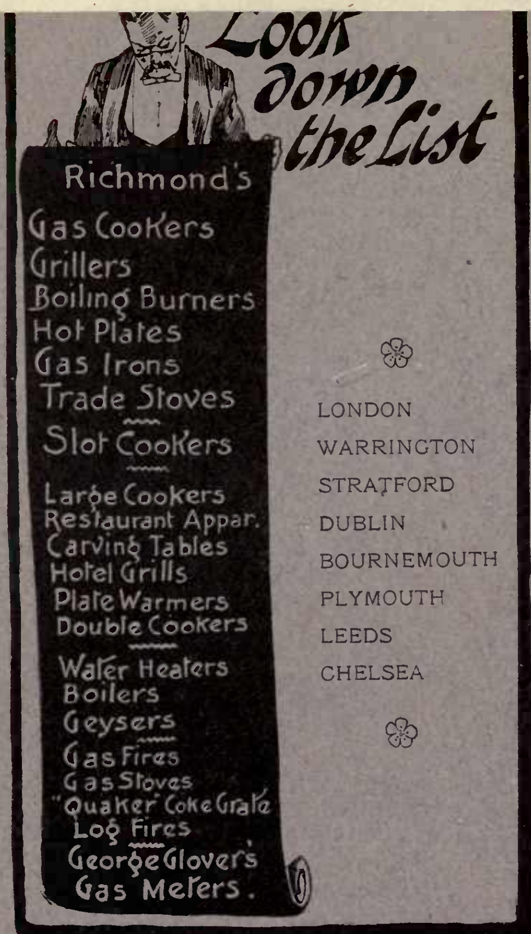
MODERN APPLIANCES IN GAS MANUFACTURE

FLETCHER W. STEVENSON, M. Inst, C.E


Look down the List
Richmond's
Gas Cookers
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Boiling Burners
Hot Plates
Gas Irons
Trade Stoves
Slot Cookers
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By FLETCHER W. STEVENSON,

M.Inst.C.E., M.Inst.G.E., &c.

LONDON:
THE FEILDEN PUBLISHING CO., LTD.,
TEMPLE CHAMBERS, EMBANKMENT, E.C.
1901.

BRADBURY, AGNEW & CO., LTD., PRINTERS
LONDON AND TONBRIDGE.

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APPENDIX.

Mr. Fletcher W. Stevenson, fifth son of the late G. W. Stevenson, of Parliament Street, Westminster, was born at Notting Hill in 1854. He received his technical education in his father's office, and afterwards assisted him in the design and construction of various gas and water undertakings. For ten years he was Engineer and Manager of the Chester United Gas Company. From 1888 to 1899 he was Chief Engineer to the Sheffield United Gas Company, and is now in consulting practice in Westminster. He is a Member of the Institution of Civil Engineers, and Member of the Institution of Gas Engineers, and also the Gas Institute.

Modern Appliances in Gas Manufacture.

CHAPTER I.

STOKING MACHINERY.

THE manufacture of coal gas dates from the beginning of the century; but its development on a large scale commenced in the fifties, and has continued at an increasing rate up to the present time notwithstanding the competition of electric lighting in recent years. In the earlier years of gas lighting, when the huge gasworks that now exist in the metropolis and in the leading provincial towns were undreamt of, the work involved in distilling the coal used for gas-making was carried on entirely by hand, the retorts being charged either with a shovel or by means of a hand-scoop, and the residual coke withdrawn by the men with a hand-rake. In small gasworks these methods still remain in use, but in almost all the gasworks of any importance in the United Kingdom this work is now performed by machinery specially devised for the purpose. Not only is the actual charging and discharging of the retorts done by machines, but many other operations incident to the manufacture of gas are performed mechanically, such as the storage of coal and coke, and the moving of the large masses of purifying material required in the process of manufacture.

Many attempts were made to construct machines to do the work of the gas-stoker before anything like success was attained. The first machine made for this purpose was devised by Mr. Henry Green, of Preston, in 1860. From that date onwards various types of stoking machines were introduced by different engineers. Up to 1875, however, no mechanical stoker previously designed can be said to have been successful, or to have continued permanently in use. Most of the earlier machines were actuated by steam power, the engine and boiler being in some cases fixed on the framework of the machine and travelling with it; in other cases, the power was transmitted through line shafting and gearing.

FOULIS-WOODWARD HYDRAULIC STOKING MACHINE.

In the year 1875 Mr. William Foulis, the Gas Engineer to the Glasgow Corporation, brought out a stoking machine actuated by hydraulic power. The water pressure employed was low, being only 120 lbs. per square inch. The machine was tried at Glasgow, but was not permanently adopted there. A set of machines (Figs. 1 and 2) was, however, made at Manchester by Messrs. Adam Woodward & Sons, and put to work at the Rochdale Road Station of the Manchester Corporation Gasworks. The machine for charging the retorts consisted of a cast-iron frame, on which a pair of hydraulic rams were mounted and connected with a vertical shaft carrying a drum. Round the drum a chain was

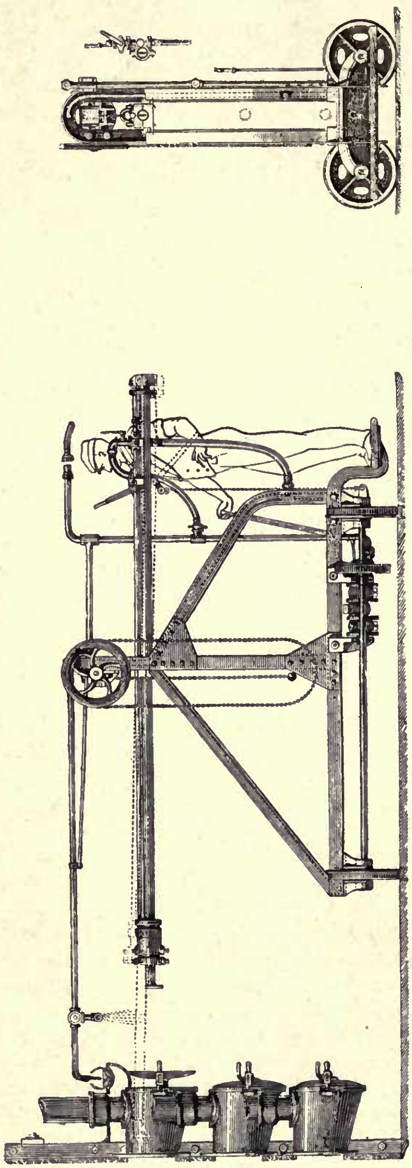


FIG. 1.—FOULIS-WOODWARD HYDRAULIC DRAWING MACHINE.

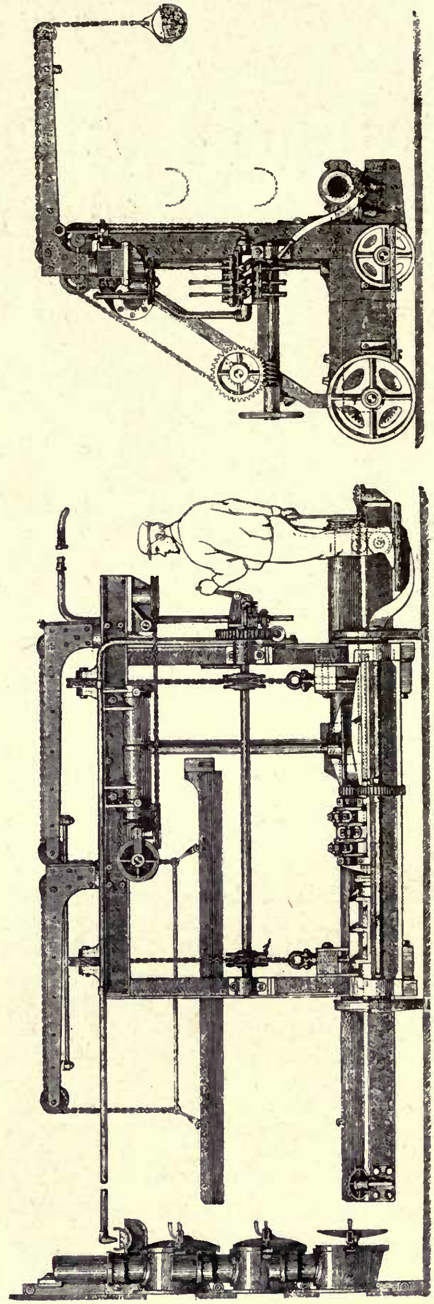


FIG. 2.—FOULIS-WOODWARD HYDRAULIC CHARGING MACHINE.

wound, the ends of which were connected to a scoop carriage travelling on a beam. The drum shaft was revolved by the movement of the rams in opposite directions, the rams having racks attached to them which geared with a pinion on a cross shaft, and from this cross shaft the motion was communicated to the drum shaft by bevel wheels. Supplementary rams actuated a pair of cranes, by which the scoop, laden with coal, was lifted and placed in position in front of the scoop-carriage. On setting the rams in motion the scoop was driven into the retort, and withdrawn therefrom after discharging its contents. The deposition of the coal in the retort was accomplished by giving the scoop a half turn at the end of the stroke, so that the coal fell from the inverted scoop into the retort, the scoop returning upside down and righting itself at the end of the return stroke. These movements were effected by setting the head-stock of the scoop in a loose collar on the carriage. The ends of the chain were passed half round the head-stock, and as the end of the stroke was reached the chain became taut and pulled the head-stock and scoop round half a circle. The discharging or drawing machine consisted of a malleable iron tube (afterwards replaced by one of drawn steel), in which a piston and rod worked. At the end of the rod was fixed the rake head. The whole was supported on a triangular frame mounted on wheels, and provided with a hand wheel and gearing for travelling on rails laid down on the retort-house floor. Suitable reversing valves were provided for both machines, worked by levers for controlling the movements of the rams. The hydraulic pressure supply was obtained from an accumulator, and conducted to the machines through "pendulum" pipes attached by swivel joints to a pressure main fixed overhead on the retort-house wall.

In general outlines may be thus described the first hydraulic stoking machines. They lacked one essential feature, viz., a means of mechanically conveying the coal to the charging machine. Nevertheless, they were used in Manchester and Salford for many years, and contributed in a marked degree to the economical production of gas. In subsequent machines of a similar type Messrs. Woodward & Sons added some important improvements. They designed and constructed a coal conveyer to bring the coal to the charging machine. In conjunction with the coal conveyer is fixed a large hopper, into which the railway coal wagons are emptied. At the bottom of the hopper is a breaker for breaking the coal and cannel into small lumps. From the breaker the coal falls into a pit, from whence it is elevated and placed in position for the buckets of the conveyer to receive it. The attention of a man to fill the buckets is required, after which the coal needs no further handling. On the top of the charging machine is fixed a hopper, which receives the coal from the conveyer, and from this hopper the coal descends into the scoop, this action taking place when the machine-man revolves a hand wheel on a shaft carrying blades fixed under the bottom of the hopper. The charging machine is also provided with automatic travelling gear, consisting of a pair of rams fixed horizontally and connected by a rack which gears with a pinion, and through this pinion to the axle of the machine by bevel gearing. A clutch arrangement allows the rams to be reversed without moving the machine backwards.

Although these machines cannot with exactitude be termed "modern appliances," they form the groundwork of modern stoking machinery, and practically embody all the ideas which in later types of machines have been somewhat differently worked out. The Foulis-Woodward machines are still in use at two of the Manchester Gasworks and at the Salford Gasworks.

WEST'S MANUAL AND PNEUMATIC STOKING MACHINE.

The next successful attempt to cope with the difficulties of mechanical gas stoking was made by Mr. John West, who, when occupying the position of Engineer to the Maidstone Gas Co., designed and patented what is known as the West Manual Stoking Machine. This machine (Figs. 3 and 4) was designed to meet the requirements of the smaller gasworks. While still actuated by hand, it

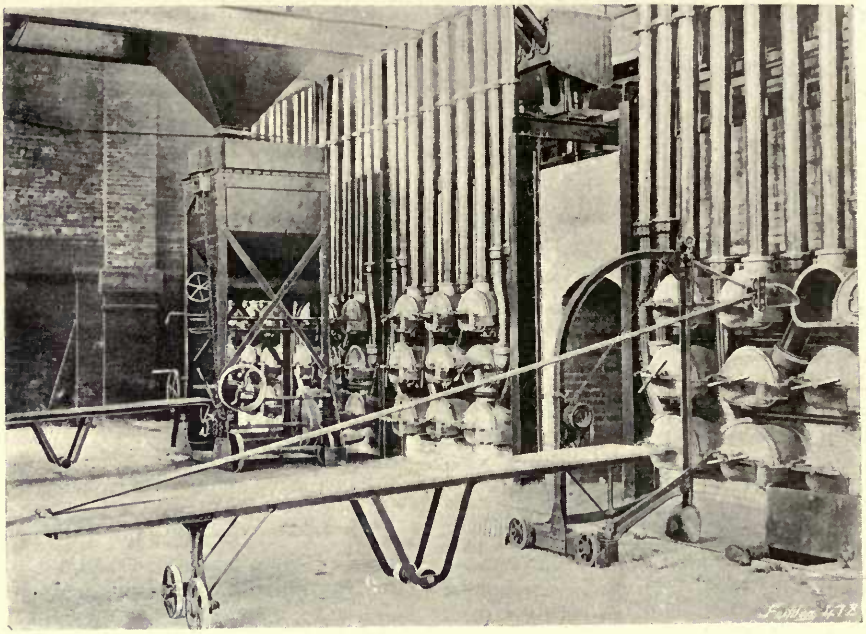


FIG. 3.—WEST'S MANUAL STOKING MACHINERY: GENERAL VIEW, DRAWING AND CHARGING MACHINES.

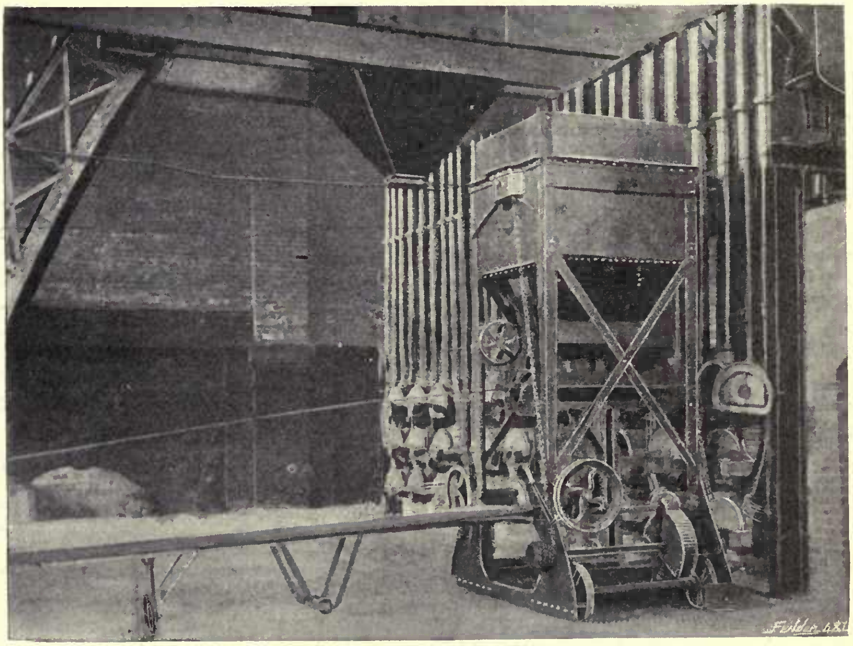


FIG. 4.—WEST'S MANUAL STOKING MACHINERY: CHARGING MACHINE.

made stoking a much easier operation, and combined with it was the most important feature of modern stoking machinery, viz., the coal breaker and elevator.

