intense heat. Lignites and dry coals, which decrepitate and fall almost into powder when heated, can be used effectively on step grates for firing boilers, although a considerable excess of air may pass through the grate, because gases, whose temperature would cool iron piles at a welding heat, can yet afford ample heat to raise steam in a boiler.

The lignites in some parts of Austria contain, when freshly mined, as much as 40 to 50 per cent. of water, which, on exposure of the fuel to the air, will fall to 20 or 30 per cent.; while in other districts peat or wet saw-dust is the only fuel available. All these materials can be efficiently used for heating furnaces, provided they are first converted into combustible gases in a gas producer. Those containing too great an excess of moisture, must have the excess of water removed, by passing the gas through cooling tubes, or spraying cold water amongst it. If the gas contains much incombustible gases, the air for combustion must be raised to a high temperature before being mixed with it.

Siemens Regenerative Gas Furnace.—Producer gas, made from such materials, was in use, with more or less success, in several places where good fuel was unobtainable, before the expiration of the first half of the last century; but it was not until the Brothers Siemens patented their regenerative furnace in 1856, and producer for working it in 1861, that the principle of gas-firing can be said to have made much advance commercially. As the Siemens melting furnace and producer have already been so fully described, it will suffice to say that the Siemens reheating furnace differs from the former chiefly because, a much lower heat being necessary, its hearth is much larger in proportion to the capacity of the regenerators; while the hearth, instead of being sunk for some distance below the level of the charging doors, is practically level with them.

According to Holley, the Siemens reheating furnace consumed only 350 to 400 lbs. of fuel, to heat the same material which required 800 to 1,000 lbs. in the ordinary coal-fired furnace.

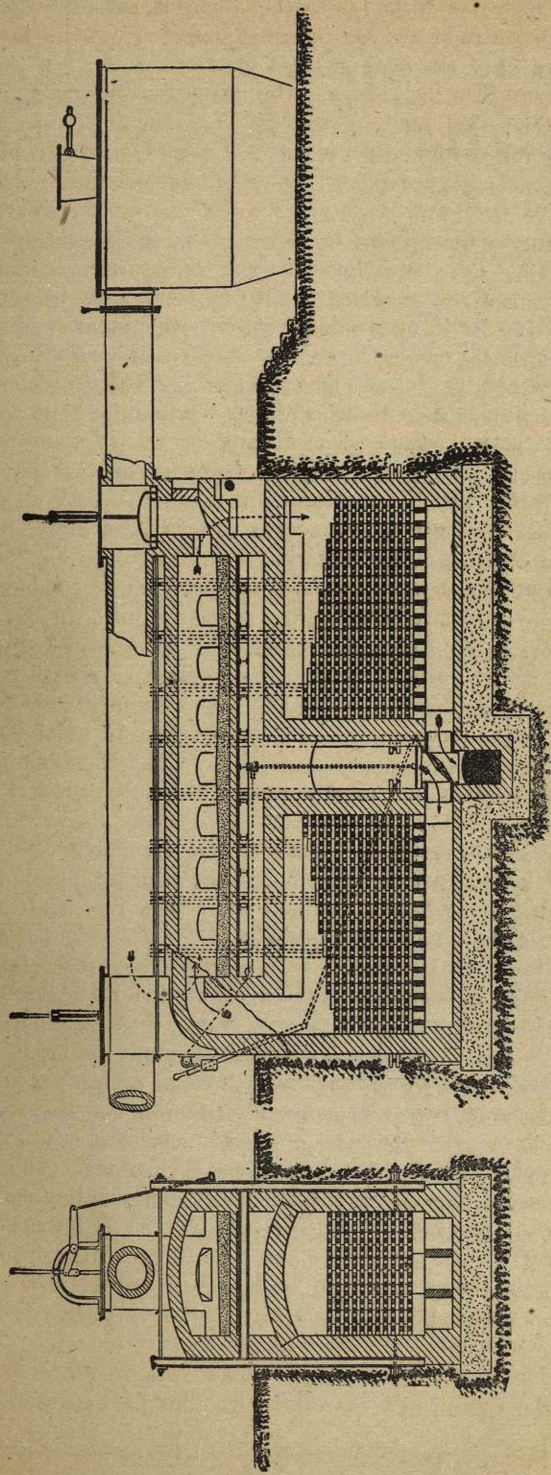
There must be a difference of pressure above and below every grate, or the air will not find its way through the fuel. In the original Siemens producer the requisite head was secured by carrying the hot gas up a brick flue about 20 feet high, cooling it in a horizontal sheet-iron flue, and leading it down another vertical flue or pipe to the furnace. The difference in density between the heated and cooled gas in the respective legs of the syphon sufficed to draw the air through the grate.

The combustible portion of such gas was rarely over 28 per cent., and its heating value, even with good coal, often below 100 B.T.U. per cubic foot, and to obtain high temperatures with it, it was necessary to pass it through regenerators.

Sir William Siemens maintained that cooling the gas in this manner involved no loss of heat efficiency, because the waste products of combustion flowing away to the chimney past the bricks in the regenerators, were cooled down to their temperature, which was in turn determined by that at which the gas had originally entered them, so that the hotter the gas entered, the hotter the waste products left. Sir William argued that in this way the same range of temperature was utilised by the gas regenerators, whatever might be the temperature of the gas entering them.

