tion is going on the whole time, and it frequently happens that the Carbon is reduced below the required limit. The tilting furnaces are more expensive to build than fixed furnaces of the same capacity, and taken all together for ordinary acid work, it seems somewhat doubtful if the advantages are so great as may appear at first sight.

The furnaces are divided into two types according to their method of tilting, one revolving on rollers about its own axis in the same way as the metal mixer shown on fig. 23, and the other tilting or rolling on rockers.

The Campbell Furnace.—This furnace is representative of the first type, and one designed by Mr. H. H. Campbell was put into operation in 1889, at the Pennsylvania Steel Company's Works. The furnace (figs. 131 and 132) revolves on its own axis, on four rings of rollers running on circular paths, and is rotated by a horizontal hydraulic cylinder, B. In

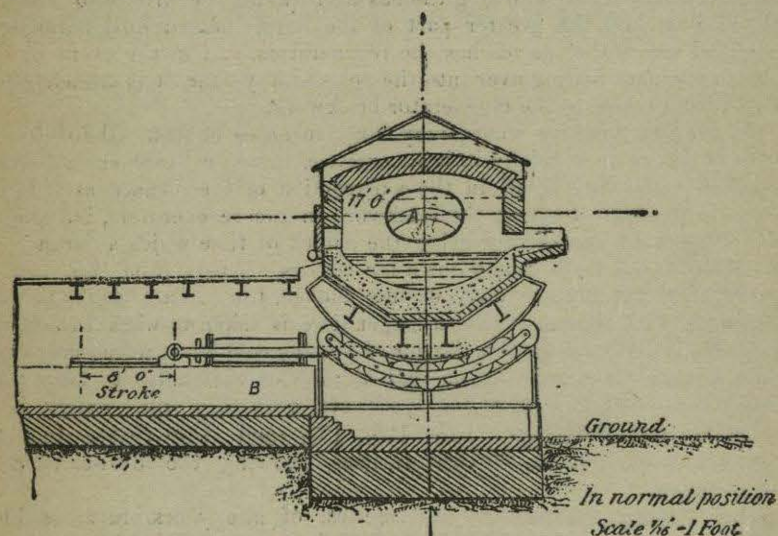


Fig. 131.—Campbell Furnace in normal position.

the movable section of the furnace at each end is an oval opening, A, opposite the fixed gas and air ports, and to allow this portion of the furnace to move freely, a space of about half an inch is left between the furnace ends and the fixed ports. Both ports and furnace ends are faced with water-cooled cast-iron plates, and the block forming the ports is enclosed in an iron framework, so arranged that the whole can be changed when repairs are necessary. This latter detail is due to Mr. C. E. Stafford, of Pittsburg.

When the furnace is tilted the air ports are partially closed. Molten blast furnace metal is now being used in these furnaces with considerable increase in output, and without, it is stated, appreciably increasing the wear and tear on the furnace bottom. In charging cold pig-iron the furnace is usually tilted, and the half pigs are shot in from a shoot which severely tries the bottom. The furnace can be charged by hand or by a Wellman charging machine (fig. 147). At the Pennsylvania Steel

Company's Works horizontal regenerative chambers are used, and air is blown into the chambers by an electrically-driven fan.

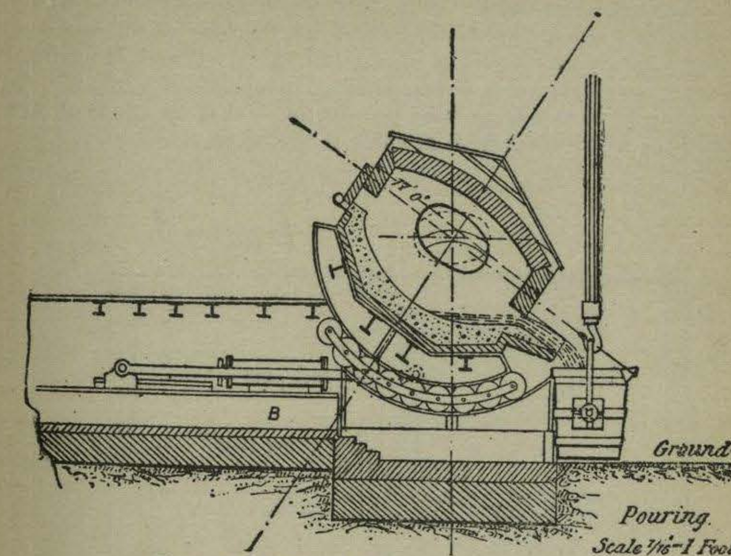
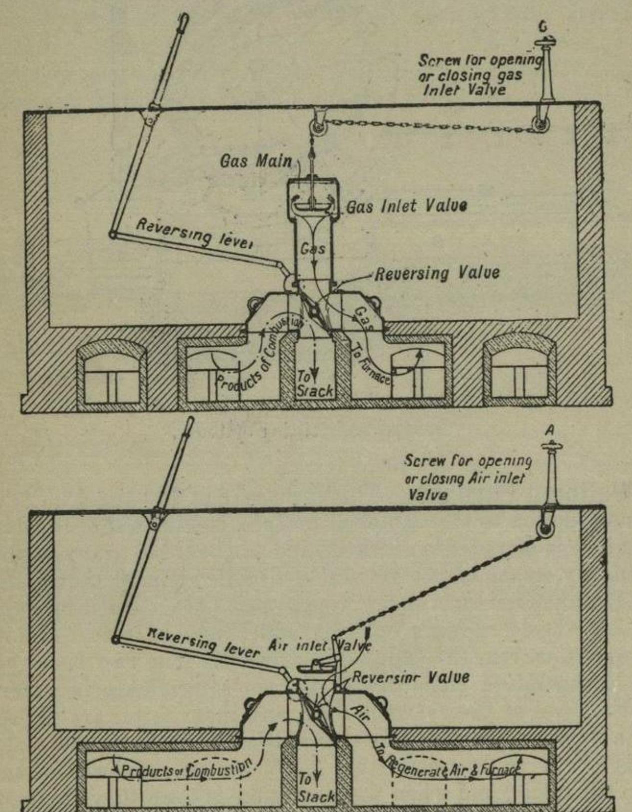


Fig. 132.—Campbell Furnace, position when pouring.
B, Hydraulic tilting cylinder.

