued with an intense heat, while the yield was sacrificed. It was found impossible to adjust the supply of air so nicely as to prevent waste while the coking proceeded, except by means of reducing the area of the flue, which proved quite efficient. Since in all classes of ovens perfectly air-tight work can scarcely be secured, the regulation of the area of the flue is a matter of importance even where the air is purposely excluded during the coking, in order to prevent its being drawn into the oven through the innumerable small interstices in the brickwork. The prevention of the undue admission of air by this simple expedient was attended with a diminution of the quantity of coal which could be coked in the same time; but this was counterbalanced by the increased yield of coke from the smaller quantity of coal charged. It may be that the checking of the draught has a beneficial influence by causing the gases to lie back a little longer in the oven and there expend a little more of their heat by being more completely consumed. On the other hand it is possible to reduce the flue area too much: for when it was attempted to work with the flue reduced at the passage from the regulator from 49 to about 23 square inches area, the effect ceased to be of any benefit, and on the contrary was slightly injurious in retarding the rapidity of coking and perceptibly lowering the temperature of the oven.

When the coking is completed, the communication between the oven and the chimney is cut off by a damper, consisting of a plain wrought iron plate, which prevents air from being drawn in through the brickwork whilst the coke is lying as it should do from two to four hours after disengagement of gas has to all appearance ceased. The fact is however that a slight disengagement is still though imperceptibly going on, which is made manifest by opening the door of the

oven, when immediately the gas is seen burning at the surface of the coke. It thus gives an improved appearance to the coke to let it lie a little, by getting rid of a tinge of dark colour which exists at the bottom of the coke if drawn too soon after being done.

As regards the general size of the new ovens, it is thought at present that 44 feet external diameter will prove the most convenient, as shown in Figs. 1 and 2, Plate 20 ; though at the Tursdale Colliery the first and second blocks are constructed 48 feet diameter. The objection to the large size is the necessity of providing for a greatly increased expansion of the structure.

As regards the quantity of coke which can be produced from a block of ovens, the second block at Woodside, 44 feet diameter, has turned out about 60 tons of coke per week during the two months that it has been in work. The first block at Woodside, 42 feet diameter, has scarcely turned out 55 tons per week, for the reason already given of too great thickness of the partition walls: whilst the first block at Tursdale, 48 feet diameter, where half the walls are $4\frac{1}{2}$ inches thick and half 9 inches, is capable of turning out 80 tons per week. The block of ovens at Briton Ferry, 44 feet diameter with $4\frac{1}{2}$ inch partition walls, is turning out from 65 to 70 tons of coke per week; and so satisfied are the proprietors that a second block has been erected.

As regards the time occupied in coking, an ordinary oven of 11 feet inside diameter with 95 square feet of floor area will burn off a charge of $5\frac{1}{2}$ to 6 tons of Newcastle or Durham coals in 72 hours. One of the new ovens with 97 square feet of floor area, in the first block at Tursdale 48 feet diameter, with 9 inch partition walls, burns off $4\frac{1}{2}$ tons in 72 hours with only a trifling difference in the gross amount of coke produced. But no account is here taken of the irregularities to which ordinary ovens are subject, and of which some idea may be formed from an incident that took place with the first block of the new ovens at Tursdale. Red bricks having succeeded perfectly in the chimney at Woodside were employed without hesitation in that at Tursdale; but owing to the increased size of the block of ovens, 48 feet diameter instead of 42 feet, and the more intense character of the combustion of the bituminous coals as

compared with the mixture of Staffordshire and Welsh slack, the heat was too great and caused the red brickwork to melt, and ended by closing up every flue. The chimney was then lined with firebricks: but during the time occupied in lining it, the ovens, which were then working in effect as ordinary open-topped ovens, worked most irregularly, never came up to their proper time, and in one instance a three days' charge occupied six days to burn off. It is not meant that ordinary ovens would be frequently subject to such an extreme irregularity as that just mentioned: for in the absence of the central chimney an oven of the new form is ill calculated to create a sufficient draught; whereas in an ordinary dome oven with chimney at top everything is pretty favourable for the admission of the requisite air. Irregularities of one or even two days in ordinary ovens are however of not unfrequent occurrence; and coupled with the accident which led to the necessity of working the new ovens at Tursdale Colliery without the assistance of the central chimney, they show of how great importance the chimney is to secure good and reliable results.