In the West Manual Machine, the coal, after being broken and elevated into an overhead hopper, is introduced into the retort by means of a trolley - carriage, which is run into the retort by hand. The trolley-carriage consists of a light frame, on which are fixed two short scoops side by side. The scoops are pivoted on axles, so connected by gear wheels that by the movement of a lever at the end of a central rod the scoops are made to revolve on their axles in opposite directions, and deposit the coal in the retort. The trolley-carriage is mounted on small wheels, which run on the floor of the retort. The carriage is introduced twice into the retort, the first time depositing the coal at the back half of the retort, and then, after being refilled, charging the front half.

This machine has recently been remodelled and greatly improved to make it capable of more fully meeting the modern requirements of heavy charges to suit high heats.

On looking at the illustrations (Nos. 5 to 10) an idea of the

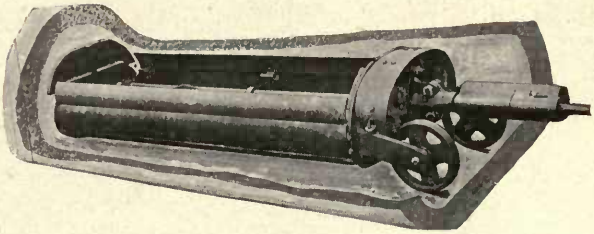


FIG. 5.—WEST'S NEW MANUAL CHARGER.

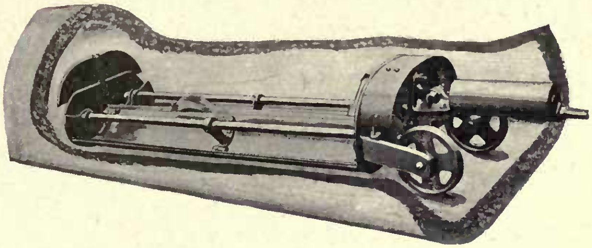


FIG. 6.—WEST'S NEW MANUAL CHARGER: THE SCOOPS BEING REVERSED AND THE SEVERAL PARTS OF EACH SCOOP FOLDED TOGETHER.

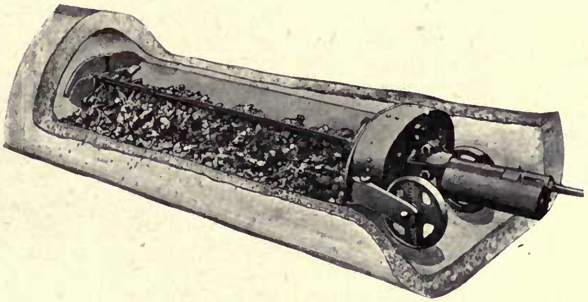


FIG. 7.—SHOWS THE CHARGER WITH COAL DELIVERED IN THE RETORT, THE SCOOPS BEING PARTLY REVERSED.

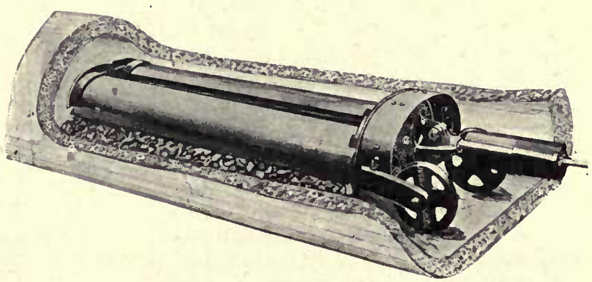


FIG. 8.—SHOWS THE CHARGER WITH COAL COMPLETELY DELIVERED IN THE RETORT, THE SCOOPS BEING REVERSED AND RAISED ABOVE THE COAL TO PERMIT THE CHARGER BEING WITHDRAWN.

construction and working of the new charger will be readily understood. The main differences between this and the older form is that the side flaps which were necessary in the old charger to contain the coal are dispensed with, and each

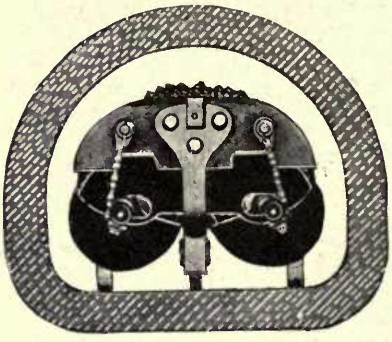


FIG. 9.—FRONT END VIEW OF CHARGER ENTERING RETORT, WITH SCOOPS IN LOWEST POSITION.

scoop has the form of a double scoop. That is to say, each scoop is made of two scoops folding in one another, and the gearing is so arranged that the scoops open out wide to take the place of the flaps already mentioned; when the coal is being deposited, one half of the scoop folds into the other and causes the coal to be delivered to the sides of the retort without any obstruction.

The advantages of this new charger are that the machine occupies less space in the retort, and at the same time a larger charge of coal is contained in the charger than by the old type, ensuring a much larger make of gas per retort. Several of these new chargers are in daily use, and have fully maintained the anticipations formed of its great improvement over the old form. One of the chief features of the new charger is that the coal is more evenly deposited in the retort, and the charger does not drag the coal on to the mouthpiece when a large charge is deposited; this is effected by the action of raising the front end of the charger above the layer of coal as shown on Fig. 8, when the charger is in position for being withdrawn from the retort.

The drawing machine is a rake—balanced between pulleys on a suspended bracket, and thrust into and withdrawn from the retort by hand, the weight of the rake being supported by the pulleys.

From the manual machine to a similar machine actuated by power was an easy transition. In 1880 Mr. West became Gas Engineer to the Manchester Corporation. At Manchester the hydraulic machines were already in use. Mr. West quickly transformed his manual machines into machines worked by compressed air. The trolley carriage was retained, and only such modifications of the machines took place as were necessitated by the application of power. The manner of supplying power is as follows: Air is compressed in a compressing engine to a pressure of 60 lbs. per square inch and stored in cylinders fixed over the retort bench, with the object of preventing a reduction of temperature and pressure as the air is released. The compressed air is communicated to the machines through strong indiarubber tubes wound on drums, the pull of the tubes being counterbalanced

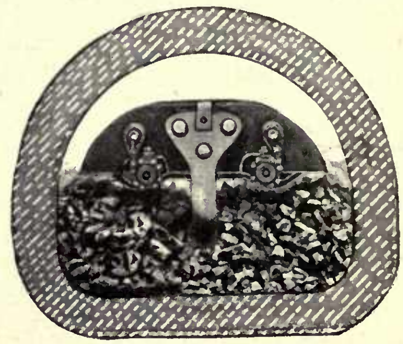


FIG. 10.—FRONT END VIEW OF CHARGER IN RETORT, WITH SCOOPS REVERSED AND CHARGER END RAISED ABOVE LAYER OF COAL.

by weights, so that the drums automatically unwind or wind up the tubes as the machines travel from or towards the position where the drums are suspended overhead. Cylinders with reciprocating pistons are used for actuating the machines, and the motion is communi-

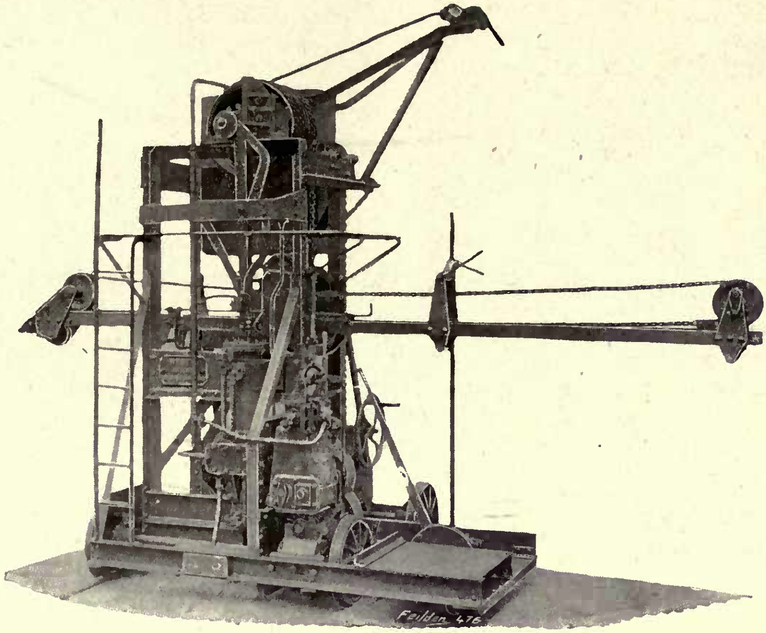


FIG. 11.—WEST'S PNEUMATIC DRAWING MACHINE.

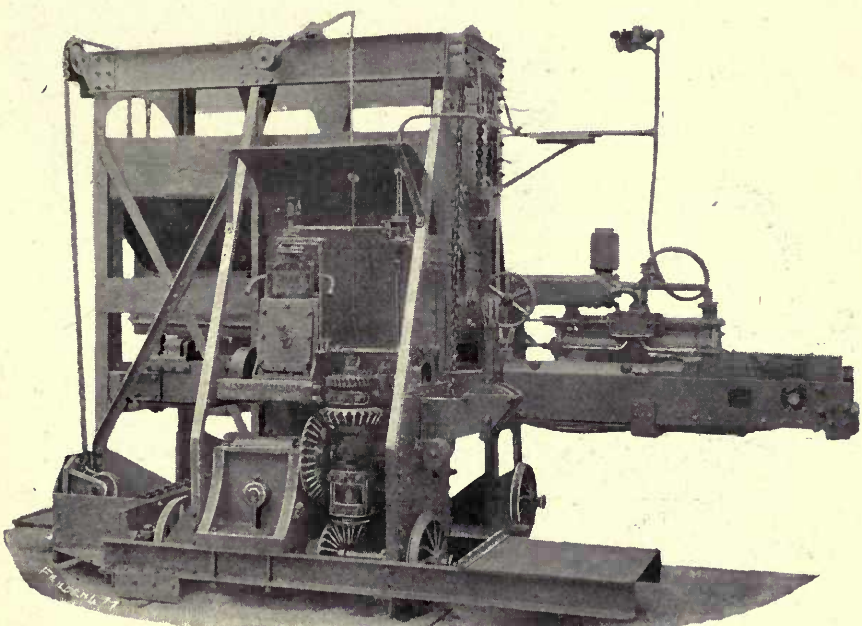


FIG. 12.—WEST'S PNEUMATIC CHARGING MACHINE.

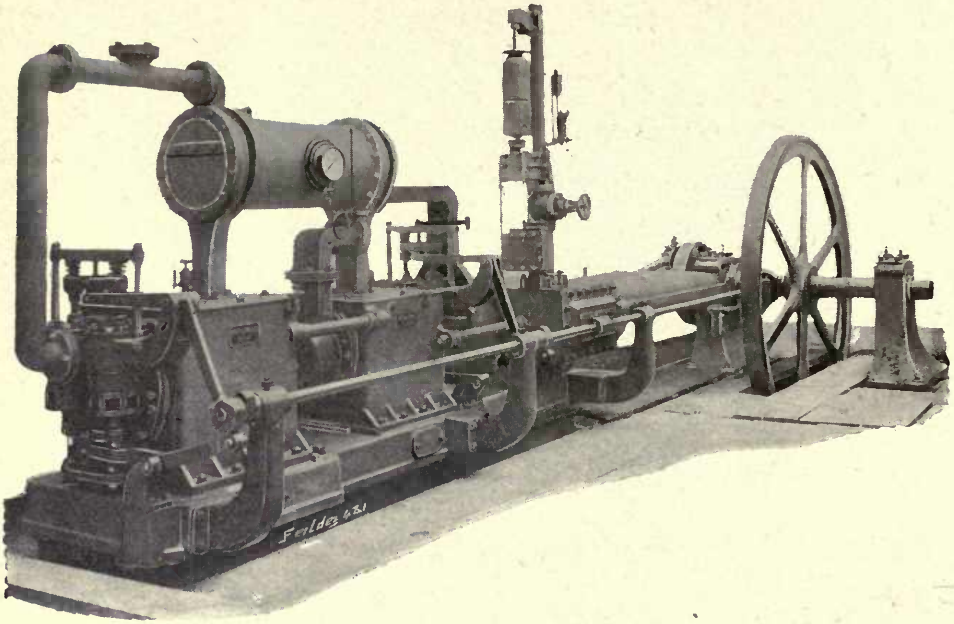


FIG. 13.—WEST'S SINGLE AIR-COMPRESSING ENGINE.

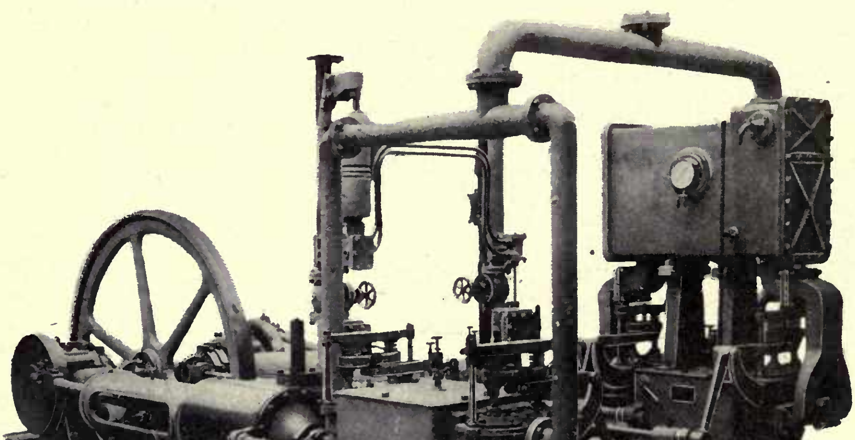


FIG. 14.—WEST'S DOUBLE AIR-COMPRESSING ENGINE.

cated to the charger and to the rake by means of multiplying chain pulleys.