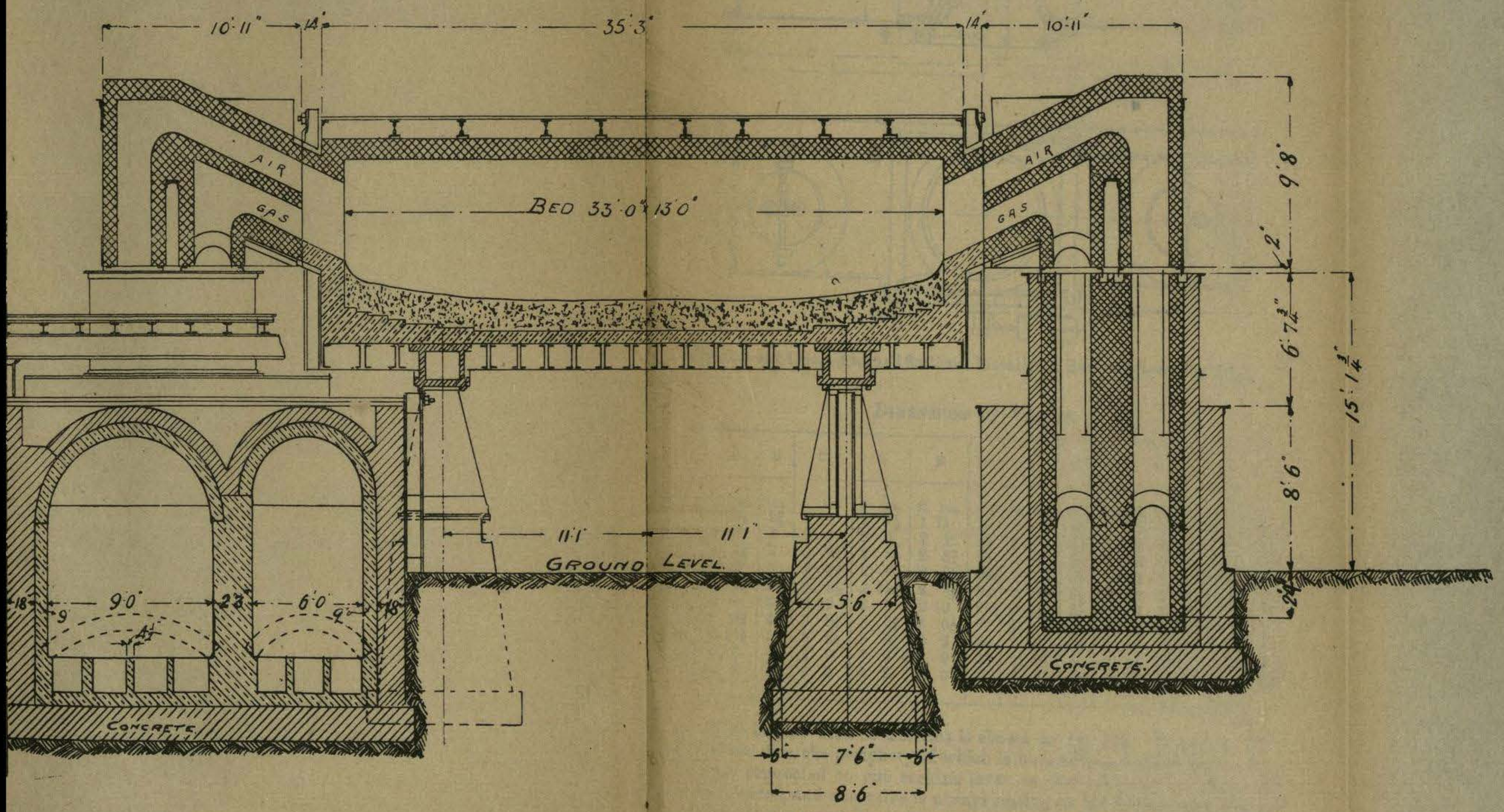
The Wellman Furnace.—This furnace (figs. 133 and 134) is similar in general construction to the Campbell furnace, but instead of revolving about its own axis it is mounted on rockers, and can be tilted to any required angle for pouring by means of the vertical hydraulic cylinder shown in fig. 134, Plate x. In the latest form of furnace the ports are encased in a metal cage, mounted on wheels running on rails, which enable it to be moved a few inches towards or from the end of the furnace. The two passages leading from the regenerative chambers to the ports terminate in water troughs about on the level of the charging floor, and these latter are so designed as to allow a small motion of the port without breaking the seal. When pouring is about to commence the ports are moved away to enable the furnace to tilt freely, and when the operation is over they are moved back into contact with the furnace. During pouring the port ends of the furnace open to the air are larger than in the Campbell furnace, thus admitting more air into the furnace. Both the Campbell and Wellman furnaces are doing good work, but the latter is somewhat cheaper to build.