The cost of erection of a block of ovens on the new construction has been as follows at the Woodside Iron Works, the block being 44 feet diameter:—

35,000 Firebricks and clay	112	0	0
27,000 Red bricks and mortar	33	0	0
Cast and wrought ironwork	91	10	0
Tools	8	10	0
Labour in excavation, bricklaying, and concrete, &c.	70	0	0
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	£315	0	0

This gives £26 5s. as the cost per oven, complete with water fittings, coke benches and tools, but exclusive of any attendant conveniences for keeping the coke in stock. The cost is of course subject to the addition of carriage of materials for erection at any other site, and minor modifications for the variation of circumstances. Where a mixture of coal is not wanted, the ovens can be made with a circular railway so as to be filled from the top, as at Tursdale, the additional expense of which is about £6 per oven.

The cost of working the new ovens where a uniform quality of coal is used is slightly in excess of the working of ordinary ovens in one particular only, that of loading up the coke from the benches into the wagons. In a straight row of ovens nothing is simpler than to run a train of wagons alongside the benches, off which the coke is conveniently filled at one lift. Against this there is the advantage that the labour of cleansing and charging the coal in the case of the new ovens is divided over a larger quantity of coke produced from the same quantity of coal; so that really the difference if any is but slight. The working cost per ton of coke made has been as follows, in the ovens already at work at Tursdale, 48 feet diameter :—

2 men drawing ovens, levelling coals, manufacturing, and keeping coke benches clean, at 3s. each per day, (coke made per day 12 tons) . . .	6d. per ton.
2 boys cleansing coals and charging with tubs, at 2s. 8d. each per day to feed 3 blocks of ovens . . .	1½
Wheeling and loading coke into wagons . . .	2½
Interest on outlay, say £450 to cover incidentals, at 5 per cent. . . .	1½
Redemption in say 7 years . . .	3½
Wear and tear say	¾
Royalty	3
Total cost of coke exclusive of coals . . .	<u>1s. 7d.</u> per ton.

In Staffordshire, with the mixture of slack and the charging done at the mouth of the oven instead of from the top, as might be expected the labour is somewhat greater, while the outlay is about £75 less per block. The cost per ton of coke made in this case is as follows :—

4 men drawing and charging ovens, mixing slack, &c., at 3s. 4d. each per day, (coke made per day 9 tons) . . .	1s. 6d. per ton.
Interest on outlay, say £375, at 5 per cent.	1½
Redemption in say 7 years . . .	4
Wear and tear say	¾
Royalty	3
Total cost of coke exclusive of slack &c. . .	<u>2s. 3d.</u> per ton.

To the above particulars of cost it is simply necessary to add that of material to arrive at the total cost of the coke manufactured. Taking the value of a North country bituminous slack at 3*s.* 6*d.* per ton, and a yield of 68 per cent. of coke, the cost of coals would be 5*s.* 2*d.* per ton of coke produced. Adding this to 1*s.* 7*d.* the cost of working, the total cost of the coke into wagons would be 6*s.* 9*d.* per ton. It is of course impossible to fix on any uniform price at which to charge the slack: some collieries produce "duff," as the small of the coal is called, in such abundance as to make them glad to have a means of getting rid of it; others set a higher value upon it. Hence it is for each in his particular circumstances to determine how far the adoption of the new system is economical.

It is easier to arrive at the real cost of the coke manufactured in the Staffordshire district, where slack suitable for the purpose can be bought in any quantity at 2*s.* 6*d.* per ton. Assuming this price, the mixture of 45 per cent. of Staffordshire slack at 2*s.* 6*d.* per ton with 55 per cent. of Welsh slack at 12*s.* per ton will cost 7*s.* 9*d.* per ton: and a yield of 57½ per cent. makes the cost of the coke 13*s.* 6*d.* per ton. Adding this to 2*s.* 3*d.* the cost of working, the total cost of the coke amounts to 15*s.* 9*d.* per ton.