Since the first pneumatic machines were made they have undergone very considerable modification. The present type of West's Compressed Air Stoking Machine (Figs. 11 and 12) shows a great advance on all earlier attempts at mechanical stoking in gasworks. The framework of the machine is built up of steel. The charging machine carries a hopper capable of containing from 4 to 6 tons of coal. The hopper, together with a massive beam of steel, on which the charger travels and to which the air cylinders are attached, is raised or lowered by a pneumatic motor. The motor is also utilised for the automatic travelling of the machine on the rails in front of the retort bench. There are three air cylinders, the larger and central one being for pushing the charger into the retorts, and the two smaller ones for cushioning at the end of the stroke. The charging carriage to which the scoop is attached is sufficiently heavy and strong to support the weight of the scoop and its charge entirely, the end of the scoop hanging free. An ingenious arrangement is included in the carriage, by which the headstock of the scoop may be turned round either to right or left when depositing the charge in the retort. The scoop is somewhat smaller than that used on the Foulis-Woodward machine, and is introduced twice into the retort, being turned over first one way and then the other, so as to deposit the coal towards each side of the retort. The drawing machine is still usually travelled by hand, but the largest machines are provided with motors. The rake is carried on a beam, which can be raised or lowered as desired. It is actuated by a piston working in a cylinder placed vertically, and the motion is communicated by means of a chain passing round multiplying pulleys. Both the rake and the charger work at a much higher speed than was adopted for the earlier hydraulic machines, and the retorts can be drawn and charged at an average rate of 45 seconds each. Figs. 13 and 14 are illustrations of the most modern type of air-compressing engine, and Figs. 15 and 16 are coal and cannel breakers as adopted for West's machines.

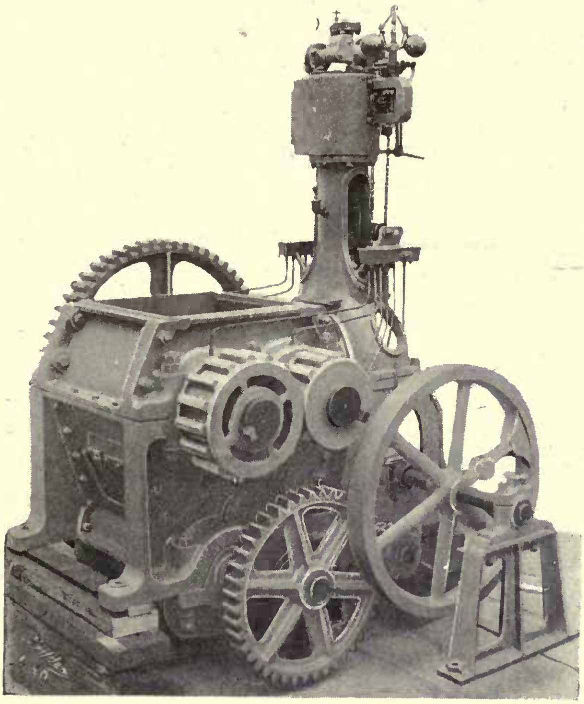


FIG. 15.—WEST'S COAL AND CANNEL BREAKER.

FOULIS-ARROL HYDRAULIC STOKING MACHINE.

The latest style of stoking machine is one designed by Mr. Foulis with the assistance of Sir William Arrol. In this new type of machine hydraulic pressure is retained as the motive power, but the machine differs essentially in several particulars from the hydraulic machines originally brought out by Mr. Foulis. In the first place, the pressure is increased to 350 lbs. per square inch, and the rams being smaller the machines are of a lighter character. Wire ropes are used instead of chains for communicating motion from the rams to the reciprocating parts. The principal change, however, is in the method of charging the retorts. The scoop is abandoned in favour of a "pusher," the coal being no longer conveyed into the retort in a receptacle but dynamically thrust into the retort by the pusher. The quantity of coal descending on to the shoot is regulated by a revolving drum or paddle-wheel, which is divided up into several compartments by radial diaphragms. Each compartment holds 50 lbs of coal. The wheel is rotated by a hydraulic cylinder having a rack arrangement actuating the shaft of the wheel. At each stroke of this rack the wheel rotates just so far as to bring one of the compartments in an inverted position over the shoot; the contents then

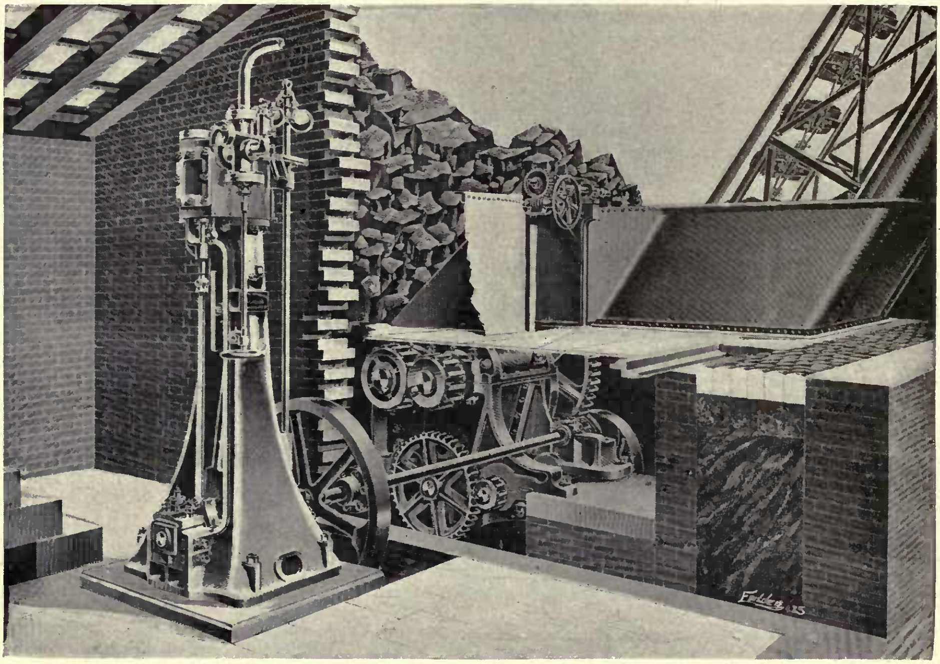


FIG. 16.—COAL AND CANNEL BREAKER, WITH ENGINE AND ELEVATOR.

means of the pusher. The charging machine has two hydraulic cylinders attached horizontally to a beam, one, the larger of the two, being for pushing in the charge of coal, and the other, of a smaller diameter, for withdrawing the pusher. The coal is carried in a hopper fixed on the top of the framework of the machine, and it is allowed to descend on to a plate, or shoot, one end of which rests on the mouthpiece of the retort, and from which it is pushed into the retort by

fall on the shoot, and are immediately pushed into the retort. As the total charge required to fill the retort is 3 or 3½ cwts. of coal, the operation has to be performed six or seven times; and in order that the coal may be evenly deposited along the length of the retort, and not heaped up at the back of it, it is necessary that the stroke of the ram actuating the pusher should be shorter at each succeeding stroke. This is effected by a stopper rod, on which is a series of collars.

The rod is slightly rotated by gearing after each stroke, and the collars brought successively into action to reverse the valves at the proper moment, and arrest the forward motion of the pusher. The raising and lowering of the beam is done by the direct action of a vertical ram, the beam being supported by wire ropes passing over sheaves at the top of the framing, and connected to the inverted head of the ram. The charging machine is also provided with a hydraulic motor for automatic travelling movements.

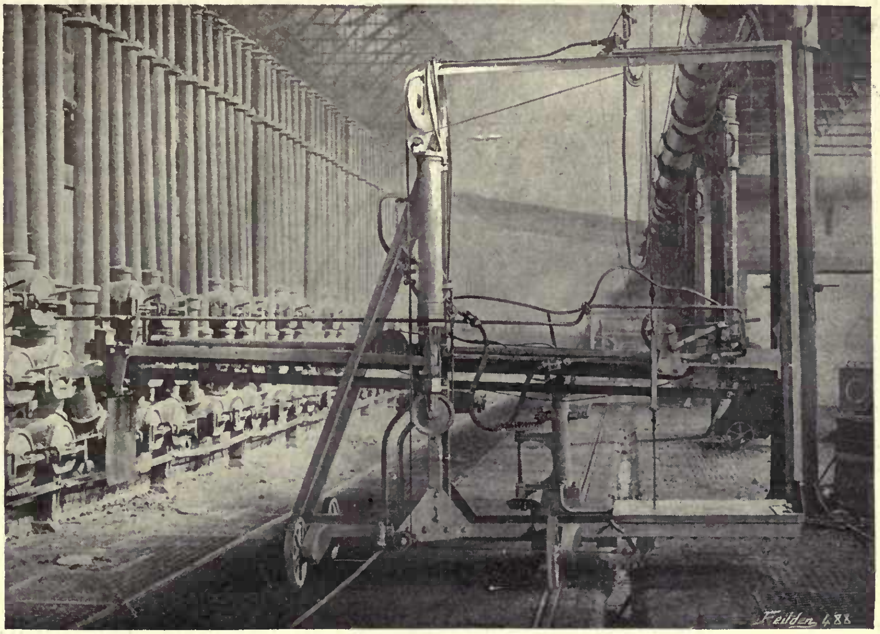


FIG. 17.—FOULIS-ARROL HYDRAULIC DRAWING MACHINE.

The drawing machine consists of a beam carrying two horizontal cylinders, one for driving in the rake and the other for drawing it out, the action being similar to that of the charger; but in the case of the drawer the larger cylinder is required for withdrawing the rake, together with the coke. The lever actuating the valve for working the rake is attached to the beam in such a manner that the movement which sets the valve for pushing in the rake at the same time depresses the back end of the beam, allowing the rake to rise and pass over the coke. The reverse movement elevates the back end of the beam, allowing the rake to drop into the coke. Only a portion of the coke is drawn at each entry and withdrawal of the rake, which is made to enter further into the retort at each successive stroke.

The water pressure is communicated to the machine through flexible hose-pipes fixed to travelling carriages running on bars, secured either to the walls of the retort-house or the tie-rods of the roof. A duplicate set of pipes is provided for the return water from the charging-machines. The connection with the machines is made by swivels, similar to those used for connecting fire-hose.

In Mr. Foulis' new arrangement the coal is stored in large hoppers fixed over the centre of the retort bench, and provided with shoots at either side for filling the hoppers on the charging machines. The coal is previously broken and elevated into the storage hoppers.

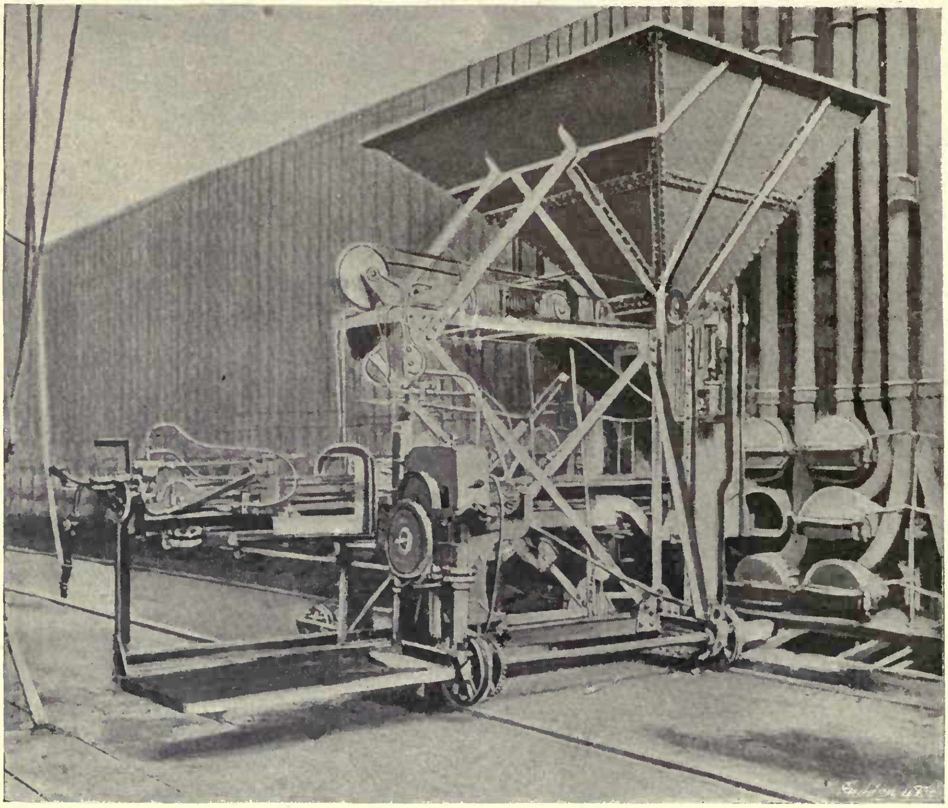


FIG. 18.—FOULIS-ARROL HYDRAULIC CHARGING MACHINE.

An addition to the charging machine has quite recently been made in the shape of an elevator attached to the machine itself, which picks up the coal from a continuous bunker behind the machine, thus dispensing with the necessity of previously elevating the coal into storage hoppers. This arrangement is, however, only applicable for coal that is sufficiently small to require no breaking.

The mechanism of the Foulis-Arrol Stoking Machines is of a very superior class and well adapted for its purpose. Rapidity of movement is combined with strength and compactness. This machinery has been introduced into the works of the three Metropolitan Gas Companies. It is in use throughout the gasworks of the Glasgow Corporation, also in the Birmingham Gasworks, and in several gasworks of less magnitude in other towns.

With the modern stoking machinery one drawing and one charging machine will draw and charge from 900 to 1,000 retorts in the 24 hours ; that is to say, they will put in 1,000 charges of 3 to 4 cwts. each and withdraw the coke. This means the manipulation of some 175 tons of coal and 110 tons of coke—together, 285 tons of material.

Altogether about forty-five men will be the number employed for the carbonising work which one set of machines can comfortably undertake. The weight of coal will work out to 4 tons per man for eight-hour shifts, or 6 tons per man if twelve-hour shifts are in vogue.

It is generally agreed that the saving in wages effected by the adoption of stoking machinery amounts to a sum equal to 1*s*. 3*d*. per ton of coal carbonised. The work of drawing and charging each retort is accomplished in a shorter space of time than under the old system, and the duty percentage of the retorts is higher both in point of time usefully occupied and in weight of material carbonised.

Before leaving this portion of our subject a very ingenious mechanical charger must be described, devised by Messrs. Biggs, Wall & Co., which enables the smallest works to dispense with the skilled labour necessary for charging gas retorts.

The machine is at once simple, efficient and economical, and enables two men with very little manual labour to charge a retort with a scoop which would ordinarily require three strong and skilled men. It consists essentially of a drum worked by a chain-wheel. To the drum is attached a steel-wire rope, or a chain, to the other end of which is fixed a cradle, which slides over the scoop containing the charge of coal. Upon the side of the drum there is a ratchet-wheel and pawl which engages with it, by which the load can be suspended at any desired height.

The lifting gear, as described, is hung from a travelling carriage, which travels to and from the retort by means of two pairs of wheels on a double line of rails, whilst the carriage itself is so arranged that it travels on another set of rails fixed parallel to and in front of the retort bench, so as to enable it to deal with any number of settings of retorts.

In working, the scoop resting in the carrier is filled with coal. Then the chain-wheel is set at work, and the wire rope is fed over the drum. When the scoop is opposite the mouth of the retort, the scoop-driver "drives" the machine, and the impetus obtained by the 5 ft. travel of the lifting-gear carriage carries the scoop the full length of the retort, when it is turned and withdrawn for refilling.

The advantages of the "Rapid" charging machine may be summarised as a saving in labour and the avoidance of skilled labour, combined with better distribution of coal in the retort, which is obtained with a scoop as compared with charging by shovel.