This argument standing alone is unassailable, but it overlooked the fact that in any producer fed with bituminous coal, volatile Hydrocarbons are necessarily distilled from the upper layers of fuel by the heat of that below. Considerable portions of these valuable volatile constituents of the fuel were

lost in the Siemens furnace, being deposited in the form of tar and soot in the cooling tubes and gas flues. Moreover, these volatile matters are the



Figs. 302 and 303.—Siemens' Furnace with Regenerators for Air only.

most valuable portion of the gas, as they afford a long flame of high radiating power, which equalises the heat over the whole length of the furnace. It was not until after the expiration of the Siemens patents, when, contrary to Sir William Siemens' instructions, furnaces were built in accordance with his patents, but receiving gas hot from the producers, that the considerable loss due to the former method of using the gas was made manifest. When a steam jet was employed below the fuel in the producer, the need for cooling the gas disappeared, and for the reasons already explained on p. 533, the quality of the gas was enriched. The combustible portions rose to 30 per cent. and over, and the heating value, apart from its sensible heat, which may amount to as much as 15 per cent. of its heating power, was increased to 140 B.T.U. per cubic foot, and sometimes even more. Under such conditions the workmen must exercise some care to avoid melting the bricks of which the furnace is constructed. The intensity of heat obtainable without regenerating the gas is more than is necessary for a reheating furnace, and regenerators for air alone will suffice.

When gas rich in Hydrocarbons is passed over red-hot brickwork, more or less thermolitic action occurs. The Hydrocarbons are split up, thus impoverishing the gas, and solid Carbon is deposited on the checkers, which is burned to waste when the valves are reversed. To such an extent does this occur with the very rich natural gas found in the States, that no gas regenerators are fitted to furnaces worked with natural gas.

The lower the temperature at which the products of combustion escape up the chimney, the greater must be the proportion of heat supplied by the fuel which is retained in the furnace; and as the temperature of the chimney is lower when the regenerators are fed with cold air only, there should be an actual gain in efficiency obtainable by dispensing with regenerators for the gas, when a sufficient intensity of heat is obtainable without them.

An incidental advantage of suppressing the gas regenerators is that the products of combustion do not return through the gas valves, and so no connection is required between them and the chimney. Leakage of gas direct from the main to the chimney, one of the chief troubles in the original Siemens furnaces, is impossible, and as there is a regenerator interposed between the two to trap the heat, leakage of the gas valves is a matter of much less importance.

Siemens' reheating furnaces, with regenerators for air only, have been in successful operation for the past twenty years. Figs. 302 and 303 show a furnace of this kind, two of which are worked from one gas producer.

As soon, however, as the value of the Siemens furnaces was clearly demonstrated, various gas furnaces were constructed by other inventors, who strove to obtain the advantages of gas-firing, with less initial outlay than was required to construct regenerators and reversing valves. These furnaces were successful, because they all had gas producers in close proximity to, if they did not form integral parts of, the furnaces, which, therefore, used the gas hot from the producers, while the air was in some way preheated, before it mixed with the gas at the bridge.

The Boetius Furnace, patented in Great Britain in 1865, was used extensively on the Continent,* and the Bicheroux,† introduced in 1872, was employed largely in France and Belgium. In both of these, a producer or "gazogene," forming part of the furnace, was provided with passages round it, through which the air passed and was heated on its way to meet the gas at the bridge. Gorman's furnace,* which was introduced in Scotland in 1870, and was employed in several Scotch and Continental works, formed a further step in advance, as the waste gases on their way to the chimney passed around horizontal fireclay pipes or "recuperators," situated below the furnace, and so heated the air required for combustion, and for the supply to the producer, both of which entered through these pipes. The consumption of fuel in this furnace, it is said, was as low as 3½ cwts. of coal, per ton of iron heated. Ponsard's furnace,† used in France, worked on the same principle, but differed slightly in detail, chiefly in the form of the fireclay pipes. This furnace used 662 lbs. or under 6 cwts. of small French coal, per ton of iron heated, and under favourable circumstances, only 4·41 cwts.; and turned out 30 per cent. more work than two direct fired furnaces beside it, which were worked with the same coal, and consumed 1,344 lbs. or 12 cwts. per ton. When employed at Seraing for heating steel rail ingots, it consumed 3·2 to 3·4 cwts. of coal containing 15 to 20 per cent. of ash.

Swindell's furnace,‡ which was introduced in America in 1875, was also worked by hot gas from a producer of the Siemens type placed beside it. The waste gases, and the air for combustion, passed in opposite directions through a series of high narrow passages both above and below the furnace, divided from each other by thin walls, through which the transfer of heat took place. Price's retort furnace,§ which was at work at Woolwich Arsenal as early as 1874, was another driven by forced blast, in which both air and fuel were heated by the waste gases, with the result of effecting a saving of just about one-half of the fuel consumed, the best results obtained being a consumption of 3·75 cwts. of coal per ton of iron heated. Radcliffe's furnace, used for melting steel at Woolwich, is another furnace with continuous regeneration, the air supplied under pressure to both furnace and producer, being heated in fireclay pipes by the waste products of combustion.

These furnaces were all fairly successful, but few of them are now in use, because of the difficulty of maintaining the tightness of the joints of the fireclay pipes, a difficulty which, however, could be overcome by better mechanical construction. The pipes are liable to crack with the changes of temperature to which they are exposed, and the cost of renewal is naturally greater than that of the plain bricks used in the Siemens system, but, for moderate heats, recuperators are a cheap and simple method of transferring the heat of the waste gases to the incoming air. For high heats, however, they suffer under the disadvantage that the current of the flame being always in one direction, one end of the hearth is always hotter than the other, while the reversal of the current in the Siemens furnace maintains much the same temperature in all parts of the bed.