The mixture of 44 per cent. of Staffordshire slack at 2*s.* 6*d.* per ton with 44 per cent. of Welsh slack at 12*s.* per ton and 12 per cent. of pitch at 20*s.* per ton costs 8*s.* 9*d.* per ton; which with a yield of 62½ per cent. makes the coke cost 14*s.* per ton. Adding this to 2*s.* 3*d.* the cost of working, the total cost of the coke from this mixture amounts to 16*s.* 3*d.* per ton.

The mixture of 72½ per cent. of Staffordshire slack at 2*s.* 6*d.* per ton with 27½ per cent. of pitch at 20*s.* per ton costs 7*s.* 4*d.* per ton; but the yield in this case is only about 52½ per cent. of coke, owing to the very volatile character of the pitch, and the coke therefore costs 14*s.* per ton. Adding this to 2*s.* 3*d.* the cost of working, the total cost of the coke made from Staffordshire slack with pitch alone amounts to 16*s.* 3*d.* per ton.

As regards the wear and tear on the brickwork of the new ovens, there seems every likelihood that this is very small and unimportant.

A small allowance has however been made in each of the above estimates of the working cost. The first block of ovens erected at Woodside has been in operation since June last year, a period of nearly a year, and does not show the slightest indication of requiring repairs to the brickwork. A little repair has been needed at the door frame castings, owing to the irregular expansion of the casting by heat and its weak form; but the liability to fracture in the faulty plan first adopted has been in a great measure corrected by an amended form of frame.

Among the advantages which attach to the new form of oven is its compactness, which is of importance and is a reason why the oven should be much cheaper in its construction than ordinary round ovens. Taking the case of a double row of ordinary ovens placed back to back, 11 feet internal diameter, the floor area of which would be 95 square feet, with a flue between them common to both leading to a chimney, such a series of 6 ovens in length or 12 ovens in the double row would cover a space of ground $84 \times 28 = 2352$ square feet; whereas the space covered by the largest block of the new ovens yet erected, 48 feet external diameter, is only 1810 square feet, while the floor area of each oven is 100 square feet, the partition walls in this case being $5\frac{1}{2}$ inches thick. Including the coke benches 9 feet wide in the case of the double row of ordinary ovens, the ground occupied would be $84 \times 46 = 3864$ square feet: whilst in the case of the 48 feet block of the new ovens a greater area of ground is covered, taking a square larger by 18 feet than the diameter of the oven, giving $66 \times 66 = 4356$ square feet; with the advantage however of larger stacking room for the coke, for whilst the bench room in the first case cited of 12 ovens in a double row is $84 \times 18 = 1512$ square feet, that of the 48 feet block is 2546 square feet.

In connexion with the subject of rapid coking, a few interesting laboratory experiments have been made at the writer's works. The material operated upon was the coal from the Tursdale Colliery, the composition of which was as follows:—

Carbon	81.46
Hydrogen	7.89
Nitrogen	2.91
Sulphur	1.34
Ash	3.26
Difference (oxygen)	3.14
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	100.00
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The yield of coke which any coal is capable of producing depends in a certain measure upon its constituents. In general the gaseous products cannot be expelled without carrying off with them a certain proportion of carbon. Could all the hydrogen, nitrogen, sulphur, and oxygen be expelled without carbon, the coal of which the above is an analysis should yield nearly 85 per cent. of coke: but the highest result obtained in the laboratory was only 69½ per cent. The yield of coke however is dependent also to a certain extent upon the rapidity with which the coal is raised to the coking temperature, as the following five experiments will show.

In the first experiment two crucibles carefully covered, containing Tursdale coal, were introduced into a close muffle, so that access of air to the contents of the crucible was rendered impossible. The muffle was at a very bright red heat, and the crucible having been put into it the mouth of the muffle was temporarily stopped. In one hour afterwards the crucible was removed, and the percentage of coke in one crucible was 62.18 and in the other 61.28.

In the second experiment a crucible was introduced into the muffle when cold, and the temperature gradually raised during one hour to cherry red, and then maintained for half an hour at a bright red heat. The yield in this case was 66.12 per cent. of coke.