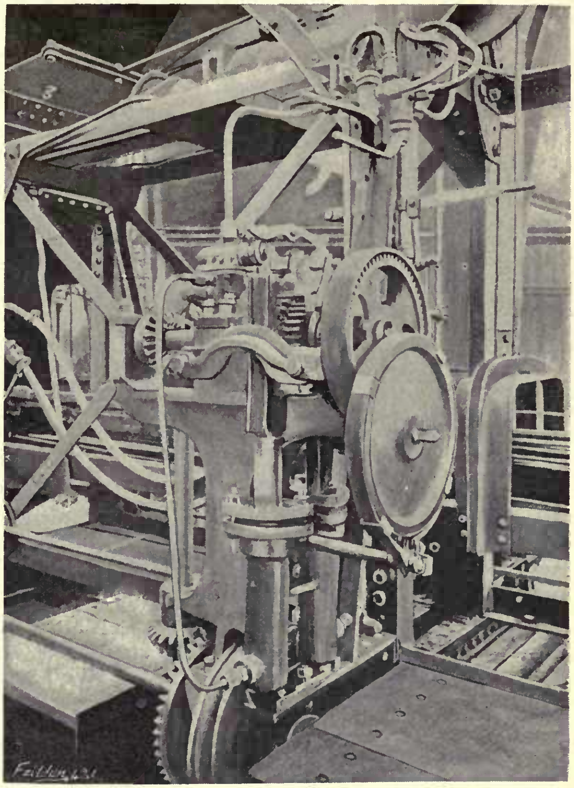


FIG. 19.—HYDRAULIC MOTOR ON FOULIS-ARROL CHARGING MACHINE.

All the principal parts are made interchangeable, as the makers expect shortly to be able to work the machine in a novel manner with steam power at a comparatively small cost. Further, a drawing-machine to be worked in conjunction with the charging-machine is now in course of construction, and will be a valuable adjunct.

CHAPTER II.

INCLINED RETORTS, &c.

A NEW method of building retort-settings has, during the past eight years,

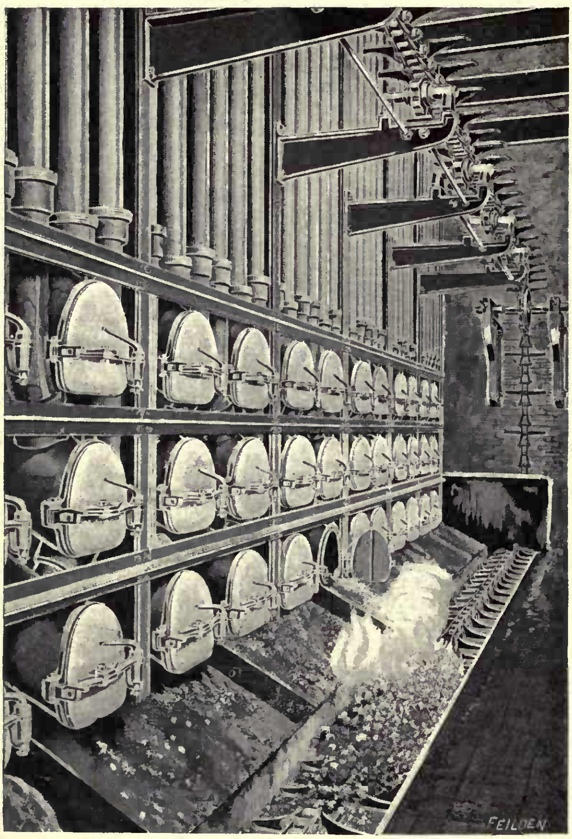


FIG. 20.—INSTALLATION OF INCLINED RETORTS, GAYTHORN STATION MANCHESTER CORPORATION GASWORKS.

come into vogue, designated "The Inclined Retort System."

On this system, the retorts are no longer placed horizontally, but are se at an angle varying from 28 to 34 degrees from the horizontal.

The object aimed at in setting retorts at an angle is to enable them to be charged and discharged by gravitation. The coal, instead of being deposited in the retorts by means of a scoop, or pushed into them by mechanical force, is allowed to slide into them from the upper end, and the coke is allowed to slide out at the lower end.

The angle at which the retorts are set is determined in accordance with the known property of solids to assume a position of rest at a certain angle so soon as the impetus due to the momentum acquired by its own weight, after it has once been set in motion, is expended. This angle, called "the angle of repose," differs for different materials, and must be determined by experiment. In the case of coal the angle varies within certain limits, owing to the varying physical constitution of the coal and its behaviour under the process of carbonisation. Certain coals of a bituminous character become pasty when undergoing distillation. Coagulating into a tarry mass in the initial stage of carbonisation, they are no longer able to retain their position on an inclined plane the angle of which is sufficiently flat to enable them to do so when cold. For such coals an angle of 28 or 29 degrees is most suitable, and the deposition of the

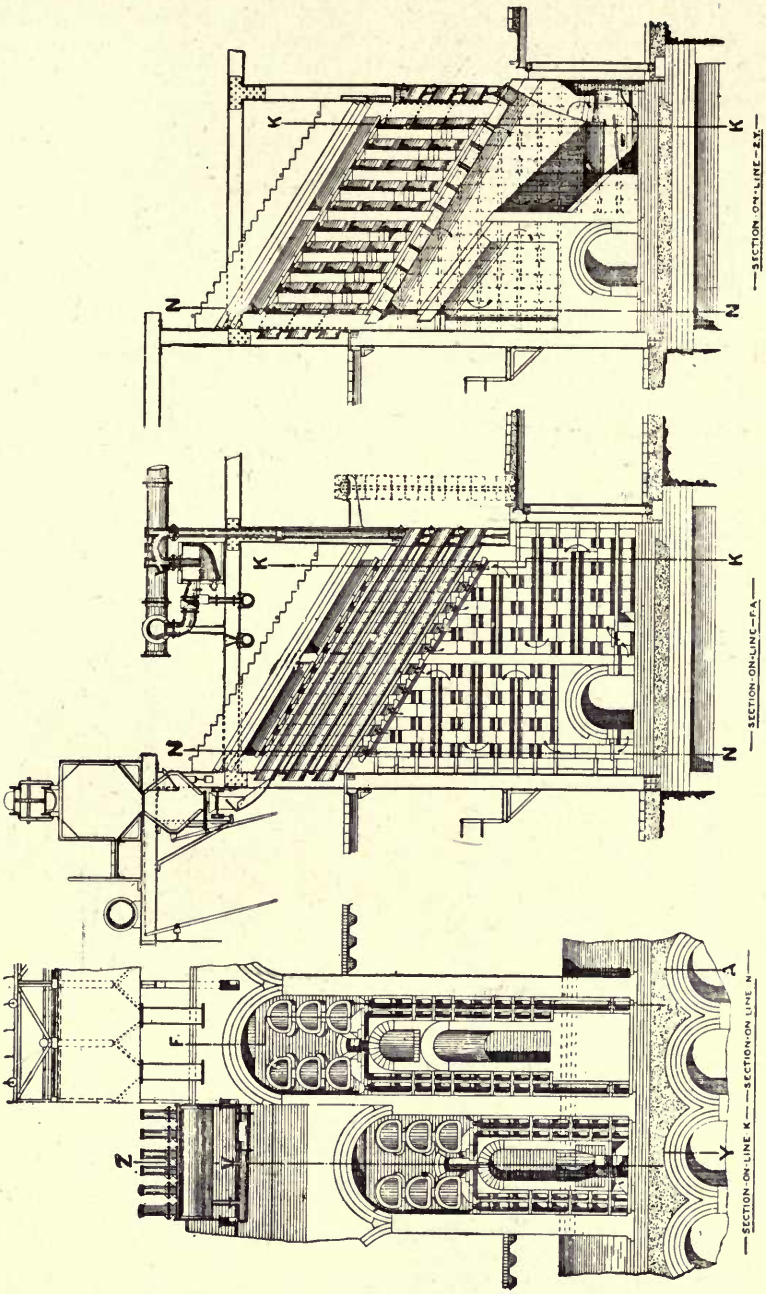


FIG. 21.—SECTIONS OF INCLINED RETORT SETTING AT GAYTHORN STATION, MANCHESTER.

coal in the retort must be brought about by giving it a greater impetus than would be necessary were a steeper angle used. Other coals, not changing their condition to the same extent, may be distilled in retorts set at a steeper angle with advantage.

The inclined system of retort setting is the invention of a Frenchman, Monsieur Coze, the Gas Engineer at Rheims. Since its introduction into England, the method of applying this principle has undergone improvements, which have rendered it more practical and more suited to the manufacture of gas on a large scale. At the present day most inclined retorts in this country are set at an angle of 31 or 32 degrees. Their length is generally 20 ft., but in some of the smaller installations it is 15 ft. The inclined retorts are heated in the same manner as horizontal retorts, by regenerator furnaces, the furnace being fired at the front side, where the lower ends of the retorts are situated, and the heat rising to the higher portion of the retorts at the back.

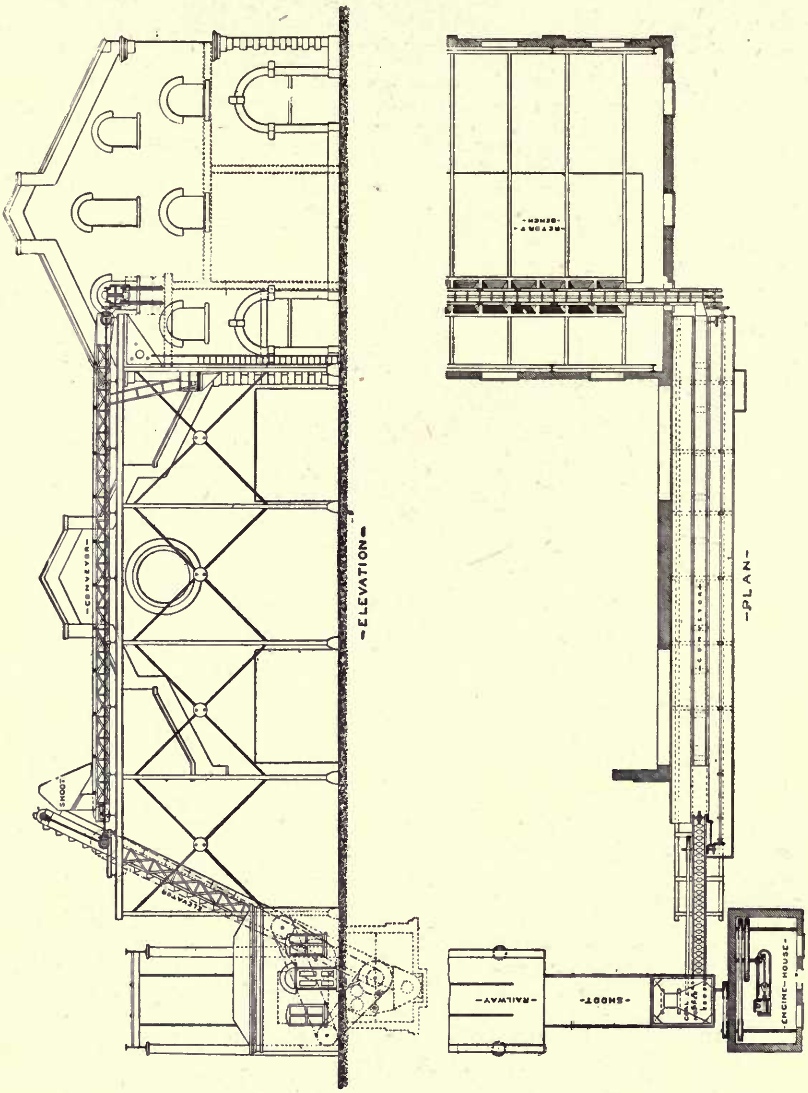


FIG. 22.—COAL-CONVEYING PLANT, GAYTHORN GASWORKS, MANCHESTER.

The inclined retort system involves the

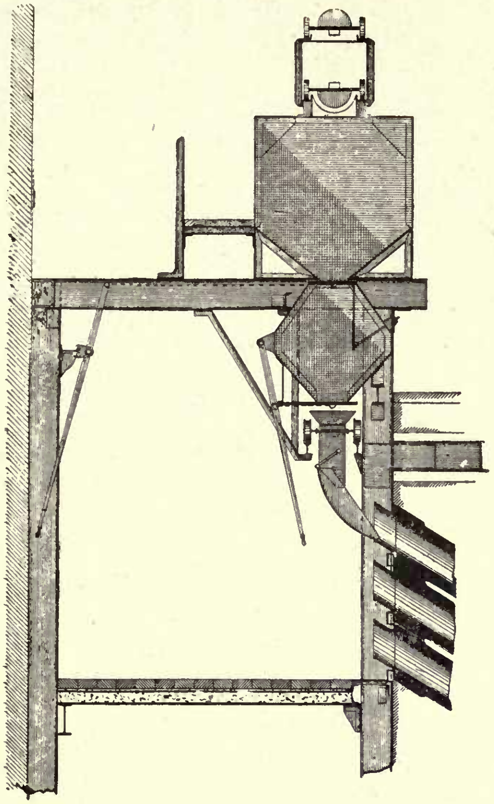


FIG. 23.—SECTIONAL ELEVATION.

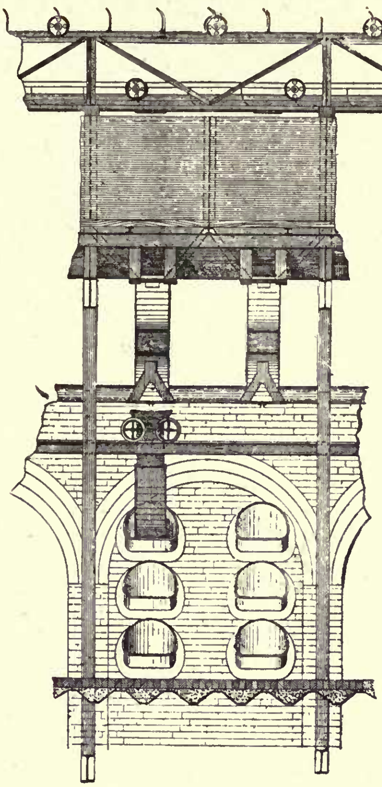


FIG. 24.—FRONT ELEVATION.

METHOD OF CHARGING RETORTS.

raising of the coal to the high level at the back of the retorts and the provision of mechanism for delivering it into the retorts in such a manner that it will pour into the retort in a continuous stream, filling the retort with a uniform layer of coal from the bottom to the top.

Hence the introduction of this system has given rise to an elaborate development of coal-conveying and distributing apparatus. The coal must first be broken into small pieces, because large lumps cannot be picked up by the elevators and carried into the conveyers, nor passed through the slides and shoots used for charging the retorts. Moreover, it is found that if the coal be not of uniform size its velocity when entering the retort cannot be properly regulated, for the large lumps roll down rapidly to the bottom end of the retort, whilst the small coal lags behind.

After being broken the coal requires elevating to a height of from 40 to 50 ft. above the discharging floor of the retort house, in order that it may be stored in overhead hoppers, or bunkers, from which supplies may be drawn off for charging the retorts.