New Form Siemens Furnace.—This type of furnace was introduced by Mr. Frederick Siemens, of London. Of the reheating furnaces put down in iron and steel works during the last few years, perhaps more have been of this type than of any other. As will be noticed from the description and drawings (figs. 304 and 305), the gas reversing valves of this furnace

* *Revue Universelle des Mines*, 1877, Tome i., p. 205; *Inst. Cleveland Eng.*, Feb. 9th, 1871, p. 268.

† *Iron and Steel Inst. Journ.*, 1882, vol. ii., p. 760; 1884, vol. i., p. 83; *The Engineer*, Aug. 3rd, 1883.

* "On the Heat-restoring Furnace," *Trans. Inst. Eng. in Scotland*, 1871, p. 245.

† *Mémoires de la Société des Ingénieurs Civils*, 1874, p. 752, and 1875, p. 292.

‡ *American Manufacturer and Iron World*, vol. xli., No. 24; *Engineering*, Dec. 31, 1880.

§ *Iron and Steel Inst. Journ.*, 1875, p. 455.

are placed between the furnace and regenerators, so that any gas leaking past the closed valves burns in the regenerators, which store the heat, and

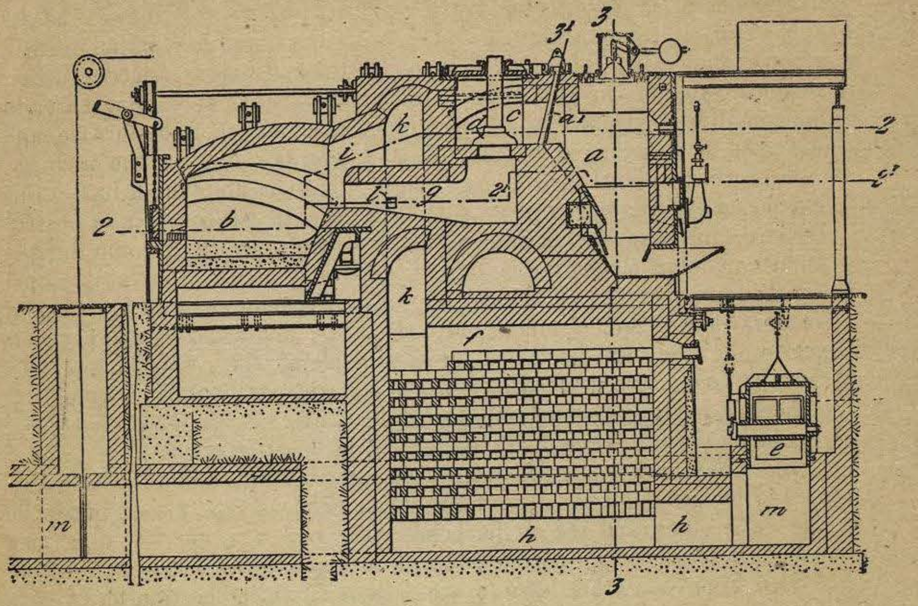


Fig. 304.

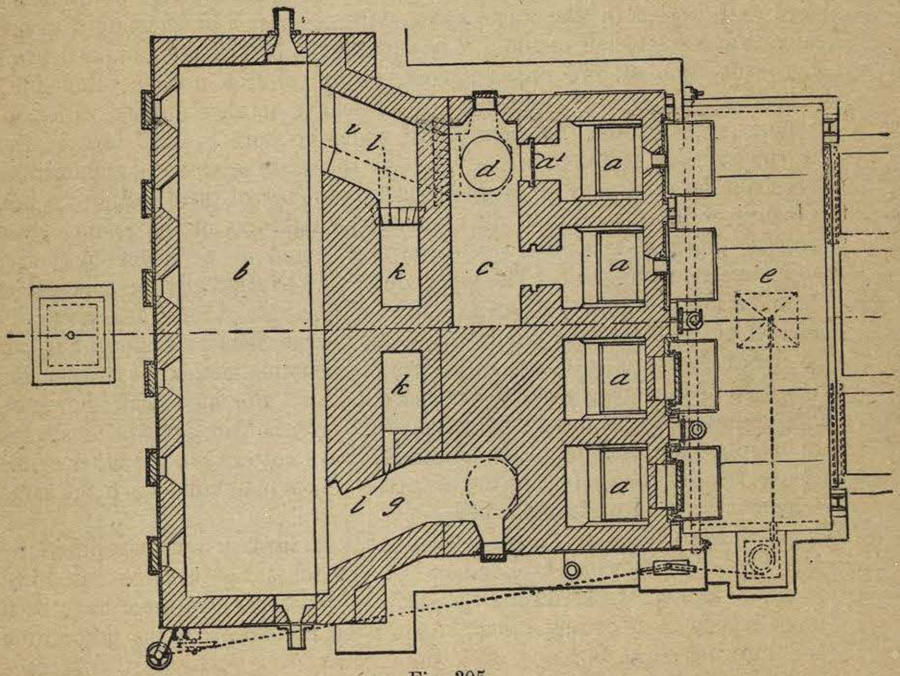


Fig. 305.

return it to the furnace when the direction of the flow of the gases is reversed. The gas reversing valves in the old form of furnace were situated between

the regenerators and the chimney, so that a leaking valve permitted the gas to escape direct to the chimney, where its potential heat was lost beyond recovery.