In the third experiment two crucibles were introduced into the muffle when at a bright red heat, but not so hot as in the first experiment, and the temperature was maintained for an hour. One crucible gave 64.77 per cent. of coke and the other 64.20 per cent.

In the fourth experiment a crucible as in the second experiment was introduced into the cold muffle, and the temperature raised in an hour and a half to cherry red, instead of occupying only one hour as in the former case. The resulting yield was 67.50 per cent. of coke.

In the fifth experiment a crucible introduced into the muffle at a dull cherry red heat and kept at that temperature for one hour yielded 69·40 per cent. of coke. A second crucible raised in one hour to a dull cherry red heat and kept at that heat for one hour also yielded 69·40 per cent. of coke.

It appears from these experiments that the more rapidly the coal is coked or the higher the temperature of the oven into which it is introduced, the less the yield; and this is no doubt due to the greater readiness with which compounds of carbon and hydrogen containing an increasing proportion of carbon are formed, the more sudden or the greater the intensity the heat. On the other hand it was noticed in the above experiments that the coke more slowly made was more bulky, that is less dense, than that made more rapidly. This result fully accords with that obtained in some flued ovens in the north, the invention of Messrs. Breckon and Dixon; the coke produced by the flued ovens being much denser in character than that made in ordinary ovens. How far yield is interfered with by the use of flues is a question which admits of further enquiry; and at some future time the writer may be in a position to make a comparison between Tursdale coke produced in flued and non-flued ovens in order to determine this point. Taking an average however of several specimens of coke produced in ordinary ovens from North country coal, the specific gravity is only 1·00, whilst the specific gravity of Tursdale coke made in the new ovens is 1·47. However much therefore this high specific gravity of the coke may be due to some favourable peculiarity of the coal, it is evident that in the new mode of coking both yield and density are secured. There is a further objection to coking from the bottom of an oven upwards, as in ovens having flues underneath the floor, from the fact that the two processes meet in an irregular plane about one third of the way up from the floor of the oven, and there result two measures, so to speak, of coke. This is perhaps a trivial objection, inasmuch as it interferes only with the commercial appearance of the coke and is no real detriment to its quality; still it is one which is obviated in the new ovens.

The CHAIRMAN exhibited specimens of the coke made in the ovens, illustrating the respective binding properties of the different mixtures of slack employed. He observed that the main object of the plan of coking now described was to effect economy of material in ironworks by making use of the great quantity of fine slack that was at present thrown away as waste ; which was of particular importance in the South Staffordshire district, where they were gradually getting short of material by the rapid consumption of the Thick coal within the limits at present worked. Attempts had previously been made to coke the fine slack by itself, but had quite failed ; and he had then tried it mixed with Welsh bituminous slack, to impart the requisite binding property, and with pitch. By this means the refuse ordinarily thrown away was converted into a coke even superior to the best coke made from the large Thick coal, the proportion of pitch mixed with the slack being about $27\frac{1}{2}$ per cent. of pitch to $72\frac{1}{2}$ of slack. The coke obtained had all the excellent qualities of the Thick coal coke, and the same freedom from injurious ingredients, since the pitch imparted no noxious elements. In bringing the subject forward for discussion his object was to show the practicability of the plan by the results already obtained ; and also to ascertain how far the same process was capable of being extended to other non-caking coals, and whether the new form of ovens was suitable for other districts, as had already been found to be the case in the trial of the ovens at Turstable with North country coals and at Briton Ferry with South Wales small coals. He was indebted to his son for carrying out the several experiments that had been made with different mixtures of slack.

Mr. W. HADEN quite agreed with the importance of the subject ; for if they were enabled to make a really good and regular coke from the waste slack of South Staffordshire it would be a great gain to the district. He enquired what was the effect of using a smaller proportion of pitch with the slack.

The CHAIRMAN said with a smaller proportion of pitch the mixture was not sufficiently binding, so that the coke produced would not hold together, but came out of the oven all in small pieces.

Mr. N. N. SOLLY enquired whether any trial had been made of New Mine slack for coking ; and whether the Thick coal slack had been tried by itself since the new ovens were got to work.

The CHAIRMAN had not yet tried New Mine slack, and the Thick coal slack would not bind at all by itself.