THE GAYTHORN INSTALLATION, MANCHESTER.

As an example of the most completely automatic plant for dealing with the coal to be used in inclined retorts, we may take the recent installation at the Gaythorn Station of the Manchester Corporation Gas-works (Figs. 21 and 22).

For the reception of the inclined retorts an old retort house was emptied of its contents and the walls raised from 20 ft. high to 35 ft. high. The retort bench comprises 18 settings of retorts arranged in two sections, there being six retorts in each setting, 20 ft. long. The settings are built up from a basement 10 ft. below the ground level. At the two ends of the retort house are two chimneys, with which the two sections of the main flue communicate.

The coal supply for the gasworks is received on sidings at a level of 30 ft. above the ground. Behind an adjoining retort house are coal stores, with lines of rails overhead for dropping the coal into store from the wagons. To one of these lines an extension was made, terminating where the upper end of a shoot commences. The bottom end of the shoot communicates with a large main hopper, below which is fixed the breaker for breaking up the coal and cannel. The wagons are brought directly over the top of the shoot and the bottom doors opened, allowing the coal to fall on the shoot and descend into the hopper. After the coal has passed through the breaker it is raised by an elevator to a height of 46 ft., and delivered on a cotton "band" conveyer, which is supported on a scaffolding of steel uprights and girders, and situated parallel to the gable end of the retort-house. On this "band" conveyer the coal travels along in a perfectly quiescent state and in a thin stream, till, at the end of it, it falls into the trough of another

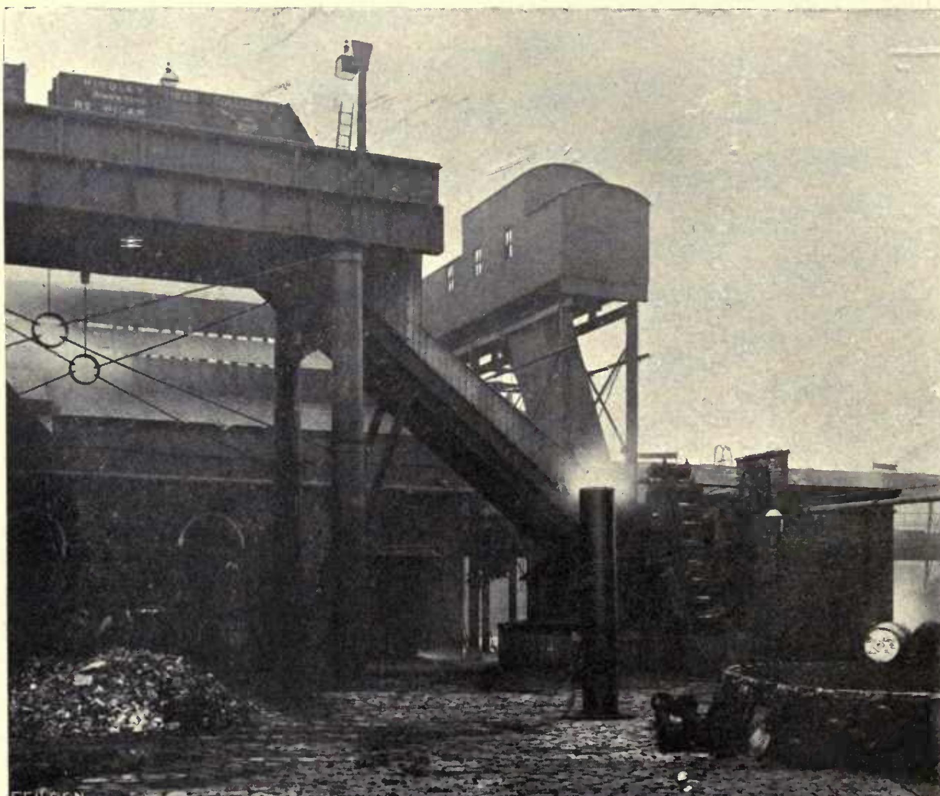


FIG. 25.—AUTOMATIC PLANT FOR CONVEYING COAL TO THE INCLINED RETORTS AT THE GAYTHORN WORKS, MANCHESTER.

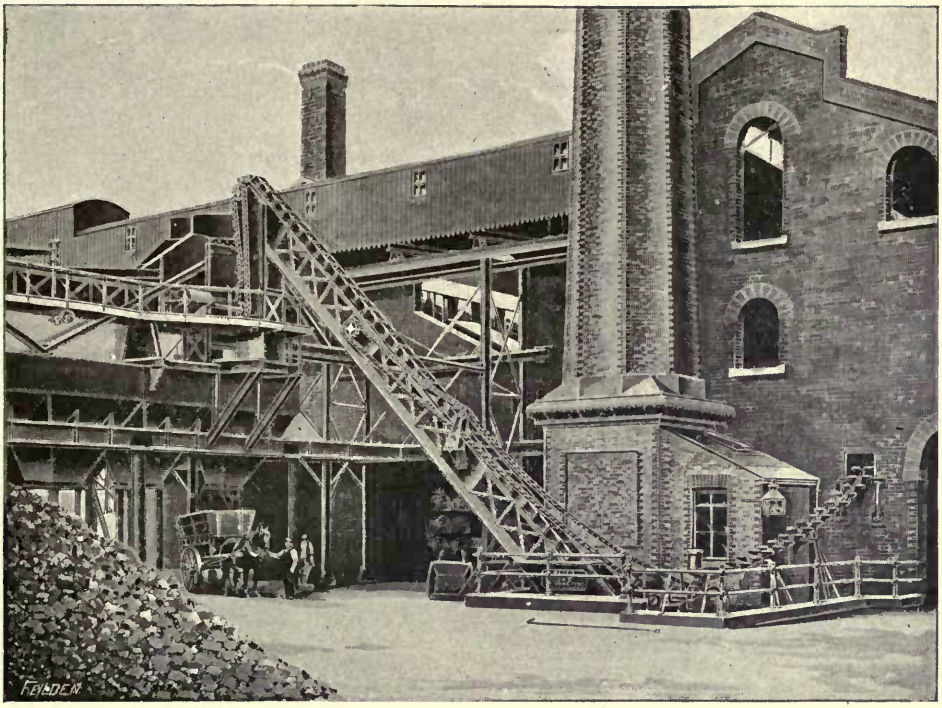


FIG. 26.—INSTALLATION OF COKE-HANDLING MACHINERY, SHOWING END OF HOT COKE-CONVEYER AS IT LEAVES THE RETORT HOUSE AND DELIVERS THE COKE TO AN ELEVATOR, SCREEN, AND OVERHEAD CONVEYER.

conveyer of a different type, known as a "push-plate" conveyer.

The push-plate conveyor is fixed at right angles to the band conveyer, and passes over the centre of a continuous rectangular coal bunker built of steel plates and situated above and behind the retort bench. In the trough of the push-plate conveyer are openings at intervals, and as the coal is pushed along by the plates, or blades, of the conveyer it falls through these openings and fills up the bunker, for, when the space under one opening is full, the coal is dragged over the coal already stored to the next opening, and fills in succession the space under each opening until the whole bunker is full. This is what occurs if the coal is allowed to accumulate and is not drawn off for use. At the bottom of the bunker, however, there is a series of conical pockets (Figs. 23 and 24), the pockets being situated immediately over the centre line of each tier of retorts. The openings in the conveyer are over the centre of the pockets, and therefore the pockets are filled first, and continue to receive and contain coal even when the upper part of the bunker is not filled. When the pockets and the bunker are completely full, the quantity of coal stored in them is about 120 tons, or sufficient for 16 hours' consumption by the whole range of retorts.

In this manner the coal supply is automatically conveyed into position for charging the retorts, no hand labour being required further than to open the doors of the railway wagons and tumble the coal out of them. When it becomes necessary to use coal that has previously been put into store, the coal is loaded into small tipping trucks, and the trucks are hauled to the main hopper, at the side of which is a supplementary elevator for raising the coal into the hopper. The whole of this machinery is set in motion by a 16-h.p.

steam engine situated in an engine-house adjoining the main hopper.

The mechanism for charging the retorts is as follows:—To the bottom of each conical pocket depending from the continuous bunker is attached a measuring chamber, something like a powder-flask. A valve, or slide, is interposed between the measuring chamber and the conical pocket, and another valve, or slide, is fixed at the lower end of the measuring chamber. These slides are actuated by levers, suspended from brackets and rods, the levers for filling the chambers being placed at the back of the charging stage, and those for charging the retorts at the front, next the retort bench.

Each chamber contains, when filled, one charge, the weight of which can be varied by an adjustable baffle-plate to from 5 cwts. to 7 cwts. of coal. For charging the retorts shoots of square section are used, which are provided at the top end with funnels and travelling carriages, the carriages running on light rails. At the bottom end is attached a shoe, which can be adjusted to enter the mouthpiece of the retort. The shoots are of three different lengths, corresponding to the three rows of retorts. When a retort is to be charged, the shoe is placed in position with its lip just inside the retort mouthpiece. The slide at the bottom of the measuring chamber is then opened by the attendant, at first partially, and then, as the coal begins to creep up the retort, more fully, until the whole charge has entered the retort. The first portion of the charge slides down to the lower end of the retort, and, coming in contact with a "stop" inserted into the lower mouthpiece, is arrested. The succeeding portions of the charge are arrested by the coal already deposited in the retort, and, if the operation has been carefully performed, the result is that a continuous layer of coal of uniform thickness is deposited on the floor of the retort. The charging stage is fixed at such a level that the mouthpieces of the lowest retorts are just above it, and those of the uppermost retorts are easily accessible to the attendants. The charging of a retort occupies half a minute.

In discharging the retorts at the lower end, the retort man, after opening the mouthpiece door, or "lid," removes the "stop." If the charge is very thoroughly carbonized the coke may at once commence to slide out. More usually it is necessary to slightly stir the end of the heap of coke with a poker before the movement will commence, on account of the sticky effect of the tar which has condensed under the ascension pipe. Provided the charge is evenly distributed and well burnt off, the coke, once set in motion, will pour out in one continuous stream, and the retort will be discharged in half the time it takes to charge it.

COKE-CONVEYING PLANT.

Similar installations of inclined retorts have been constructed at many gasworks during the past half-dozen years, though few have been provided with so completely automatic a coal-conveying plant.

At Manchester, however, a fresh departure has been made in the addition of machinery for removing the coke from the retort house.

The problem to be solved was the immediate removal from in front of each retort, as it is discharged, of 4½ cwt. of coke, falling out of the retort in 15 seconds of time. It was necessary to provide a conveyer of sufficient capacity to receive the heaps of coke, and travelling at such a speed as to convey the coke out of the way of the retort men without delaying them in their work. There was also the operation of conducting the coke to the store heap in the yard to be considered. Coke conveyors had previously been applied at the Birmingham Gasworks and in a few other works of less magnitude, but in these instances the coke was discharged from horizontal retorts in small quantities at a time, either by the drawing machine or the hand rake.

A new type of conveyor was designed for the Manchester installation, and constructed by West's Gas Improvement Company, with the approval of the author. This conveyer consists of a cast-iron trough, 24 inches wide by 9 inches deep, in which an endless chain travels on a central rail. The chain is composed of cast-steel links bolted together, and on each alternate pair of links are cast blades, or propellers, which match the section of the trough, but do not touch the sides or bottom of it. Between the links containing the propellers are placed slide blocks, which slide on the rail and support the chain links and propellers free of the rail and trough. The pins uniting the links are covered by loose sleeves, or rollers, a patent of Mr. Charles Hunt, C.E., of Birmingham, the purpose of these rollers being to minimise the friction and wear in passing round the sprocket wheels. The conveyer extends the whole length of the retort house, and, after passing out at one end, and arriving at the elevator shoot, the chain returns over-head on rollers and sprocket-wheels carried on brackets secured to the upright supports of the retort bench.

The elevator raises the coke after it is brought out of the retort house to a moving screen fixed above the storage hoppers. The elevator differs from the ordinary kind in having the buckets placed close together and mounted on wheels. A shoot conducts the coke into the elevator buckets, and is so arranged as to prevent the coke falling between the buckets into the pit. The screen at the top separates the dust, or "breeze," from the coke and delivers the latter on a "plate" conveyer of ordinary construction, by which it is carried to the store heap. A series of ploughs is arranged along this conveyor, by which, when any one of them is lowered to within an inch of the plates, the coke is thrown off and falls on the heap.

The principal difficulties met with in the mechanical handling of coke are: rapid wear of the parts of the machinery, owing to grit from the coke; excessive friction, causing undue strain on the machinery; destruction of the parts, through contact with hot coke; and deterioration of the coke, through the tumbling motion imparted to it. In the conveyor at the Gaythorn Gasworks, Manchester, these difficulties have been successfully combated. The chain in the trough conveyor works with a minimum of friction, as the only parts in contact are the sliding blocks and the rail. The parts being of cast steel are not affected by the heat of the coke, which, however, is quenched by copious streams of water immediately it falls into the conveyor. The coke does not tumble over, but slides along in the trough in a heap just as it falls from the retort.

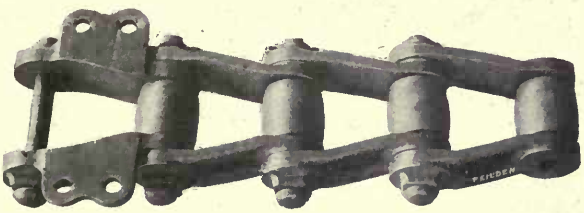


FIG. 27.—HUNT'S PATENT CHAIN USED IN NEW TYPE OF CONVEYER.

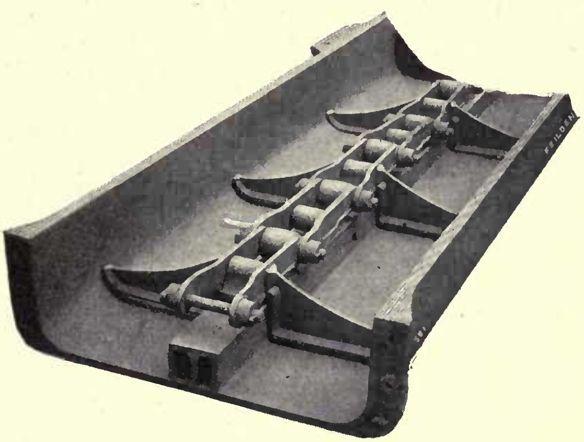


FIG. 28.—NEW TYPE OF CONVEYER, DESIGNED FOR MANCHESTER INSTALLATION.

ADVANTAGES OF THE INCLINED SYSTEM.