The New Form Siemens furnace combines in itself all the advantages of those previously described—viz., a producer fed by air driven by a steam jet or fan, being so combined with the body of the furnace as to minimise radiation from both, and to deliver the gas into the furnace as hot as possible, where it meets the air heated by passing through the regenerators; and, lastly, having a flame whose direction is reversible.

The drawings (figs. 304 and 305) show Mr. Frederick Siemens' latest design of furnace for heating steel ingots, blooms or billets embodying the improvements recently applied. Fig. 304 shows a vertical section of the furnace, the upper half being taken along the line 2-2, and the lower half along the line 2-2'. The gas producers, *a*, *a*, *a*, *a*, are built in one block with the furnace, the actual number depending on the size of the bed and temperature required. The production of the gas is regulated by a steam valve, which controls the air-blast of all the gas producers. The gas made passes into the main gas flue, *c*, and is admitted by one or other of the gas valves, *d*, into the gas port, *g*, at one end of the furnace. The air is admitted at the air valve, *e*, being regulated in amount by raising or lowering the cover; it then passes along the flue, *h*, and through the regenerator, *f*, where it is heated by the hot checker-work. The hot air passes up the flue, *k*, and into the air port, *i*, corresponding to the gas port, *g*, through which the gas is entering the furnace. By means of openings, *l*, made between the gas-port, *g*, and the air-flue, *k*, one or more small flames are produced in the gas-port over which the main body of the gas passes, so further heating the gas immediately before its combustion with the air. The products of combustion pass through the port, *i*, at the other end of the furnace down the flue, *k*, through the other regenerator, *f*, heating the checker bricks, and thence to the chimney flue, *m*. The latter is provided with a regulating damper shown in the section at the front of the furnace. The direction of the gas and air currents is reversed from time to time, as required, by means of the reversing gas valves, *d*, and the butterfly air valve, *e*. The regulators of the steam, air, and chimney damper are all placed close to the furnace front within easy reach of the furnacemen.

Usually the regenerators are built underground, as shown, but in cases where ground-water is encountered the regenerators are built mostly above ground.

There is ample evidence, from various sources, that this type of furnace is most efficient. This is shown by the fact that some of them are turning out 100 to 120 tons of billets every twelve hours, and other smaller furnaces are heating a ton of ingots or slabs, if charged hot, with from $\frac{3}{4}$ to $1\frac{1}{4}$ cwts. of small coal, and, if charged cold, with from $2\frac{1}{2}$ to $3\frac{1}{2}$ cwts. In the case of small mills, with this as with any other furnace, much depends upon the running of the mill, and the frequency with which rolls have to be changed. A ton of small billets charged cold may require from 3 to 5 cwts., $2\frac{1}{2}$ sufficing under specially favourable circumstances, the furnace waste being under 4 per cent.

Mr. Siemens reports that, with larger furnaces, the consumption in several large works is usually $1\frac{1}{2}$ to 2 cwts. per ton of steel charged cold, $\frac{1}{2}$ to $\frac{3}{4}$ cwts. per ton when charged hot; and that the furnace waste, when heating steel, is usually 5 per cent. and under for cold billets, and about 3 per cent. for hot billets, depending on the sizes, &c., the saving over coal-fired furnaces being usually $\frac{1}{2}$ per cent. for steel ingots, and 1 per cent. for steel billets.

The same principle is also applicable to vertical furnaces of the soaking-pit type, to be described later.

Distribution of Heat.—To secure more uniform heating of the material in furnaces not provided with valves which can change the direction in which the gases travel, three different methods are employed.

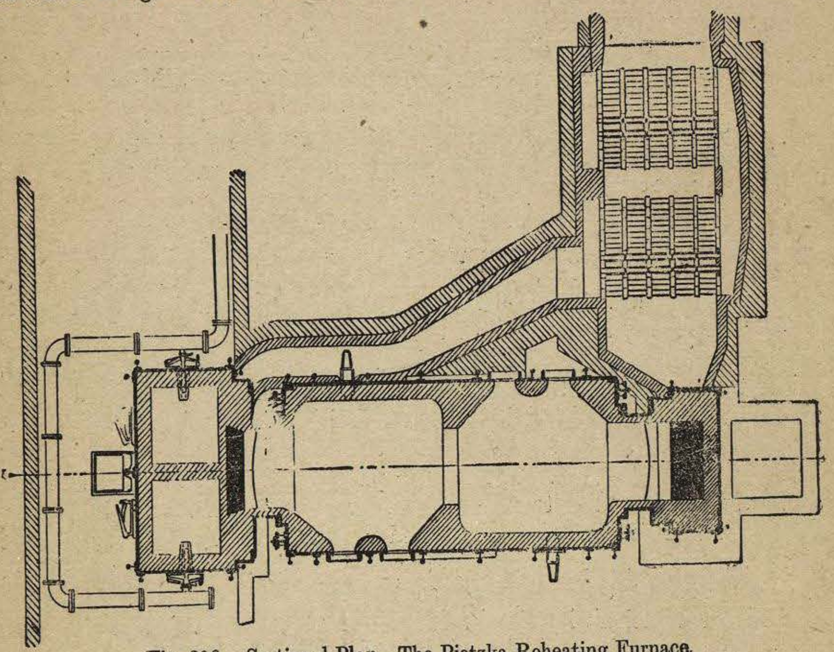


Fig. 306.—Sectional Plan—The Pietzka Reheating Furnace.