Mr. N. N. SOLLY asked whether the flues from the ovens to the chimney had ever got choked up with any accumulation of dust, in consequence of using entirely the fine slack for coking.

The CHAIRMAN said there was not the least accumulation in the flues, the draught on the ovens being so strong as to carry off any fine particles of slack.

Mr. SAMUEL LLOYD suggested that a saving might be made by placing a vertical boiler in the centre of the block of ovens, where the chimney at present stood, so as to economise the heat passing off from the ovens. He thought the heat would be found considerable from so many ovens, as four moderate sized coke ovens at their works at Wednesbury gave heat enough to raise the steam of a boiler 28 feet long and 8 feet diameter. The chimney might be placed in any convenient position near, with an underground flue to it from the ovens.

The CHAIRMAN replied that in this instance the boilers were too far off from the ovens to make that practicable; and it would be a question whether it was really advisable to encumber the ovens with a boiler, as there did not appear to be gas enough escaping from the chimney to be worth the trouble of saving.

Mr. E. A. COWPER asked what sort of coke was made in the ovens referred to at Wednesbury, whether as large and dense as that shown from the new ovens; for if there were gas constantly burning out of the chimney there must be a waste of material in the oven and a smaller yield of coke.

Mr. S. LLOYD replied that the coke made at those ovens was only a light soft coke.

The CHAIRMAN remarked that the new ovens had an important advantage in the greatly increased density of the coke produced, which had a great deal to do with its quality as fuel and its value in the blast furnace: with the mixture of fine slack and pitch, the specific gravity of the coke produced was as much as 1.25 or 1.30; and the Tursdale coke made in the new ovens had a specific gravity of 1.47, while that of the best North country coke scarcely reached 1.00 in

the regular make. This showed clearly the importance of preventing the waste of so much valuable material out of the coke, which at present took place with ordinary ovens. The specific gravity was ascertained by weighing the coke solid in air and in water.

Mr. J. E. SWINDELL asked what was the value in the blast furnace of the coke made by the new method, as compared with the best North of England coke.

The CHAIRMAN replied that there was no question as to the superiority of the Staffordshire slack; it made a better and purer coke than the North country coals, whether coked with pitch alone or with a mixture of Welsh slack and pitch. With Durham coke they were not able to make a good open-faced grey forge pig, but with this coke good grey pig was regularly made. It also gave a better yield in the furnace than either the Durham coke or that made from the Thick coal.

Mr. S. LLOYD supposed the coke would be more free from sulphur than the North country cokes.

The CHAIRMAN said that was the case, the slack being like the Thick coal itself for purity of quality.

Mr. E. A. COWPER asked whether any means were taken to rid the slack of iron pyrites by having it picked before being put into the ovens.

The CHAIRMAN replied that the slack was not picked or cleaned in any way before coking, but was put in the ovens just as it was thrown over the bank; the fine slack that he was using was the refuse left after the coarse slack had been screened for making what was called breeze to be used under boilers and for other purposes. In this way 60 tons of good coke per week were now being produced from refuse coal slack previously of no value whatever.

Mr. W. HADEN had no doubt many colliery owners would be glad to supply any quantity of the refuse slack for coking, merely for the sake of getting rid of it out of the way.

Mr. J. MURPHY enquired whether the mixture of Welsh slack or pitch alone produced the cheapest coke.

Mr. C. COCHRANE replied that the coke made with pitch alone was decidedly the cheapest at their works at Dudley, about 1s. per ton

cheaper than with Welsh slack, on account of the price of the Welsh slack and the cost of conveyance from such a distance. The cost of the two modes of coking in any locality depended of course on the relative cost of the materials for mixing ; and the estimated cost given in the paper was of a general character, based upon the full market value of the pitch and Staffordshire slack, which however had been obtained at a lower rate in this particular instance at their works at Dudley.

Mr. J. MURPHY enquired which coke was best for ironmaking.

Mr. C. COCHRANE replied that the mixture with pitch alone gave the coke that made the best iron ; with this coke grey forge pig iron could be produced with great facility, as the sulphur contained in the coke was not more than 0·8 per cent., whilst that quality of iron could not be made with Durham cokes at all.