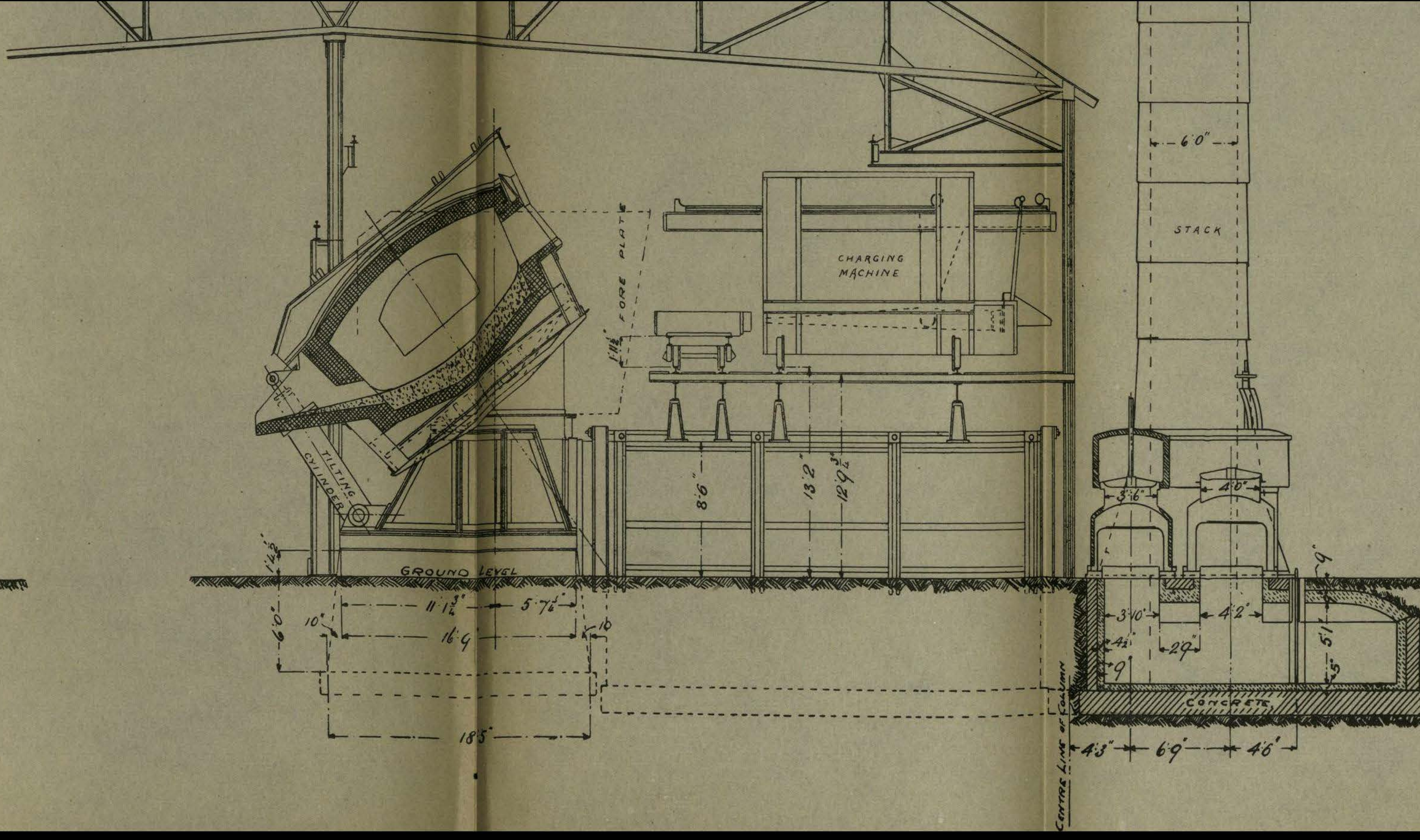
Valves.—There are two kinds of valves used in connection with Siemens furnaces, the inlet valves for regulating the admission of air and gas, and the reversing valves for controlling the direction of the air and gas, and the products of combustion. The former are usually the simple mushroom form, shown in figs. 135 and 135*a*, marked air and gas inlet valve respectively, and require no special description; but the reversing valves vary very considerably in design, and have to be most carefully constructed if they are to do their work efficiently. In the case of the gas-reversing valve, it is exposed to the hot incoming gases from the producer on the one side, and the escaping hot products of combustion on the other, and it is not an easy matter to devise a valve which will work gastight over a considerable period of time under these conditions. The old form of "butterfly valve" shown in position in figs. 135 and 135*a*, and marked reversing valve, has done excellent service, and is still very largely used, but with the greatest care is liable to warp and become leaky. When this occurs, the condition of the valve rapidly becomes worse owing to the leaking gas burning at the valve seat, and it is practically impossible to repair the valve without removing it. The construction of the valve is very simple; it consists of a cast-iron flap, supported at its centre on a trunnion or spindle, so that by means of levers it can be swung over at will from one side to the other.



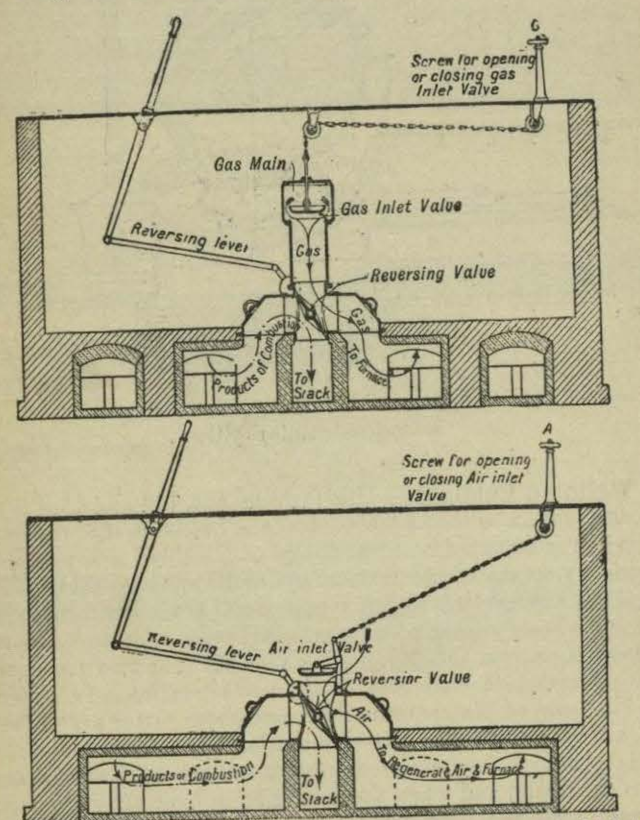
Figs. 135 and 135*a*.—Sketch showing general arrangement of inlet and reversing valves of Siemens furnace. The latter are of the "Butterfly" type, one for gas and one for air, and are reversed by the levers shown.

Figs. 136 and 136*a* give on a large scale plan and sectional elevation of this form of valve, and show it in the reverse position to figs. 135 and 135*a*, and from the table attached detailed dimensions of valves from 15 inches to 36 inches can be obtained. A modification of this valve, patented by Mr. William Kirkham, of Sheffield, is shown in figs. 137 and 138, in which the valve flap is made in two parts, *a* and *b*, the bottom portion, *b*, with the trunnion, *c*, being cast in one piece, and the top portion, *a*, having a deep groove cast in its thicker end of such a width that it rides or clips on the trunnion of the lower portion. By this arrangement, although the entire valve moves as one piece when reversed by the lever, by allowing a little play between the two connecting parts of the valve, the respective parts


10'-11"
35'-3"
10'-11"
AIR
GAS
BED 33'-0" x 13'-0"
9'8"
2'
6'7½"
15'1¼"
8'6"
11'1"
GROUND LEVEL
9'0"
6'0"
5'6"
7'6"
8'6"
CONCRETE