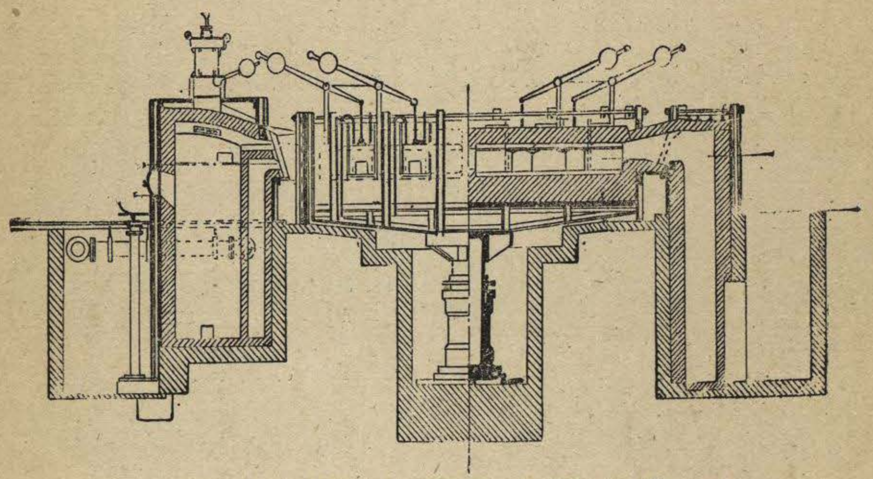


Fig. 307.—Sectional Elevation—The Pietzka Reheating Furnace.

1. Reversing the furnace itself, instead of reversing the direction of the current of the gases.
2. Admitting the air and gas at several points in the furnace.
3. Accepting the fact of the difference of the temperature at various points, and deliberately turning the fact to account, by charging the material

at one end of a long furnace, and pushing it regularly and continuously forward towards the fire.

The Pietzka Furnace.—This furnace was introduced at the Witkowitz works, by Herr Pietzka, about the year 1898, and a large number are now in use on the Continent. The body of the furnace (see figs. 306 and 307) is built upon a frame work supported by a vertical pivot, which forms the ram

Fig. 309.

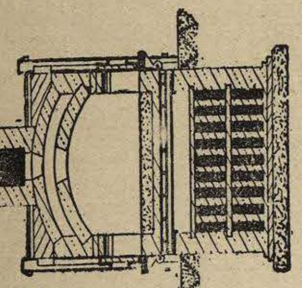


Fig. 308.

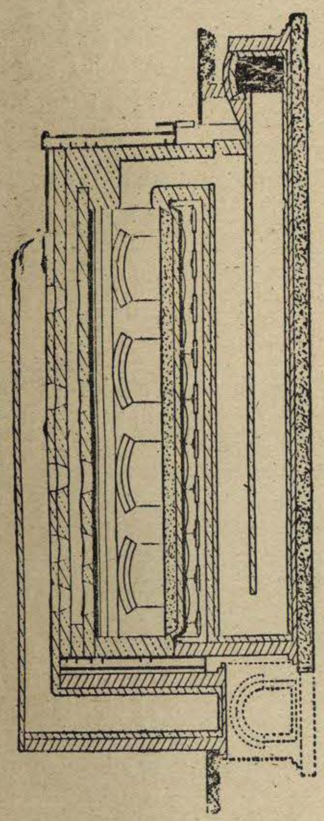
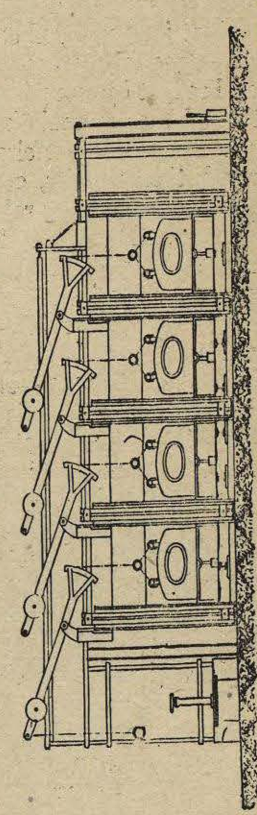


Fig. 310.



The Hollis Reheating Furnace.

of a hydraulic cylinder; the ends of the furnace are shaped to form portions of the surface of a huge inverted cone, of which the central pivot forms the axis. By admitting water under hydraulic pressure beneath the pivot, the whole furnace is slightly raised, when it can be turned end for end and again lowered, so that although the actual direction of the flame remains constant, it is reversed relatively to the furnace. The coal is gasified in a producer, the blast for which, in the case of fuel which contains an excess of moisture, is produced by a jet of air, compressed to a pressure of 45 lbs. on the square inch, and the air for combustion is heated in fireclay pipes to a temperature of 900° C. by the escaping products of combustion, which then pass away to a boiler for raising steam. The furnace is said * to heat blooms of $3\frac{1}{2}$ to 4 cwts. each, with an expenditure of 56 cwts. of poor Austrian coal per shift of 22 tons of billets, equal to a consumption of 2·6 cwts. per ton, some steam being also produced by the waste heat. One used for heating 30-ton ingots for armour plates, which required heating for twenty-four hours, consumes 6 tons every twelve hours.