Mr. J. PADDON observed that the economy and advantage of any mode of coking would vary much in different localities, according to the quality and cost of materials in the district. In Staffordshire it was a great object to economise the waste slack now thrown away as useless ; and the plan of coking just described converted into a valuable fuel what was otherwise worthless. In some parts of South Wales also there was material which had never before been converted into coke, such as the Aberdare slack and other small coals, and this was now coked in the new ovens by mixing with it a portion of bituminous slack. In other parts of South Wales however the case was not the same, the cost of slack being not more than 2s. or 3s. per ton less than that of the whole coal : where the slack was bituminous it made good coke by itself without any mixture, and anthracite slack was mixed with half as much of the bituminous slack, producing one of the best blast-furnace cokes in South Wales, which cost only 8s. 6d. or 9s. per ton.

The value of the new ovens he thought had been rather understated in the paper than the contrary, the coke having been weighed dry immediately on being drawn ; but if stacked and left exposed to the atmosphere for some time, as was usually the case, it absorbed a considerable proportion of moisture which increased the apparent weight ; and in estimating the commercial value of the coke as

compared with that made in the ordinary ovens, both should be weighed under the same conditions. Even without this precaution however the new ovens appeared decidedly superior in yield; he was satisfied they would yield in regular work as much as 70 to 75 per cent. of the coal used, and knew of one instance in which the yield reached 78 per cent., when the coke would have weighed still more if it had been left stacked after drawing. As regarded the duty of the coke in the blast furnace, he had seen the new ovens working at the Briton Ferry Iron Works, and was informed by the furnace manager that the coke from the new ovens did fully 7 per cent. more duty and was a finer coke than any made from the same coal in ordinary ovens.

The new ovens had therefore a superiority not only in the greater yield and density of the coke produced, but also in giving the means of making a commercially valuable coke from a material never before successfully employed for any useful purpose; and he was sure the economical using up of the vast quantities of waste slack at present thrown away was a most important problem for the future prosperity of the South Staffordshire district.

Mr. J. ANDERSON moved a vote of thanks to the Chairman for his very interesting and valuable paper, which was passed.

The following paper, communicated through Mr. Walter May of Birmingham, was then read:—

Fig. 1. General Elevation

of Eaton's new Coke Ovens.

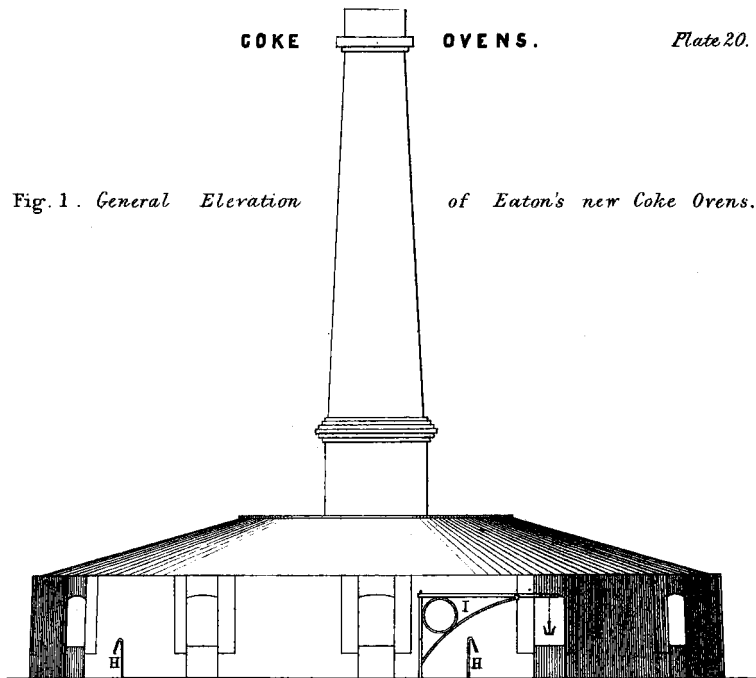
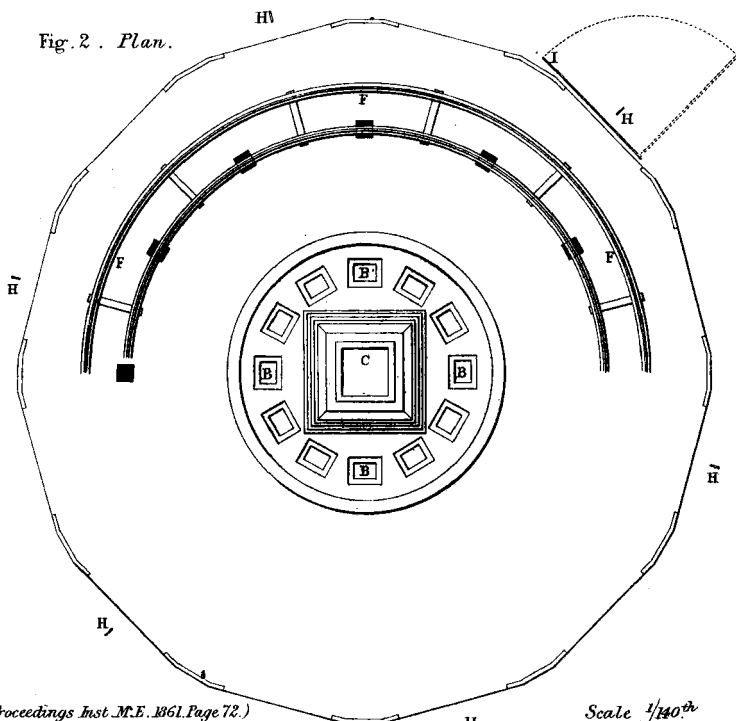