The advantages claimed for the inclined

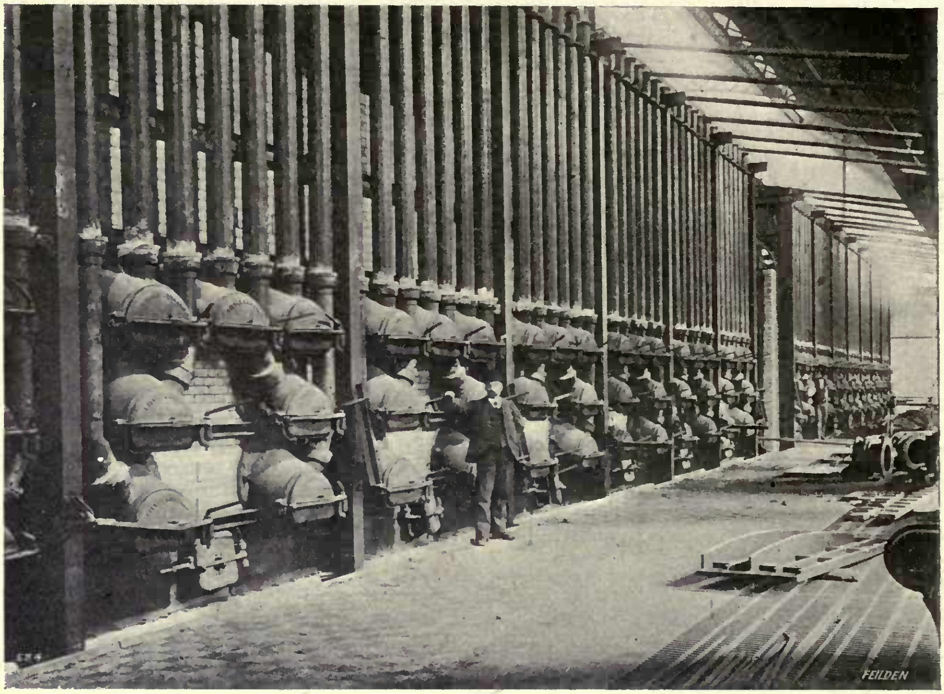


FIG. 29.—INCLINED RETORTS; DRAWING STAGE, MEADOW LANE WORKS, LEEDS.

system of retorts are: that it provides a means of carrying on the work of gas making without the necessity of heavy manual labour, that the system is equally applicable to operations on a large and a small scale, and that the labour expenses are less than with horizontal retorts. That the labour of charging and discharging inclined retorts is less severe than that of drawing or charging horizontal retorts by hand is obvious, but it is by no means so certain that in this respect the system is an improvement over machine stoking; nor has it yet been proved that the labour expenses are less than in the case of machine stoking, albeit in this respect also the system is in advance of hand stoking on horizontal retorts. The first cost of inclined retorts, with their attendant machinery, is high compared with horizontals.

Although some of the claims made on behalf of the new system may, perhaps, not be substantiated, its adoption is being rapidly extended. The reason for this is not far to seek. The labour difficulties of the present period are becoming more and more accentuated in respect of two items, viz., the amount of labour men are willing to undertake, and the length of time they are willing to continue working. In manufacturing towns men are accustomed to watch machinery do the work, and they will always be more willing to move levers and turn hand-wheels rather than lift heavy weights, or incur in other ways great physical exertion. The time question is also an important one. Even under the *régime* of eight-hour shifts, the gas-stoker does not care to be kept working all the time. The speed with which inclined retorts are charged and emptied is of itself a great recommendation, permitting, as it does, of a much longer period of rest between each set of operations than under the old system.

As regards saving in wages, the mechanical handling of the coal and coke plays a very prominent, if not the most important, part. The abolition of coke wheelers alone, which the coke-conveying plant herein described accomplishes, results in a saving of nearly 5d. per ton of coal carbonised.

The inclined system of retorts was first adopted in its present improved form by the Brentford Gas Company, under Mr. Frank Morris, the Engineer. This Company now manufactures gas entirely with inclined retorts, and their adoption has resulted in a marked reduction in the cost of manufacture. One of the earliest to adopt this system was Mr. George Winstanley, of Coventry. At Huddersfield, Mr. W. R. Herring introduced it. Mr. Herring, now Chief Engineer of the Edinburgh Gasworks, has decided to adopt the inclined system entirely at the new Edinburgh Gasworks, which he is about to construct. At Leeds, a large installation of this system has been constructed, comprising 28 retort settings, and further extensions are being carried out by Graham, Morton & Co., Leeds. A still larger installation is in course of construction at the Saltley Gasworks, Birmingham, the machinery in connection with which will be erected by the New Conveyor Co., of Smethwick.

The introduction of this system has given an impetus to the manufacture of conveyers and elevators, &c., for coal and coke, and there are several firms, notably Graham, Morton & Co., the New Conveyor Co., and West's Gas Improvement Co., which are devoting themselves very extensively to the improvement of appliances for this purpose. Several fire-brick manufacturers have turned their attention to making retorts specially designed for this system, and manufactured by machinery, amongst whom may be mentioned Messrs. B. Gibbons, Junr., of Dudley, and Messrs. Cliffe & Sons, of Wortley, near Leeds.

OTHER METHODS OF HANDLING COAL AND COKE.

Where coal or coke is required to be unloaded from vessels at a wharf, or stacked in large heaps, the use of cranes

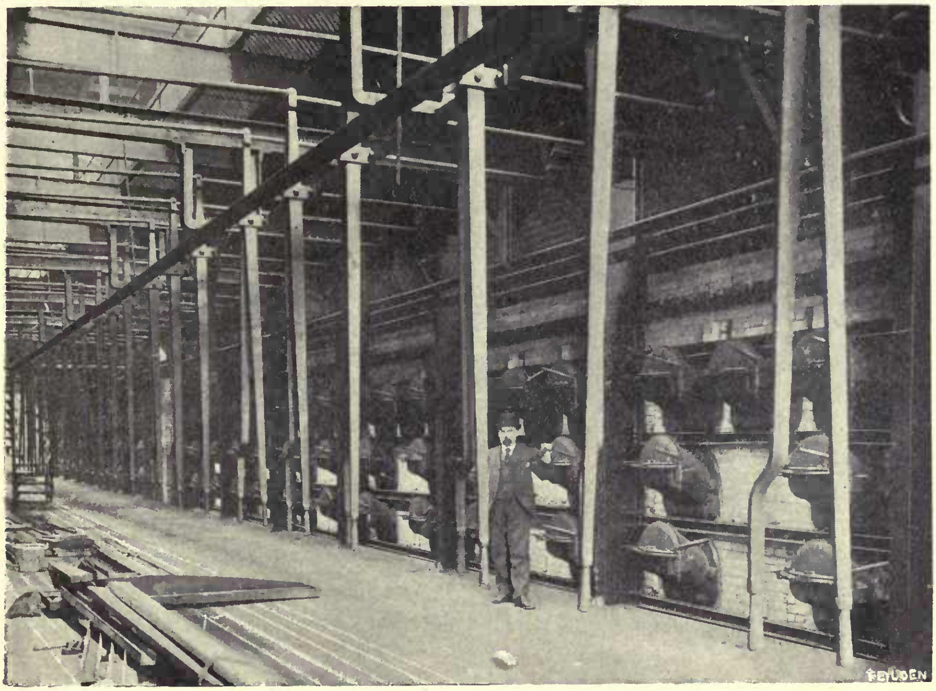


FIG. 30.—INCLINED RETORTS: CHARGING STAGE, MEADOW LANE WORKS, LEEDS.

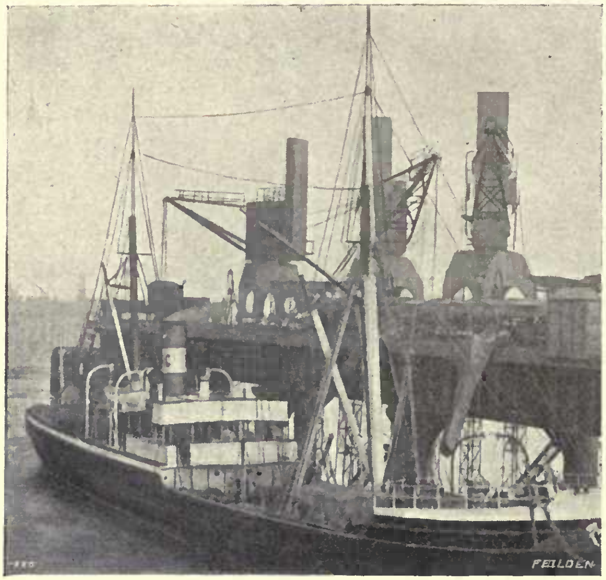


FIG. 31.—INSTALLATION OF HYDRAULIC CRANES AT THE GAS LIGHT AND COKE COMPANY'S PIER, BECKTON, FOR UNLOADING COAL.

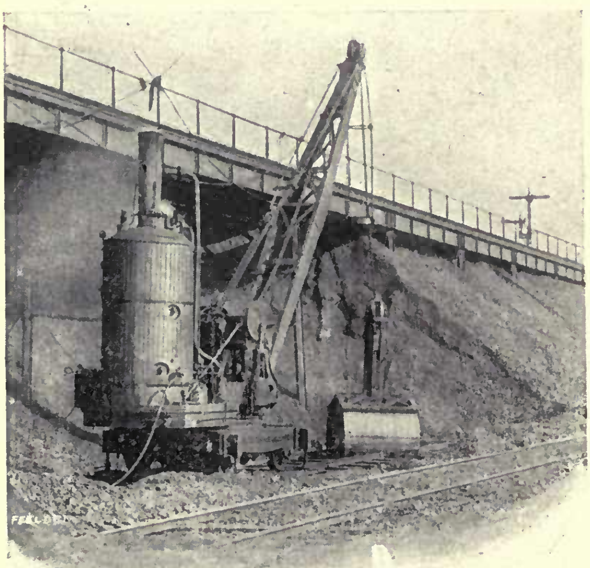


FIG. 32.—CRANE USED IN THE MANCHESTER GASWORKS FOR STACKING COKE.

and grabs is common. A fine installation of hydraulic cranes is possessed by the Gas Light and Coke Co., at their new pier on the Thames at Beckton. Here some 4,000 tons of coal are unloaded from steamers daily, and placed in railway trucks to be conveyed either direct to the retort houses or placed in store in the yard. For stacking coal or coke in the yard, cranes with grabs are employed. This system has the advantage that the coal or coke may be removed from the heap by the same means by which it was placed there. Cranes are used at the Manchester Gasworks for stacking coke, and also for unloading coal wagons, the wagons being up-ended by the crane and the contents emptied into storage bunkers.

At the Saltley Works, Birmingham, the stacking of coke is performed by a hydraulic crane of large radius fixed centrally in the yard, the jib of which covers the whole area of the yard in its circuit. Recently a new arrangement has been devised by Mr. John Woodward, of Manchester, to effect the same purpose. This consists in a circular gantry, or ring of girders on columns, on which a crane revolves, the crane being secured to a centre column by a radial arm. This coke-stacking plant has been erected at the Bradford Road Gasworks, Manchester. By means of it a heap 200 feet in diameter may be stacked, the coke being brought in tipping trucks to the crane,

FIG. 33.—HYDRAULIC CRANE FOR STACKING AND LOADING COKE, SALTLEY WORKS, BIRMINGHAM.

the bucket of which is sunk into a well level with the ground and the tipping trucks emptied into it. The bucket holds one ton of coke and is provided with bottom doors, which can be opened by the crane attendant, thus allowing the coke to fall out on the heap.

CHAPTER III.

CONDENSERS AND EXHAUSTERS.

CONDENSERS.

It is necessary before coal gas can be freed from impurities that it should be cooled to a temperature, varying with climatic conditions from about 50° to 70° F. In the earlier days of gasmaking this was done by simply passing the gas through a series of cast-iron pipes placed either vertically or horizontally, and exposed to all changes of the atmosphere, very little notice being taken of the temperature to which it was reduced. It is now generally recognised that though a fixed temperature cannot be taken as universally applicable in summer and winter, yet it is very necessary to keep within a certain range, and for this purpose a ready means of regulation is necessary. This undoubtedly can best be obtained by the use of water.

One of the earliest types of water condensers will be found at the Old Kent Road Works of the South Metropolitan Gas Company, where Mr. George Livesey

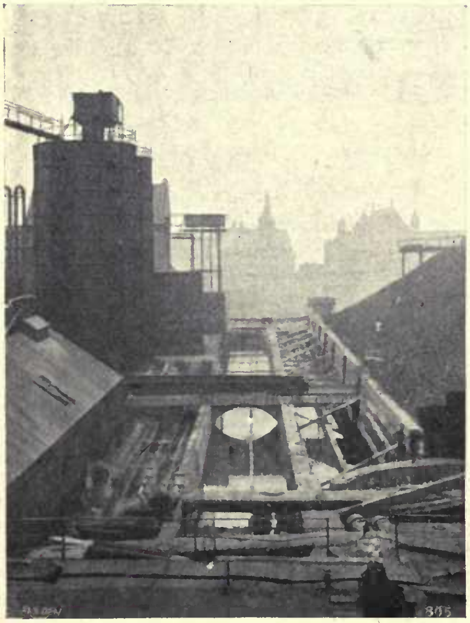


FIG. 34.—WATER CONDENSERS AT THE OLD KENT ROAD STATION, SOUTH METROPOLITAN GAS CO.

FIG. 35.—WATER CONDENSERS AT THE OLD KENT ROAD STATION, SOUTH METROPOLITAN GAS CO.

adopted large-sized cast-iron pipes laid in a shallow open brick tank (Figs. 34—37.) The pipes are laid in straight parallel lines. Between each line is built a brick division, a waterway being left through the divisions at alternate ends. Cold water is admitted at the end where the gas leaves the tank, and flows in the opposite direction to that of the gas, so that no sudden chill is experienced by the gas, and the cooling operation is gradual and even throughout.

This form of condenser, however effective, requires considerable ground space for the necessary surface contact with the water.

A very efficient self-contained water-tube condenser, and one occupying very little ground space, is that patented by Morris & Cutler and manufactured by Messrs. Saml. Cutler & Sons, of Millwall. It consists (Fig. 38) of a cast-iron rectangular box, having vertical divisions forming compartments eight or nine inches wide, with the divisions stopped short at alternate ends to leave room for the passage of the gas, which in this way is made to travel to and fro several times the length of the apparatus before reaching the outlet. Within these compartments are a number of wrought-iron tubes, each $\frac{3}{4}$ in. or 1 in. in diameter, placed about 6 in. apart. To prevent the warm gas from rising to the top and stratifying into layers of different temperatures, two or three vertical baffle plates are inserted in each compartment, the gas being made to pass under and over these alternately. Cold water is admitted into the tubes at the end of the compartment at which the gas leaves the condenser, and flowing through them in the opposite direction to the flow of gas, is gradually warmed by absorbing heat from the gas until it finally leaves at the end of the compartment at which the gas enters.