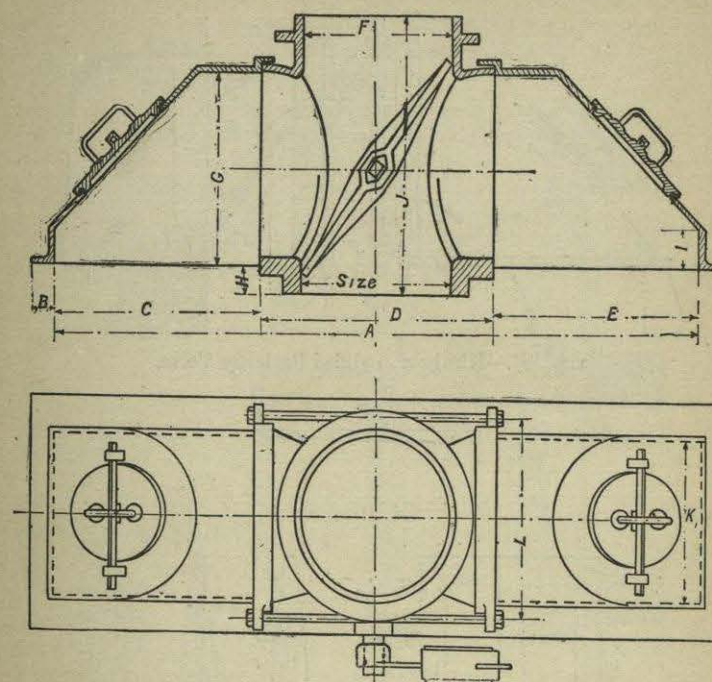

6'0"
STACK
CHARGING MACHINE
FORE PLATE
TILTING CYLINDER
GROUND LEVEL
8'6"
13'2"
12'9½"
11'1¼"
5'7½"
16'9
18'5"
3'6"
4'0"
3'10"
4'2"
2'9"
CONCRETE
CENTRE LINE OF COLUMN
4'3"
6'9"
4'6"

period of time under these conditions. The old form of "butterfly valve" shown in position in figs. 135 and 135*a*, and marked reversing valve, has done excellent service, and is still very largely used, but with the greatest care is liable to warp and become leaky. When this occurs, the condition of the valve rapidly becomes worse owing to the leaking gas burning at the valve seat, and it is practically impossible to repair the valve without removing it. The construction of the valve is very simple; it consists of a cast-iron flap, supported at its centre on a trunnion or spindle, so that by means of levers it can be swung over at will from one side to the other.



Figs. 135 and 135*a*.—Sketch showing general arrangement of inlet and reversing valves of Siemens furnace. The latter are of the "Butterfly" type, one for gas and one for air, and are reversed by the levers shown.

Figs. 136 and 136*a* give on a large scale plan and sectional elevation of this form of valve, and show it in the reverse position to figs. 135 and 135*a*, and from the table attached detailed dimensions of valves from 15 inches to 36 inches can be obtained. A modification of this valve, patented by Mr. William Kirkham, of Sheffield, is shown in figs. 137 and 138, in which the valve flap is made in two parts, *a* and *b*, the bottom portion, *b*, with the trunnion, *c*, being cast in one piece, and the top portion, *a*, having a deep groove cast in its thicker end of such a width that it rides or clips on the trunnion of the lower portion. By this arrangement, although the entire valve moves as one piece when reversed by the lever, by allowing a little play between the two connecting parts of the valve, the respective parts will bed better on their faces, and become less affected by warping and distortion than when the valve is one rigid piece. The author has received very satisfactory reports from several people who are using this valve.



Figs. 136 and 136*a*.—Plan and Sectional Elevation of Butterfly Reversing Valve.

DIMENSIONS OF VALVES.

Size.	A	B	C	D	E	F	G	H	I	J	K	L
ins.	ft. ins.	ins.	ft. ins.	ft. ins.	ft. ins.	ins.	ft. ins.	ins.	ins.	ft. ins.	ft. ins.	ft. ins.
15	5 11½	2¾	1 11	2 1½	1 11	15	1 6⅜	3½	2	2 5	1 3	1 8
18	6 7	3	2 1	2 5	2 1	18	1 10⅛	3½	2	2 9¼	1 6	1 11½
21	8 1¾	3	2 8⅞	2 8	2 8⅞	21	2 0⅝	3½	2	3 0	1 9	2 2
22½	8 2	3	2 8½	2 9	2 8½	22½	2 2½	3½	4½	3 3	1 10½	2 3¾
24	8 4¼	3	2 8½	2 11¼	2 8½	24	2 3⅞	3½	5	3 5	2 0	2 5⅜
25½	8 8	3½	2 10	3 0	2 10	25½	2 6	3¼	7¾	3 7	2 1½	2 7
27	9 3¾	$3\frac{5}{16}$	3 0½	3 2¾	3 0½	27	2 7	3¾	5	3 8¼	2 3	2 9
30	9 10¼	3½	3 2½	3 6¼	3 2	30	2 10	4½	6	4 1¼	2 6	3 0½
33	11 3	4	3 9	3 9	3 9	33	3 2⅞	4	9¼	4 6⅛	2 9	3 2½
36	12 2	4	4 0	4 2	4 0	36	3 5⅞	4¾	9¼	4 9¼	3 0	3 5⅞

A valve largely used in America is shown in fig. 139. It consists of a thick hollow disc, the periphery of which is formed to a double bevel. Two valves are connected to one rocking lever, so that when one is raised the other is lowered, and one valve is always resting on the bottom seat, and the other against the upper seat, when at the end of its range. The special shape of the valve gives great stiffness, and reduces the danger of leakage through warping. Two pairs of valves are required—one to control the gas, and one the air.

the valves come to their seats with a sharp blow, and are held in contact with both the upper and lower seats by gravity. The blow not only enables the valve and seat to come together in spite of any soot present on them, but assures the furnaceman that the valve is properly home. The steel valves are hollow and contain no ribs, so that they are free to expand equally in all directions, and do not change their shape when heated. Their faces are turned to form an arc of a circle, so that the valves will fit the seats with mathematical precision when canted to very considerable angles, and being attached to the spindle, which is a very free fit, find their own position on the seats even if the spindles should be considerably out of centre with the seats. The cast-steel seats, which are reversible, and can be turned over when worn, are kept cool by contact with the external air, and by turning the nuts which hold the parts of the boxes together so as to lift the box a small distance, a seat can be removed and a new one put in from the outside while the furnace is working if the seat is at the bottom, and by shutting off the gas for less than two minutes if the seat is at the top. Some of these valves and seats have run for four years without any sign of wear, probably owing to the fact that leakage has never occurred.