Fig. 2. Plan.



COKE OVENS.

Plate 21.

Fig. 3.

Sectional

Plan

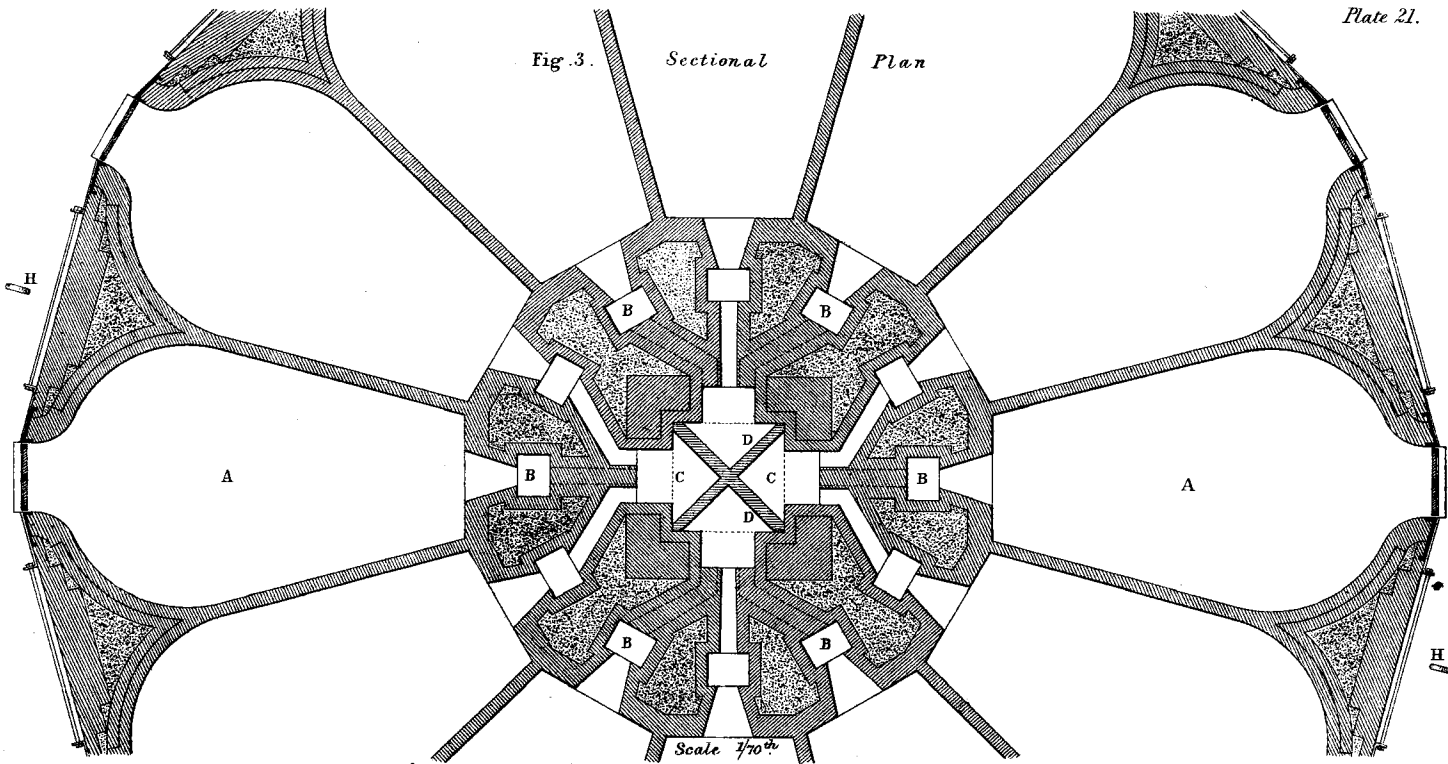


Fig. 5. Transverse Section.

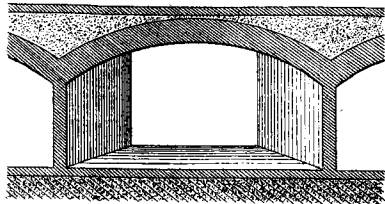