Another condenser of a similar type is that made by Messrs. Clapham Bros., of Keighley. In this case the condenser (Figs. 39 and 40) usually consists of three towers, each having top and bottom water chambers, separated from the gas by horizontal diaphragm plates, perforated

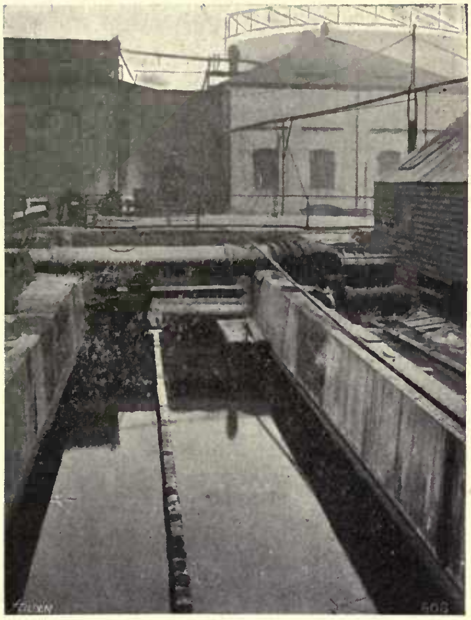


FIG. 37.—WATER CONDENSERS AT THE OLD KENT ROAD STATION, SOUTH METROPOLITAN GAS CO.

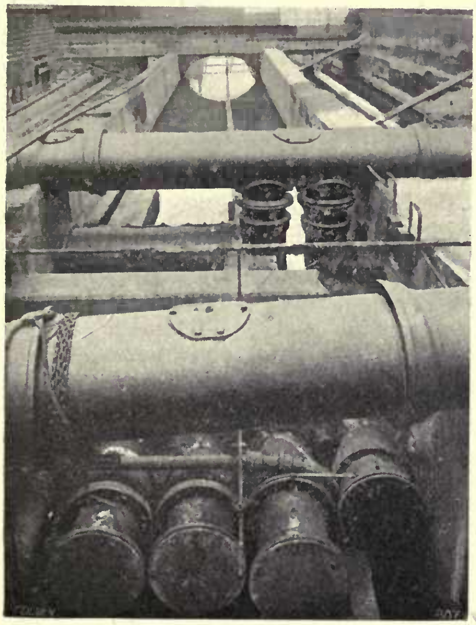


FIG. 36.—WATER CONDENSERS AT THE OLD KENT ROAD STATION, SOUTH METROPOLITAN GAS CO.

for water tubes. The top and bottom chambers are connected by means of a number of $1\frac{1}{2}$-in. diameter vertical tubes, which are firmly secured by back nuts to the lower diaphragm plate, but pass through special glands and stuffing boxes in the top diaphragm plate to allow for expansion and contraction. Any one of these tubes can be taken out and replaced without disturbing any other, and all the tubes can be cleaned with a tube brush from the top, which is open. The gas enters the gas way at top of the first tower, descends to the bottom, and is then conveyed by a diagonal outside pipe to the top of the second tower, and so on to the outlet of the last. The water is admitted at the lower water chamber of the last tower, passes upwards through the tubes into the top water chamber, and is then carried downwards by an outside connecting pipe to the bottom water chamber of the second tower, and so on until it flows away hot at the top of the first tower where the gas enters.

With the latter form of condenser, and when using well-water, the author has obtained diagrams showing that the temperature of gas at the outlet has been steadily maintained with only one degree of variation per 24 hours.

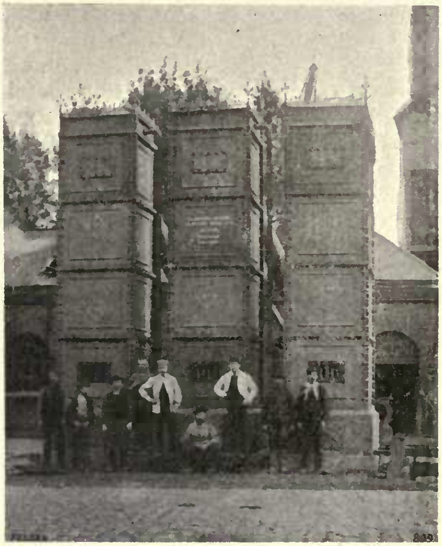


FIG 39.—CLAPHAMS' WATER-TUBE CONDENSERS: BRUSSELS GASWORKS.

A combination where the gas is passed first through atmospheric condensers, and the cooling is finished off in the water-tube type, is probably the most desirable, and this plan has been adopted by Mr. Henry Hack in the new works of the Birmingham Corporation at Saltley, and also by Mr. S. Y. Shonbridge at the Crystal Palace District Gas Company's Works.

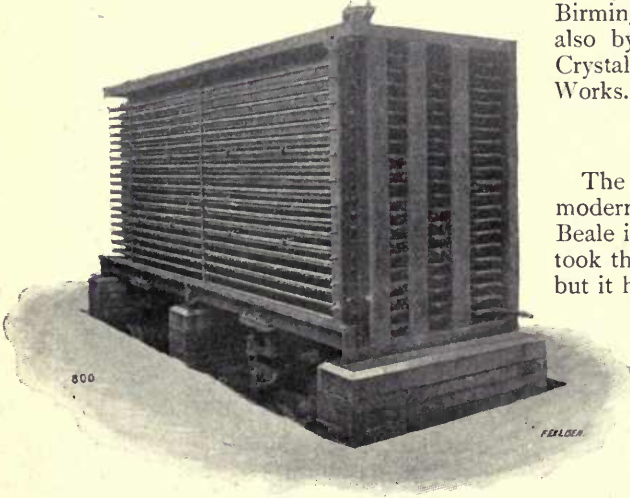


FIG. 38.—MORRIS AND CULTER'S WATER-TUBE CONDENSER, WITH END AND SIDE PLATES REMOVED TO SHOW WATER TUBES: STRATFORD-ON-AVON GASWORKS.

EXHAUSTERS.

The exhauster cannot be described as a modern appliance as it was invented by Beale in the Forties when fire-clay retorts took the place of those made of cast-iron; but it has been so vastly improved, both in design and workmanship, and is of such importance upon gas-works that a description of it must find a place in any modern work upon gasworks' apparatus.

The exhauster most generally to be found in modern gas-works is still of the form invented by Beale, and as improved by Gwynne & Beale,

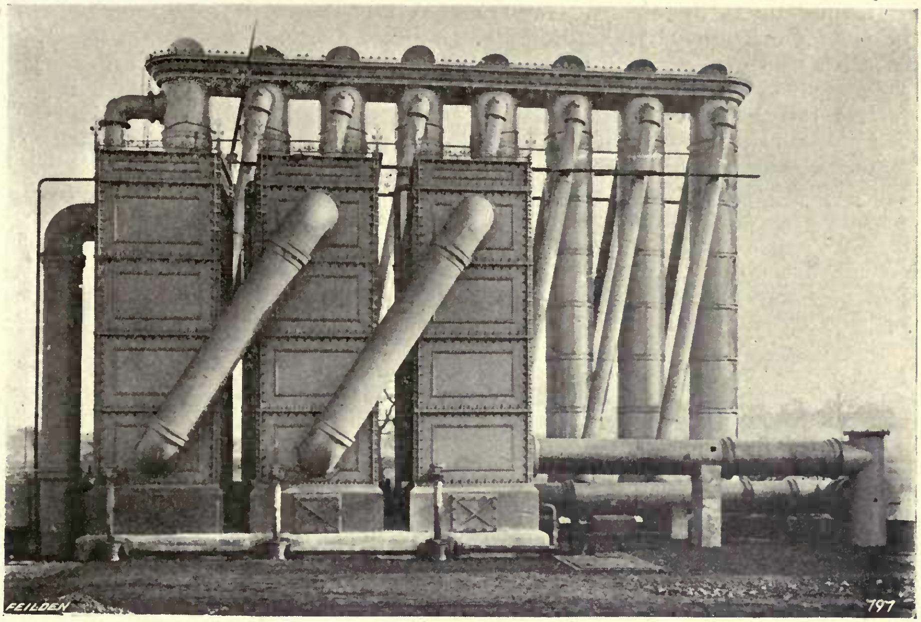


FIG. 40.—CLAPHAMS' WATER-TUBE CONDENSERS AT THE CRYSTAL PALACE DISTRICT GAS CO.'S WORKS.

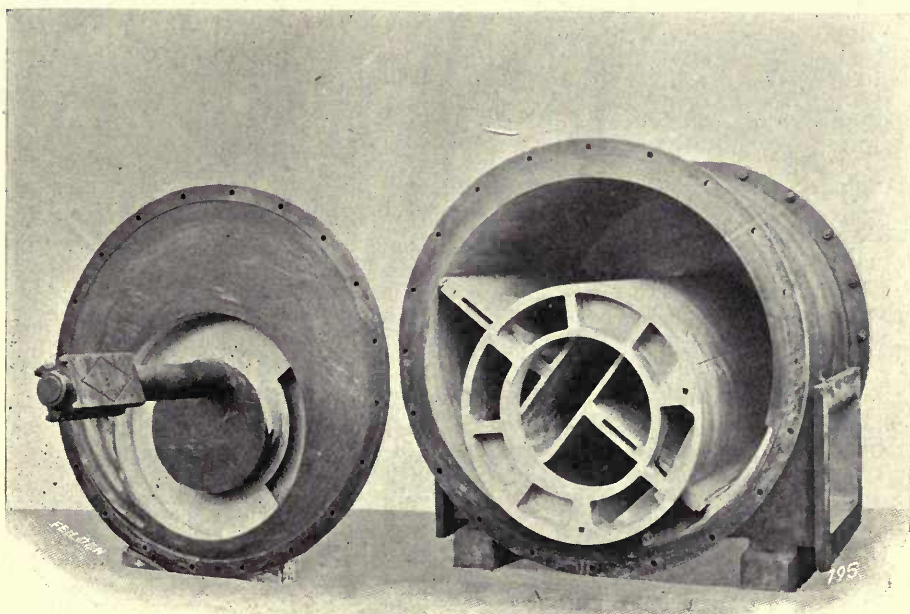


FIG. 41.—DONKIN'S 1892 PATTERN OF EXHAUSTER,
WITH END PLATE REMOVED AND PLACED ALONGSIDE TO SHOW INTERNAL ARRANGEMENT.

and manufactured by Messrs. Gwynne & Co., of Brook Street Works, Holborn. It consists of a cast-iron cylindrical case having inlet and outlet branches. Within this case revolves a cast-iron drum of much smaller diameter, having shafts cast on at each end projecting through stuffing boxes in the end plates and carried on outside bearings. At one end the shaft is provided with a pulley, or is coupled direct to the crank shaft of an engine, the latter plan being now usually adopted. The drum is fixed parallel but eccentrically to the outer case and touches the bottom of it. Passing through the drum at opposite sides are fitted two blades, which, guided by sliding segments running in recesses in the end plates or covers of the outer case, are made to sweep out the latter twice in every revolution. Slips and springs are fitted to the edges of the blades to ensure close contact with the case. The gas being drawn in is carried round the case above the drum and forced out at the other side. A certain percentage of slip with a rotary exhauster is unavoidable, as between the ends of the blades and the outer case, and again between the drum and the bottom of the case there must be contact without any undue friction. It is said that with a clearance of $\frac{1}{32}$ of an inch, slip occurs of the whole of the gas when working against a pressure equal to 20-in. column of water. It will therefore be understood that the workmanship must be of the very best descripton to obtain effective duty, especially when working against pressures of 36 to 50 in., which is not unusual in large gasworks.

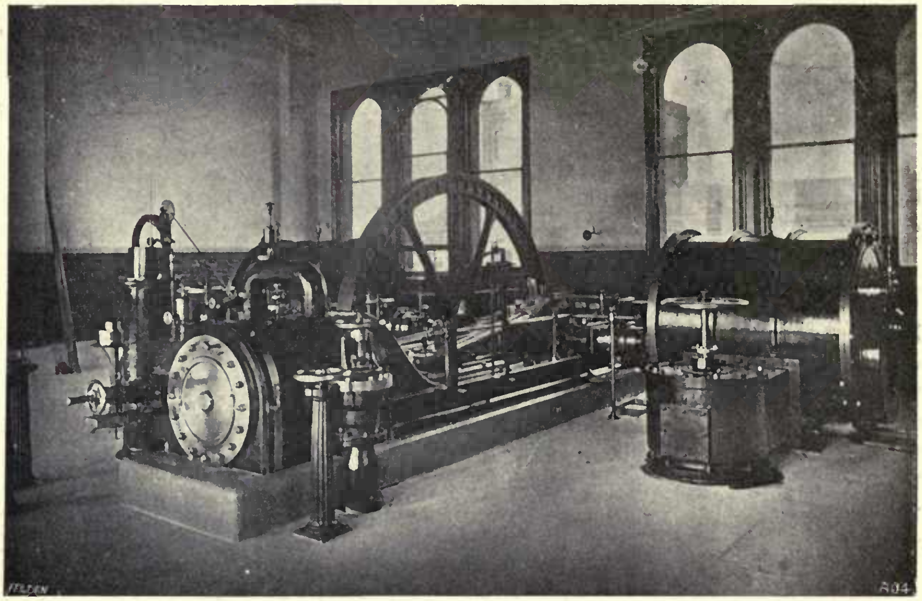


FIG. 42.—PAIR OF DONKIN'S 1887 PATTERN OF EXHAUSTERS: CAPACITY 350,000 CU. FT. PER HOUR EACH: BECKTON WORKS, GAS LIGHT AND COKE CO.

In the form of exhauster just described considerable friction is set up by the segmental slides or rings, which revolve in the recesses of end plates near periphery of the outer case. John Beale's latest type, patented in 1877, and manufactured by Messrs. B. Donkin & Co., of Southwark Park Road, obviates this by doing away entirely with these slides or rings. In this exhauster the outer case is made elliptic in shape, the width being greater than height; the blades are joined by a cast-iron guide, which slides on a simple block in the centre of the exhauster where the velocity of course is lowest, and friction therefore much reduced. The outside bearing on the drum shaft is retained at the end at which the exhauster is driven, but at the other end the drum forms the bearing by being made longer and running in recess in end plate. This type may be run at higher speed, and as the percentage of slip is constant at all speeds a greater proportionate duty is obtained.

Following on this form of exhauster, Mr. E. B. Donkin patented, in 1892, an arrangement for utilising the internal drum and thus further increasing capacity (Fig. 41). By flattening two sides of the interior of the drum and providing projections from the sliding guide (in this case made the full length of the drum), the guide is converted into a piston working to and fro in the drum in a similar manner to the piston of a steam engine. Ports are provided in the end covers, so that when gas is being drawn into the drum at one end it is being forced out at the opposite end. The gain in capacity is claimed to be fully 40 per cent., but against this must be placed the disadvantage that an increased strain is thrown upon the centre block while the gas is being forced out of the drum. On the whole, the author questions the advisability of complicating the exhauster, which it must be remembered runs continuously day and night, usually for some six months in the year, with a stop only for a few hours on Sundays.

An exhauster made by Messrs. George Waller & Co., of London and Stroud, and having four blades instead of two, is now being largely adopted by some engineers (Fig. 43).