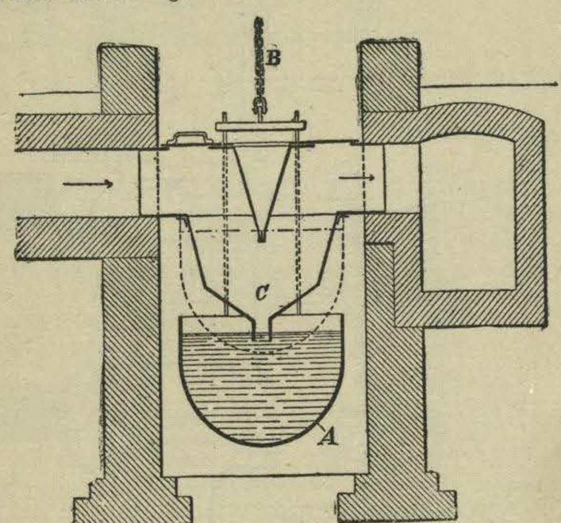


Fig. 141 —Wailes Siphon Reversing Valve.

Below is a cup of water, A, which is kept full, and can be raised or lowered by chain, B, and into this dips a funnel, C. In the position shown in the sketch any gas is prevented from escaping from the funnel-shaped orifice, but can pass along the flue, as shown by the arrows. When the cup of water, A, is raised into the position shown by the dotted lines, so that the V-shaped mid-feather dips below the surface of the water, the flow of gas is prevented altogether. This valve has been used experimentally in several works in England, but has not been generally adopted.

The gas enters from the gas flue, A (fig. 140), through the centre pipe, B, and passes through the regulating valve, C, to the reversing valves on each side. The bend pipes, D and E, lead the gases to or from the brick flues, F and G, which are in connection with the regenerators, while the waste gases pass through the base castings to the chimney flues, H and K. The arrows show the directions of the currents. If the regulator valve shown in the figure were raised, the gas would enter the regenerator on the right, and the waste gases would leave that on the left.

Some years ago a water-cooled valve, called the siphon valve (shown in fig. 141), was introduced by the late Mr. Wailes, formerly manager of the

Patent Shaft and Axle-tree Company. From the sketch it will be seen that it consisted of a cup which was kept full of water, which could be raised or lowered at will to form a water seal. Another water-seal valve, designed by Mr. Wailes, is shown in fig. 142, and this, and modifications of it, have been largely used. The arrangement will be readily understood by referring to the sketch and description.

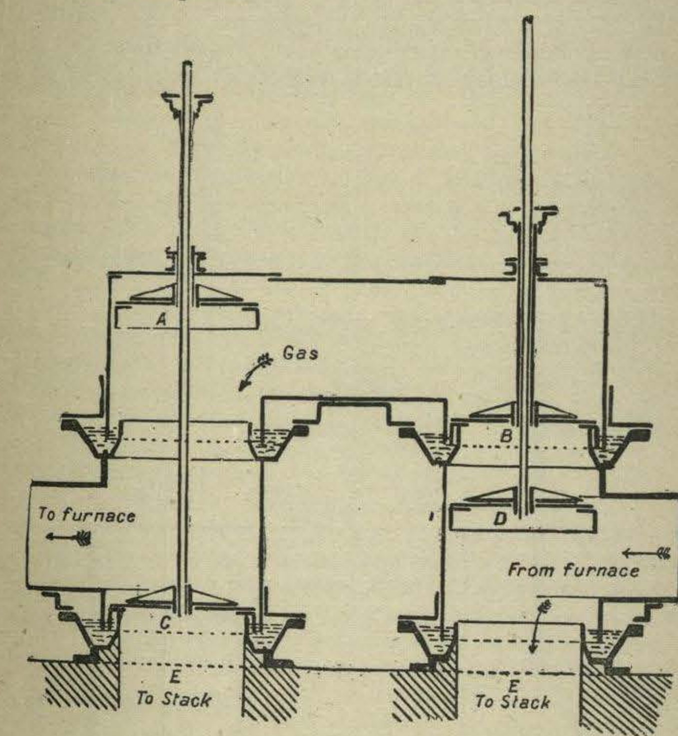


Fig. 142.—The Wailes Water-Seal Reversing Valve.

There are two valves on the same rod, but having independent motion, the top one being attached to a sleeve and the bottom one to the rod. When the valves are lowered the peripheries dip into the troughs of water shown, which are kept full of running water. When the valves are in position, A and C, the gas is passing to the regenerators and the furnace; and when in position of B and D, the gas valve, B, dips into the water seal, and the products of combustion pass from the regenerators under D through E to the stack. The valve, D, is largely protected from hot gases by being raised into a recess between the two valves. The reversal of position of valves reverses the direction of the gas. There are similar sets of valves on each furnace to control the direction of the air.

Another form of water-cooled valve is that patented by Mr. F. Mills (shown in fig. 143). In this valve a stream of water is constantly flowing down the stalk of the valve, which is made hollow, and the valve is of such a section that it is always water cooled, whether at the top or bottom of its range. The details of the design will be seen from the sketch.

The Chimney.—For the efficient working of a furnace nothing is of greater importance than a good draught, and each furnace should have a *separate* stack of such a size that a strong draught can always be insured, even when a furnace is in bad condition. It is always easy to damper a chimney if it is pulling too strongly, but it is impossible to increase the pull above the point limited by its dimensions, and hence the importance of

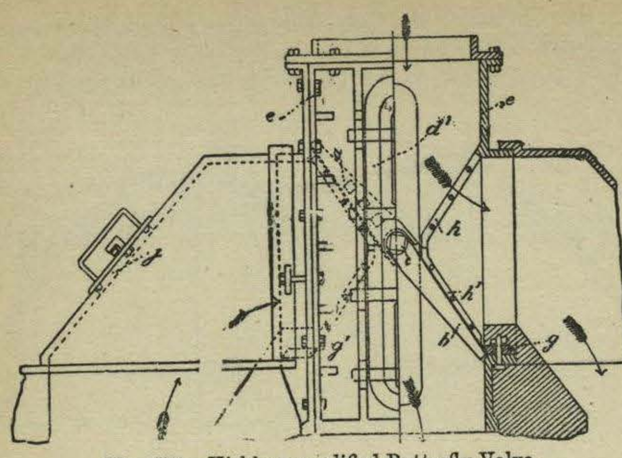


Fig. 137.—Kirkham Modified Butterfly Valve.