The Hollis Furnace.—This furnace (figs. 308, 309, and 310) is the invention of Mr. Hollis, of the Weardale Steel Works, and was described by him at a meeting of the Iron and Steel Institute.† It takes advantage of the second method of equalising the heat. The air required for combustion enters through a series of narrow passages below the bed of the furnace, which alternate with similar passages, through which the waste gases pass to the chimney flue, shown in black on the right of fig. 308. As there are only thin fire-brick walls separating the passages from each other, and the inflowing air travels in the opposite direction to the outflowing waste gases, much of their waste heat is transferred to the entering air, which then finds its way into the hollow roof of the furnace, where it is still further heated.

Hot gas, brought by an underground gas flue on the left of fig. 308, passes upwards through the gas regulating valve, into a flue on the roof of the furnace, having on its under side five circular nozzles. The gas is discharged downwards through these nozzles, on its way passing through the hollow roof, in which are five round holes rather larger in diameter than the gas nozzles and immediately below them. The hot air thus forms an annular stream entirely surrounding each jet of gas; the two are driven down on to the bed of the furnace by a species of blowpipe action, and keep it always at a high temperature. The furnace illustrated is made by Messrs. W. F. Mason, Limited, of Manchester.

Continuous Furnaces.—Ingots which contain a high percentage of Carbon must be regularly and slowly heated, or they will be spoiled; so that to charge such ingots into a hot furnace damages them, and to charge them into a cool furnace, and then gradually raise the heat, consumes too much fuel. To meet these difficulties the Swedish metallurgist, Gustaf Ekman, at some time previously to the year 1848, constructed a long furnace with a sloping bed. The ingots were charged through a door in the upper end of the furnace, and were rolled over by bars inserted through small doors provided for this purpose in the side walls of the furnace, and so descended the slope towards the fire, and when sufficiently hot were drawn out and rolled. A great number of ingots were thus in the furnace at one time; the heating process was a continuous one, the ingots being charged into the upper end of the furnace, where the chimney was situated, at which point there was sufficient heat to warm up the cold ingots, which were advanced gradually and regularly through zones of constantly increasing temperature, until the point of highest temperature was reached, when the ingots were ready for rolling. By turning over the ingots in the furnace, each side in turn was exposed to the full action of the hot gases, and every ingot received identically the same heat treatment. Moreover, the heat was employed in the most efficient manner possible; the hottest gases met the hottest piece, and

* *Stahl und Eisen*, Nov., 1899, vol. xviii., p. 988.
† *Iron and Steel Inst. Journ.*, 1897, vol. i., p. 56.

after heating it, still retained sufficient heat to raise the temperature of those not quite so hot, till finally the gases going to the chimney came in contact with the absolutely cold pieces. Naturally a considerable saving in fuel resulted, and any sudden changes of temperature in the steel were rendered impossible.

To avoid the labour involved in turning over the ingots in this way, and to reduce the leakage of air through the doors, William Allen, of Sheffield, replaced the furnace floor by two wrought-iron pipes, through which water was circulated to cool them. The ingots or billets were much more easily skidded down these pipes, the destruction of the furnace bottom was avoided, and the number of doors was considerably reduced. To ensure uniform heating when the billets are not turned over, the pipes are laid on two dwarf walls on the furnace floor, so that the heated gases may play above and below the material; there are always two darker and colder spots where the billet rests on the pipes, and to remove these the pipe skids are now usually stopped short of the end of the furnace, and are turned suddenly downwards, so that the billet rolls over on to a short length of ordinary furnace bed, with that side upwards which previously rested on the pipes; these small spots then disappear immediately.

In 1895 Mr. Morgan introduced what he called a gravity discharge furnace. In this furnace the bed sloped in the opposite direction to those of the two previous furnaces, and the billets, which are brought up on a small waggon opposite the door of the furnace, are pushed in by a hydraulic ram, and so forced to travel up instead of down the pipe skids, until they arrive at the hottest end of the furnace, where there is a sudden sharp incline in the pipes in the contrary direction, down which they slide on to a live roller bed which takes them to the mill. Each ingot as it is introduced drives its predecessor before it, until the first charged is pushed out at the opposite end of the furnace.

Inclined furnaces are made for heating either with gas or by direct firing. The slope of the bed when no pipes are used, and when the ingots have, therefore, to be turned over, is usually from 1 in 8 to 1 in 9.

According to M. Lantz,* German inclined furnaces will heat per turn 260 to 270 tons of warm ingots weighing 1,700 to 2,000 kilos. (say, 34 to 40 cwts.) each, with a waste of 3 per cent. American furnaces have turned out each shift 100 tons of 6×6 inch blooms per furnace.

In the *Iron Age* † is given a test of such a furnace lasting for a fortnight, in which from 81 to 84 tons of billets $1\frac{3}{4}$ inches $\times$ $1\frac{3}{4}$ inches $\times$ 30 feet long were heated per 12-hour turn, with a consumption of fuel of 122·1 to 143·5 lbs. per ton of steel, the waste in the furnace being almost 1 per cent.