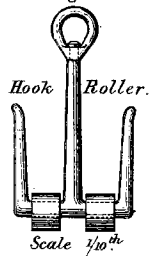


Fig. 6.



COKE OVENS.

Fig. 4. Vertical Section.

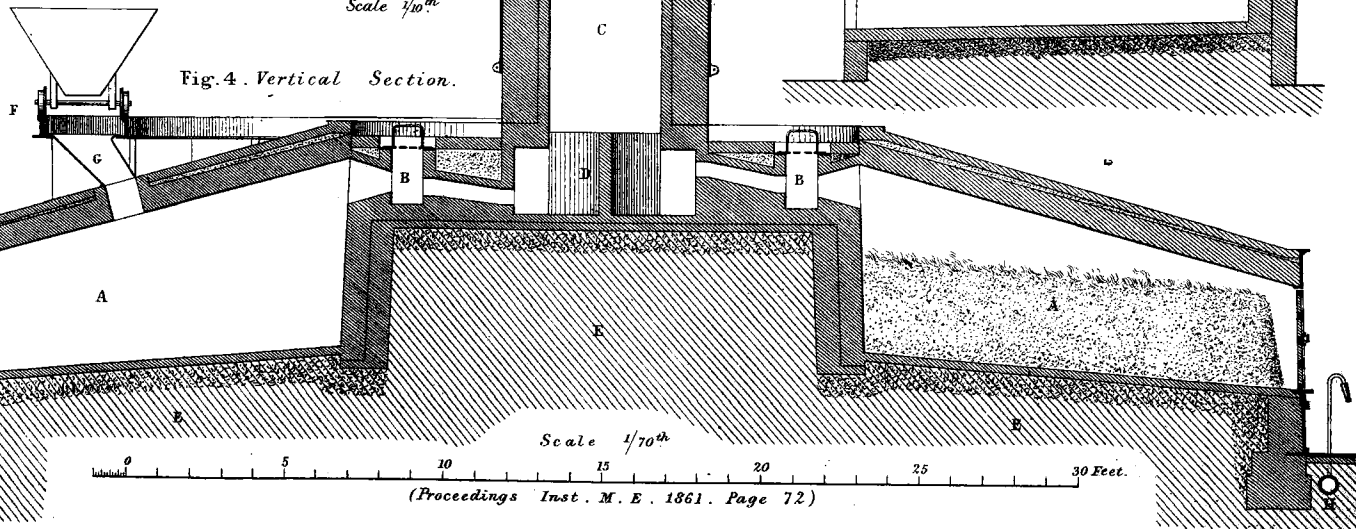


Plate 22.

Fig. 7.
Section of
Ordinary Oven.