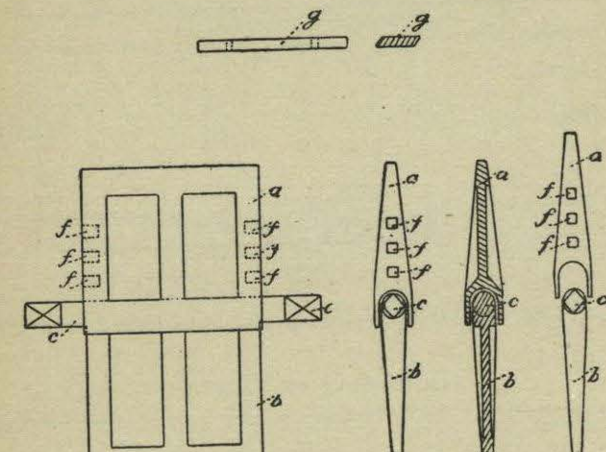


Fig. 138.—Details of Kirkham Valve—*f*, Holes for inserting bar to assist in removing flap, *a*, for repairs; *g*, removable valve seat which can be replaced when worn.

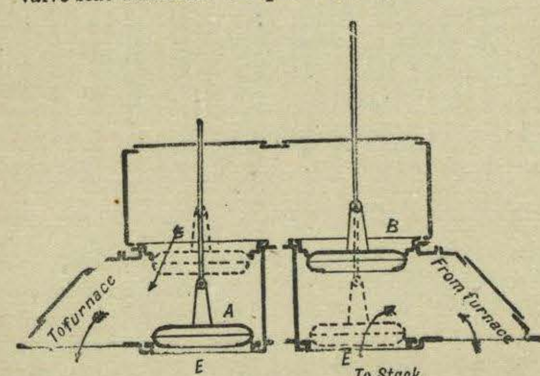


Fig. 139.—Hollow Disc Reversing Valve. Position, A, open to regenerators and furnace; position, B, products of combustion passing from furnace to the stack.

The last form of valve, although an improvement on the ordinary "pot-lid" flat valve hung on opposite ends of a rocking lever, is open to the same objection, that both valves are never closed simultaneously, any difference in temperature of any of the parts causing one or other valve to tend to leave its seat, and thus establish a leak, which rapidly grows worse owing to the gases burning, and may cause considerable damage to the gas valve before it is discovered by the furnaceman.

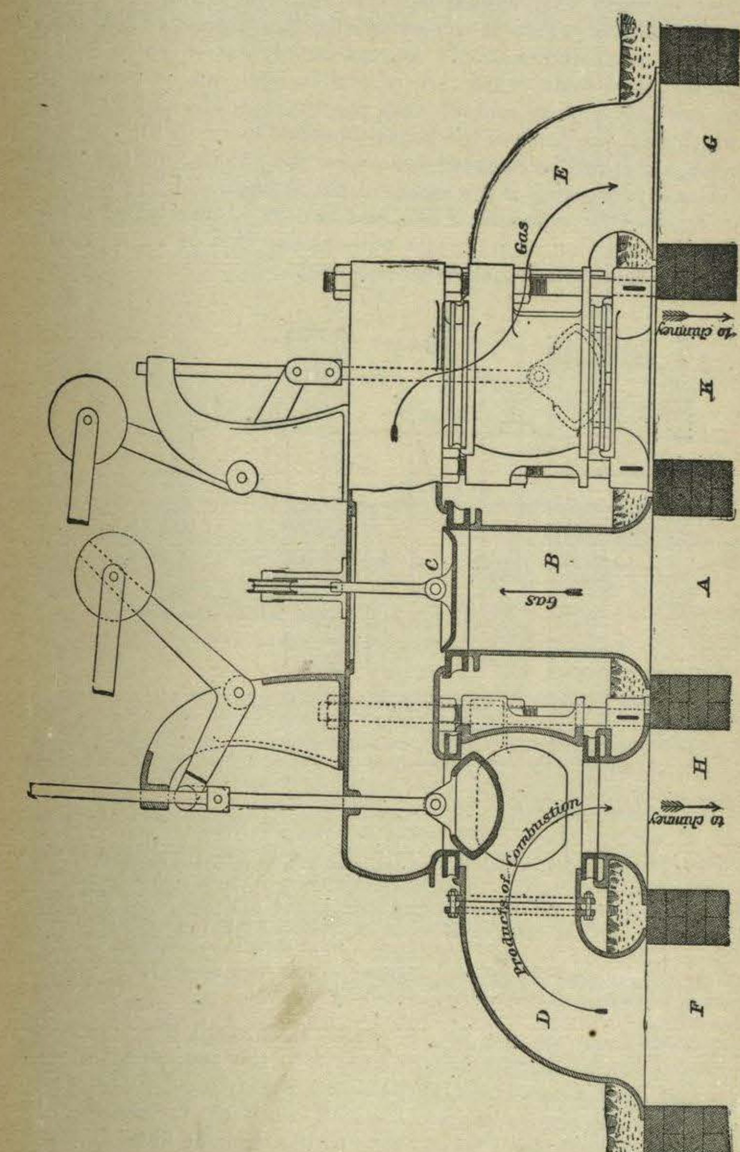


Fig. 140.—The Hall Valve.

On raising the gas inlet valve, C, the gas passes from B to the regenerators and furnace above the valve on the right hand through E and G, and the products of combustion from the furnace pass from F and D underneath the valve on the left hand through H to the stack, as shown by the arrows.