Talbot Continuous Furnace.—This is one of the most recent of these furnaces. It is illustrated in figs. 311 and 312, Plate xxiv. The bed is nearly horizontal, having a fall of only 12 inches in its entire length. It is provided with pipe skids and circular iron-cased vertical regenerators, filled with the usual checker bricks, for heating the air, the gas being supplied hot from the producers. There is a reversing valve both at top and bottom of the regenerators, the bottom one, through which the heated air and products of combustion pass, being water-cooled. When the valves are in the position shown in the cut, the cold air, supplied by a fan, passes up through the cold-air pipe to the reversing valve, N, which allows it to pass down through the regenerator, M, over the water-cooled reversing valve, Y, and through the

* *Stahl und Eisen*, vol. xviii., 189.
† "Efficiency Test of a Continuous Rod Mill," *Iron Age*, Sept. 12, 1901, p. 8.

air flue, O, into the furnace by the ports, K, K, where it meets the hot gas admitted at the ports, H, H. The products of combustion pass thence to the flues, P, P, P, below the reversing valve, Y, and up through the regenerator, L, and thence through the reversing valve, N, whence they escape by the chimney, Q. On reversing, the air passes down through the hotter regenerator, L, and the products of combustion up through the regenerator, M. The flow of the air in the flue, O, is always in the same direction—viz., from right to left—and the products of combustion always travel from left to right along the furnace, the reversal being confined to the way in which the air and products of combustion pass through the regenerators between the valves N and Y. The shaded ports, X, X, X, open into a transverse flue, into which the scale is pushed, and from which it is withdrawn at convenient intervals.

Soaking Pits.—If ingots are lifted from the casting pit too soon the outer crust gives way, and some of the fluid centre flows out, these "bleeding ingots" showing conclusively what a large amount of heat is stored in the inside. Trusting to this fact, attempts were early made to roll them without reheating, but the pressure of the hammer or rolls squirted out the fluid centre over the workmen, or the centre still remained soft and spread so much more than the colder skin that this cracked and the material was spoiled.

The difficulty was surmounted in 1882 by Mr. Gjers, who dropped the ingots, as they were removed from the casting pit, into small holes in the ground, lined with firebrick, thus retarding the loss of heat from the exterior long enough to permit the excess of heat in the fluid interior to soak through to the outside. When the heat contained in the ingot is thus distributed more evenly, it is sufficiently hot, and in the best possible condition for rolling, for which purpose it is desirable to have the interior slightly hotter than the exterior, a condition it is obviously impossible to obtain by applying the heat to the outside, as in a reheating furnace.

It can readily be proved that the heat lost when ingots are allowed to cool is considerable. Taking the temperature at which the ingot sets as 2,500° F., and the average specific heat between this point and 50° F. as 0·16, the heat lost by 1 ton of ingots would be 2,450 × 0·16 × 2,240 = 878,080 B.T.U., and represents as much heat as is given out by 73 lbs. of good coal having a calorific value of 12,000 B.T.U. per lb. To reheat this ingot to a temperature sufficiently high to admit of its being rolled, say, to 2,000° F., and calling the average specific heat between this and 50° F. 0·15, would require as much heat as could be given out by 54·6 lbs. of the same coal.

As will be shown later in the section dealing with the calorific efficiency of furnaces, this is so low that it is quite understandable that ten times this quantity of inferior slack was frequently used in reheating the cold ingots.

The pits originally consisted of a series of rectangular "chambers," somewhat larger than the ingots, sunk in the ground to a depth of about 18 inches in excess of the length of the ingot, and closed at the top by a firebrick lid in an iron frame. At starting, the ingots, as taken from the moulds by a crane, were dropped one by one, each into a separate pit, and allowed to remain for about an hour; they were then drawn out and another set introduced. After a few sets of ingots had been put in and taken out in this way, the firebrick walls practically became heated up to the temperature of the ingots, and it was then only necessary to bring a fresh set of ingots direct from the casting pit, and to allow them to soak or remain about twenty minutes in the pits, in which time the centre solidified, and the heat became equally distributed through the mass of steel. The ingot was then ready to be removed and taken to the rolls.

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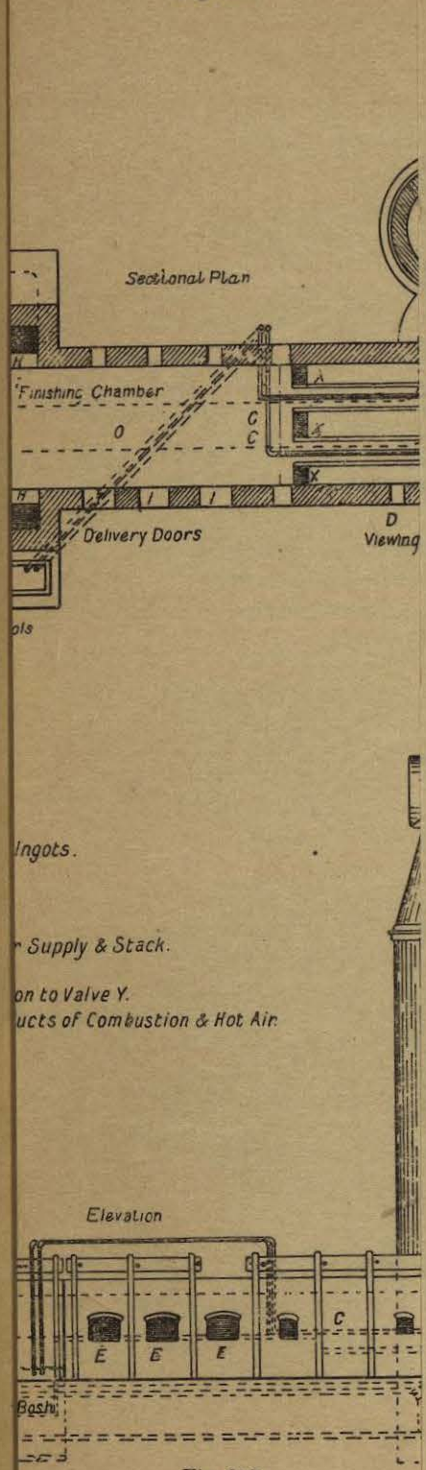
Fig. 311.