The valve (fig. 140) fitted by Mr. John W. Hall of Birmingham to furnaces of his construction removes this objection. The two valves are entirely independent of each other, each being reversed by its own lever, and the preponderance of the valves and weighted levers is so arranged that the valves come to their seats with a sharp blow, and are held in contact with both the upper and lower seats by gravity. The blow not only enables the valve and seat to come together in spite of any soot present on them, but assures the furnaceman that the valve is properly home. The steel valves are hollow and contain no ribs, so that they are free to expand equally in all directions, and do not change their shape when heated. Their faces are turned to form an arc of a circle, so that the valves will fit the seats with mathematical precision when canted to very considerable angles, and being attached to the spindle, which is a very free fit, find their own position on the seats even if the spindles should be considerably out of centre with the seats. The cast-steel seats, which are reversible, and can be turned over when worn, are kept cool by contact with the external air, and by turning the nuts which hold the parts of the boxes together so as to lift the box a small distance, a seat can be removed and a new one put in from the outside while the furnace is working if the seat is at the bottom, and by shutting off the gas for less than two minutes if the seat is at the top. Some of these valves and seats have run for four years without any sign of wear, probably owing to the fact that leakage has never occurred.

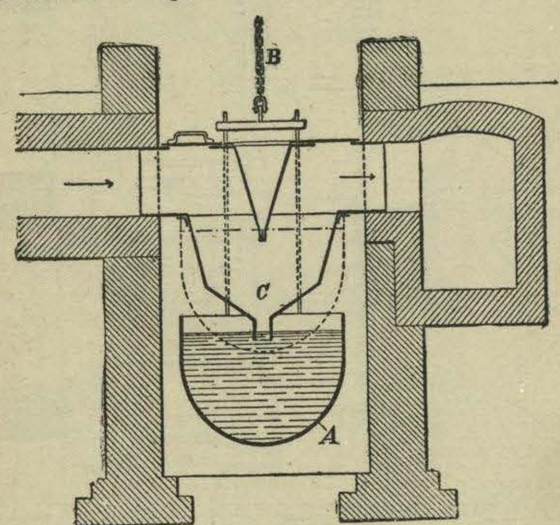


Fig. 141 —Wailes Siphon Reversing Valve.

Below is a cup of water, A, which is kept full, and can be raised or lowered by chain, B, and into this dips a funnel, C. In the position shown in the sketch any gas is prevented from escaping from the funnel-shaped orifice, but can pass along the flue, as shown by the arrows. When the cup of water, A, is raised into the position shown by the dotted lines, so that the V-shaped mid-feather dips below the surface of the water, the flow of gas is prevented altogether. This valve has been used experimentally in several works in England, but has not been generally adopted.

The gas enters from the gas flue, A (fig. 140), through the centre pipe, B, and passes through the regulating valve, C, to the reversing valves on each side. The bend pipes, D and E, lead the gases to or from the brick flues, F and G, which are in connection with the regenerators, while the waste gases pass through the base castings to the chimney flues, H and K. The arrows show the directions of the currents. If the regulator valve shown in the figure were raised, the gas would enter the regenerator on the right, and the waste gases would leave that on the left.

Some years ago a water-cooled valve, called the siphon valve (shown in fig. 141), was introduced by the late Mr. Wailes, formerly manager of the Patent Shaft and Axle-tree Company. From the sketch it will be seen that it consisted of a cup which was kept full of water, which could be raised or lowered at will to form a water seal. Another water-seal valve, designed by Mr. Wailes, is shown in fig. 142, and this, and modifications of it, have been largely used. The arrangement will be readily understood by referring to the sketch and description.

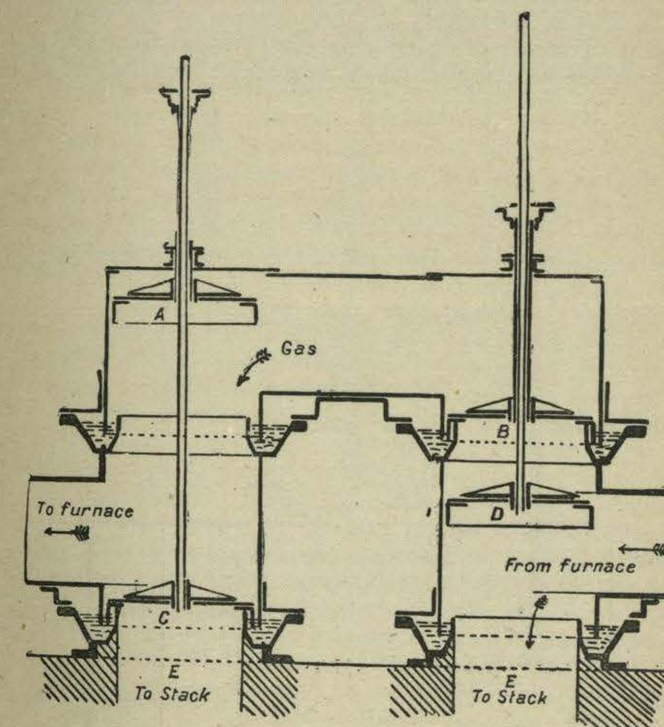


Fig. 142.—The Wailes Water-Seal Reversing Valve.

There are two valves on the same rod, but having independent motion, the top one being attached to a sleeve and the bottom one to the rod. When the valves are lowered the peripheries dip into the troughs of water shown, which are kept full of running water. When the valves are in position, A and C, the gas is passing to the regenerators and the furnace; and when in position of B and D, the gas valve, B, dips into the water seal, and the products of combustion pass from the regenerators under D through E to the stack. The valve, D, is largely protected from hot gases by being raised into a recess between the two valves. The reversal of position of valves reverses the direction of the gas. There are similar sets of valves on each furnace to control the direction of the air.

Another form of water-cooled valve is that patented by Mr. F. Mills (shown in fig. 143). In this valve a stream of water is constantly flowing down the stalk of the valve, which is made hollow, and the valve is of such a section that it is always water cooled, whether at the top or bottom of its range. The details of the design will be seen from the sketch.

The Chimney.—For the efficient working of a furnace nothing is of greater importance than a good draught, and each furnace should have a *separate* stack of such a size that a strong draught can always be insured, even when a furnace is in bad condition. It is always easy to damper a chimney if it is pulling too strongly, but it is impossible to increase the pull above the point limited by its dimensions, and hence the importance of having a chimney of such a size that it is rather above than below the ordinary requirements.