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was then ready

The ingots, blooms, or slabs are charged through the door, A, are pushed along by the hydraulic pusher, and finally fall out through G on to live rollers. The sketch shows the live rollers arranged for slabs so they can be delivered to the plate rolls without turning, but in case of blooms or ingots the live rollers would be at right angles to those shown, so that the ingot would fall across the rollers and could be delivered to the rolls without being turned round, as would be the case with rollers in present position. The gas comes direct from the producer into the combustion chamber through ports, H H, and meets the air previously heated by the regenerator, which comes through flue, O, into the combustion chamber through ports, K K. The products of combustion pass through the ports, P P P, to the other regenerator. The direction of the air through the regenerators is reversed by the valves shown. The hearth of the finishing chamber, on to which the slabs fall from the water-cooled pipes, is made of basic material, and any local chilling from contact with the pipes is removed before the slabs reach the discharging doors.

PLATE XXIV.—Talbot Continuous Regenerative Reheating Furnace. [To face p. 548.

Fig. 311.

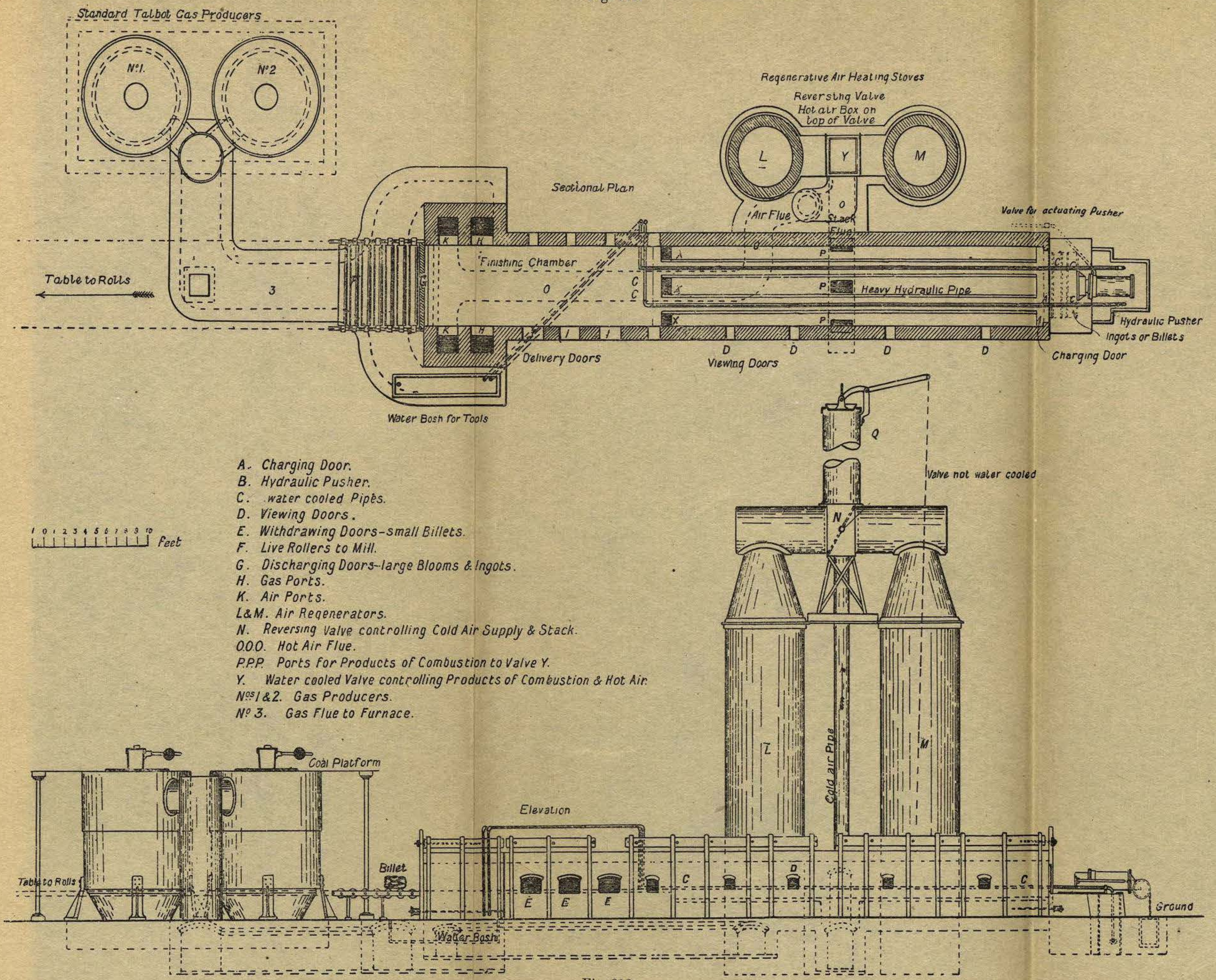

Fig. 312.