Position of Producer.—The position of the producer in relation to its distance from the furnace is still a disputed point, but the tendency in modern practice is to place the producer as near as possible to the furnace, with the double object of losing as little as possible of the sensible heat of the gas, and also of preventing the condensation of the volatile Hydrocarbons. The advantage of introducing very hot gas from the producer, may, so far as the economy of fuel is concerned, be regarded as nil, as,

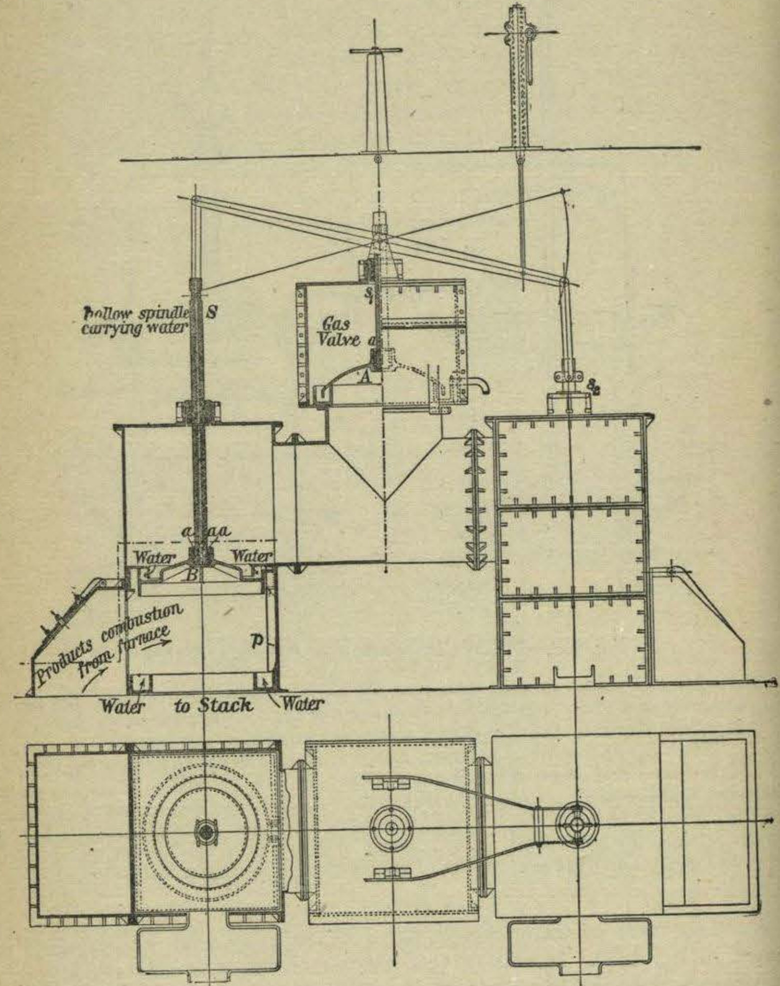


Fig. 143.—The Mills Water-cooled Gas Reversing Valve.

A is gas inlet valve; B, one of the reversing valves. When the valve, B, is in position shown, no gas can pass to furnace, but products of combustion are passing from the furnace underneath it to the stack, and the gas from the producer when gas valve, A, is open passes above a similar valve on the right to the furnace. The valves are on one rocking lever, pivotted at centre, so that raising one valve lowers the other. S, S_1, and S_2 are hollow spindles through which water is admitted, and flows out through holes, *a*, *a*, *a*, over the valve; P is a passage by which overflow water runs from the valve to the lower seat, and thence by a pipe to the cooling pond.

assuming that it is hotter than the cool end of the regenerator where it enters, it raises the checker brickwork to its own temperature, and when the valves are reversed, and the products of combustion pass through this regenerator, these gases are heated up to the same temperature as the temperature of the producer gas on entering, and consequently carry away to the stack as much heat as the latter originally introduced. To this must be added the very serious difficulty of maintaining the valves gastight, when very hot gas is used, although this risk is greatly reduced by using a good type of modern water-cooled valve. The calorific value of the Hydrocarbons has also, in all probability, been over-estimated, as these are largely dissociated when they come into contact with the hot surfaces of the regenerators, soot being deposited, and causing much trouble.

On the other hand, although no direct economy in fuel may result by taking very hot gas into the regenerators, there is no doubt the furnace works more rapidly when this is done, as, the chimney end of the regenerators being much hotter, the draught in the stack is increased, a steady flame is maintained, and rapid combustion takes place in the furnace, whereby the output may be considerably increased. All practical men know the difference between working a furnace in which the gas and air are drawn rapidly into the furnace hearth, and one in which the air and gas enter slowly; and in the opinion of some practical men, it pays to maintain these conditions for rapid working by allowing a certain proportion of unabsorbed heat to pass away to the stack. One steel works manager, of very large experience, informs the author that he always, as far as possible, maintains the temperature of his stack at 1000° F., and finds it more economical to do so when output and other practical points are considered, than to reduce the temperature to 500° or 600° F., although, theoretically, there should be no advantage when the temperature is maintained above 700° F. Against this it may be argued that if this is the only reason for taking very hot gas from the producer, it would be far better to obtain the quick working by building a larger stack in the first place; but those who favour the employment of hot gases from the producer contend that this does not give the same satisfactory results. The usual practice to-day is to place the producers from 30 to 50 yards from the furnace, and if the gas is carried through a brick-lined tube or culvert, there is very little sensible heat lost in travelling that distance, and at the same time a certain proportion of the less volatile Hydrocarbons are condensed before the gases enter the regenerators. The new form of Siemens furnace, which is fully described in the chapter on reheating furnaces, is also being used for steel melting, and is an extreme case of the producer being so close to the furnace that it forms a part of the furnace itself, and there can be no doubt that it largely owes its success to the fact that the gases are delivered into the furnace direct from the producer at a very high temperature, thus rendering it unnecessary to regenerate the gas at all. The extreme on the other side was the original arrangement of cooling tube used with the Siemens producer, in which the gases were purposely cooled down as much as possible before entering the furnace. This latter arrangement is never used now.

Drying the Furnace.—Before putting in the hearth of the furnace, it is most essential that the whole structure should be very thoroughly dried. This is best done by lighting a good fire in each of the four regenerators before the checker brickwork is built in, and keeping it burning for about two days and nights, allowing the hot air and smoke to pass up into the furnace. These fires should then be removed, the checker bricks put into the regenerators, and built up dry, and a good coke fire lit in the body of the furnace, the valves being kept open to allow all the products of combustion to pass to the stack through all four regenerators at the