The outer case is cylindrical, and is provided with greater clearances to the inlet and outlet ports than usual with other types. The inner drum is prolonged at the ends and carried in recesses in the end plates, while at one end a

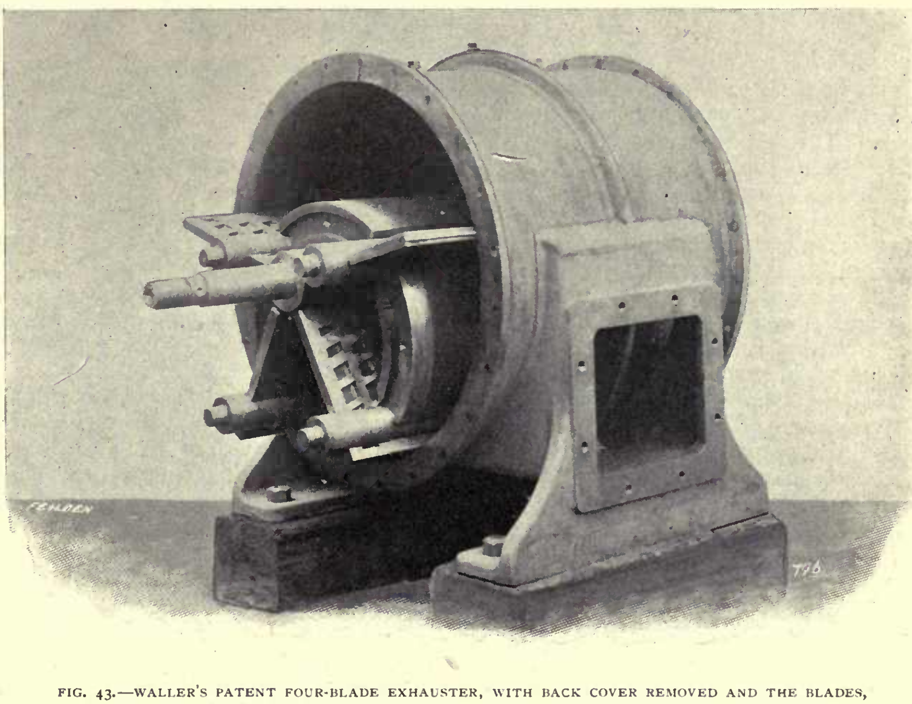


FIG. 43.—WALLER'S PATENT FOUR-BLADE EXHAUSTER, WITH BACK COVER REMOVED AND THE BLADES, ROLLS, AND CENTRE SPINDLE DRAWN SLIGHTLY OUT TO SHOW INTERNAL ARRANGEMENT.

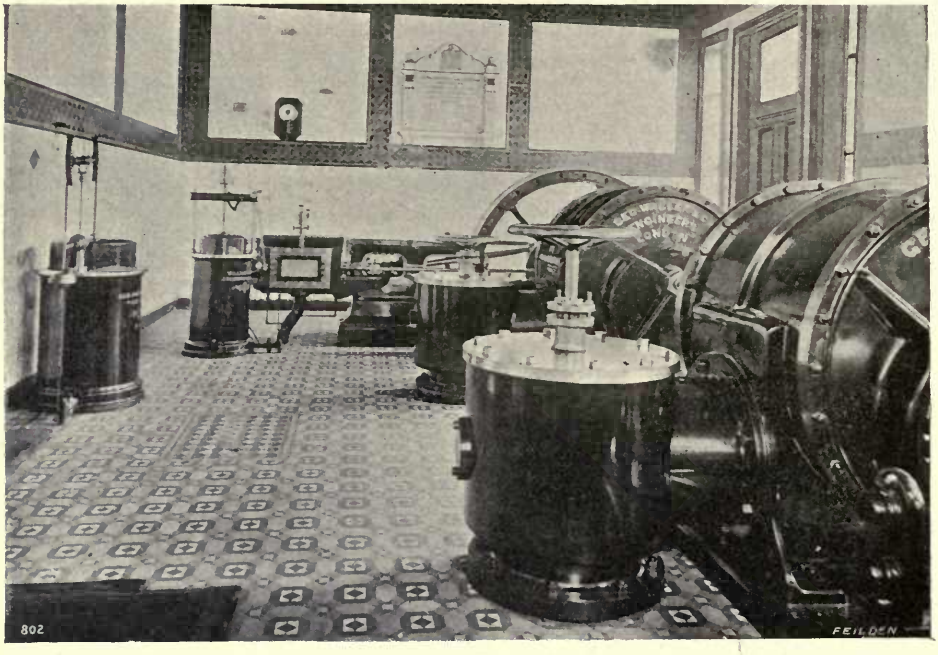


FIG. 44.—PAIR OF WALLER'S FOUR-BLADE EXHAUSTERS AND ENGINES, 150,000 CU. FT. PER HOUR EACH, AT THE SWAN STREET GASWORKS, BOLTON.

driving shaft is cast to the drum and projects through a stuffing box in the end plates. Through the centre of the case is a fixed spindle, to which are hinged, and radiate from it, four blades, passing through four small rolls fitted into truly bored holes in the periphery of the inner drum. These rolls have an oscillating motion, to give the necessary movement as the blades open and close in the revolution. A ring bored at equidistant points to take the reduced ends of the small rolls is fitted into the outer end of the inner drum.

The segment guides used in the Gwynne & Beale exhauster are unnecessary in this type, the centre spindle ensuring that the blades are kept in contact with the periphery of the outer case, and friction is therefore considerably reduced.

This exhauster has the advantage over the ordinary two-blade type that while the cubic contents between the blades is less, four deliveries are made per revolution instead of two, giving an increased delivery of somewhere about 50 per cent., and a steadier gauge and more powerful exhaust with the same engine power. On the other hand it has the disadvantage, similarly to Donkin's 1892 pattern, of being complicated and not so suitable for long continuous work as the two-blade type.

It is very necessary that the vacuum formed by the exhauster should be steady and evenly maintained, though the quantity of gas produced may vary, as may also the pressure of steam. This was effected in early days, and is still in small works, by a wing throttle valve, so placed as to allow a portion of the gas to return from the outlet to the inlet of the exhauster. This wing valve is actuated by a small gas holder, the inlet vacuum being allowed to act under the crown of the holder. If then an excess of vacuum is created by the exhauster it also acts upon the holder and causes it to sink, and in doing so the throttle valve is opened wider, more gas at once returning to the inlet of the exhauster and so restoring the vacuum to the *statu quo.* Should the vacuum be

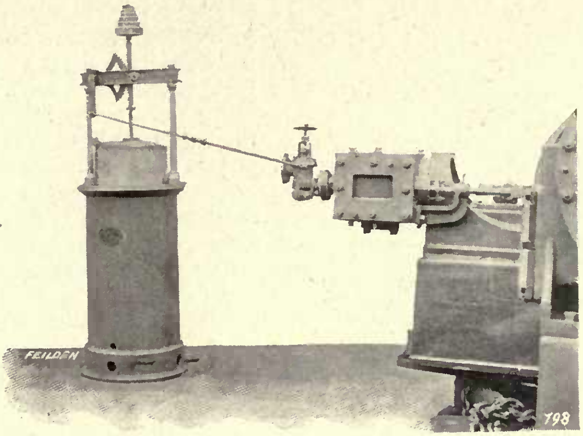


FIG. 45.—WALLER'S PATENT HYDRAULIC GOVERNOR, CONNECTED TO EQUILIBRIUM THROTTLE VALVE ON STEAM ENGINE DRIVING EXHAUSTER.

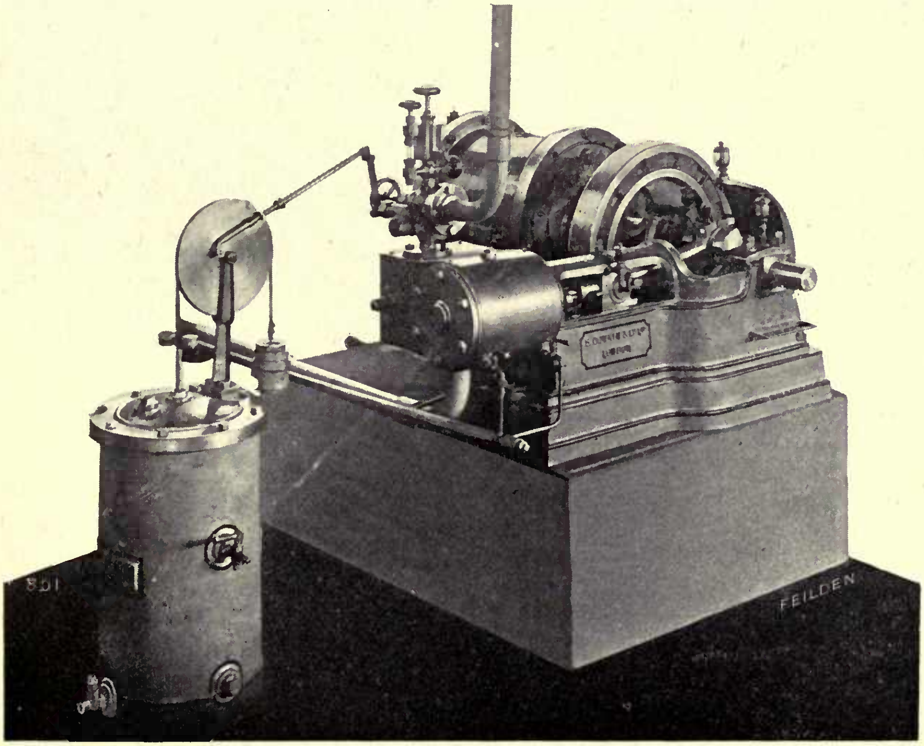


FIG. 46.—DONKIN'S PATENT HYDRAULIC GOVERNOR, ATTACHED TO EQUILIBRIUM THROTTLE VALVE ON STEAM ENGINE DRIVING SMALL EXHAUSTER.

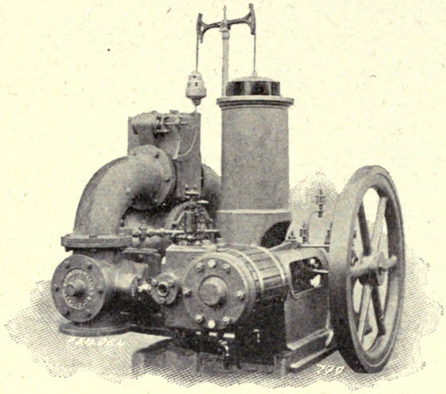


FIG. 47.—WALLER'S SELF-CONTAINED EXHAUSTER, ENGINE, AND COMPENSATING VALVE FOR USE IN SMALL GASWORKS.

reduced, the reverse operation occurs, the holder rising and closing the throttle valve so that less gas is returned to the inlet of the exhauster.

This, as will be seen, is a wasteful procedure, throwing additional work upon the exhauster by churning a portion of the gas over and over again. As long as the exhauster and the engine driving it was small this was of little moment, but as the sizes increased the importance of doing only the necessary amount of work increased also.

The throttle valve was now transferred to the steam engine acted upon in the same manner by a small gas holder, the effect being to increase or decrease the speed of the engine inversely as the vacuum increases or decreases. In details this arrangement has been improved upon by various engineers and makers, until now a very steady gauge can be maintained automatically under considerable variations.

CHAPTER IV.

WASHERS AND SCRUBBERS.

THE purification of coal gas may be said to commence from the moment that its temperature begins to fall after leaving the hot retorts in which coal is distilled; but this is almost entirely mechanical, and chiefly consists of the deposition of liquids whose vapour tension is too low to remain in a gaseous form at any but comparatively high temperatures. These liquids are sharply defined into tar and water, the latter being strongly impregnated with ammonia and technically called ammoniacal liquor.

The principal impurities left in the gas after condensation are tar, ammonia, carbonic acid, sulphuretted hydrogen, and bisulphide of carbon. The whole of the tar and ammonia, and part of the carbonic acid and sulphuretted hydrogen, can be taken out by washing scrubbing, and the remainder must be removed by lime and oxide of iron.

WASHERS AND SCRUBBERS.

The Livesey washer (Fig. 48) is one almost universally used for removal of the tar. It consists of a rectangular box made of cast-iron plates. About 12 inches from either side is a drop plate connected to the top of the washer, descending 12 inches from the top and running its whole length. These drop plates divide the upper half, or gas space, into three compartments—the wide central one being the inlet, and the two narrow side chambers the outlets. Flanges are provided on the lower edge of the drop plates, and to these are bolted inverted U tubes of sheet iron rather more than the length of the central compartment (Fig. 49). Into the U tubes are secured other bent tubes of sheet iron, but closely perforated with holes $\frac{1}{16}$ in. diameter, the ends of these and spaces between them at the ends being stopped with wood blocks or Portland cement.

The washer being filled with ammonical liquor nearly to the top of the bent perforated tubes, gas enters the central compartment, but the drop plates preventing it passing direct into the side chambers, it is forced down between the inverted U tubes and through the perforations in the inner tubes which are covered with liquor, and rises above these into the space between the perforated and plain tubes and so into the side gas chambers, from which the outlets are taken.

While the gas is being forced through the perforated tubes considerable ebullition takes place in the liquid, and this, together with splitting the gas into such fine streams to pass through the perforations, effectually breaks up the bubbles of tar mechanically carried forward, and removes practically every trace of tar from the gas.

It is a moot point with engineers as to the form of scrubber to be used after a tar extractor such as the Livesey washer; some pinning their faith entirely to the Tower scrubber, while others do so equally to the rotary washer scrubber.

The author ventures to think that a combination will give the best results—that is, after passing through a tar extractor the gas should be passed through a Tower scrubber and washed with strong ammoniacal liquor and afterwards through a rotary washer scrubber in which clean water is used to effect final removal of ammonia. In this way he believes that the least quantity of clean water (which

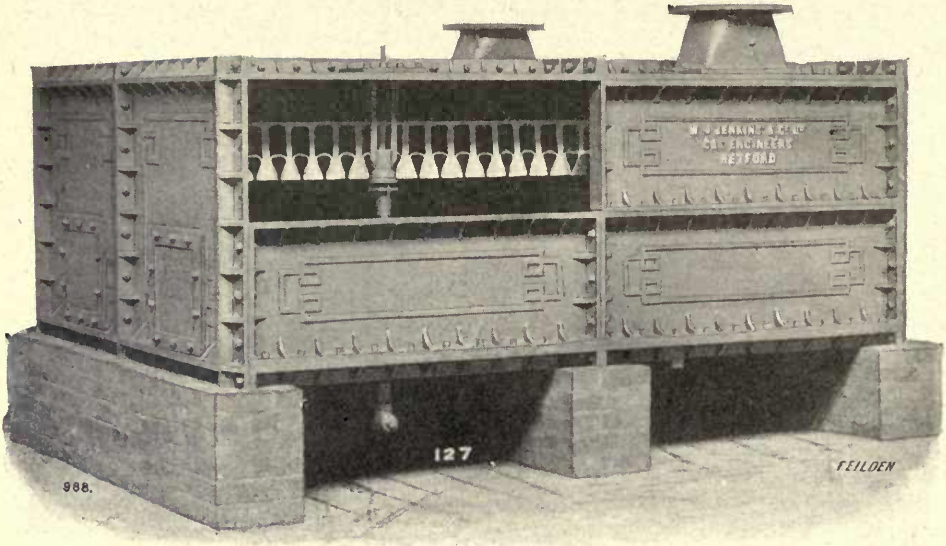


FIG. 48.—THE LIVESEY WASHER, WITH SIDE PLATE REMOVED TO SHOW END OF TUBES.

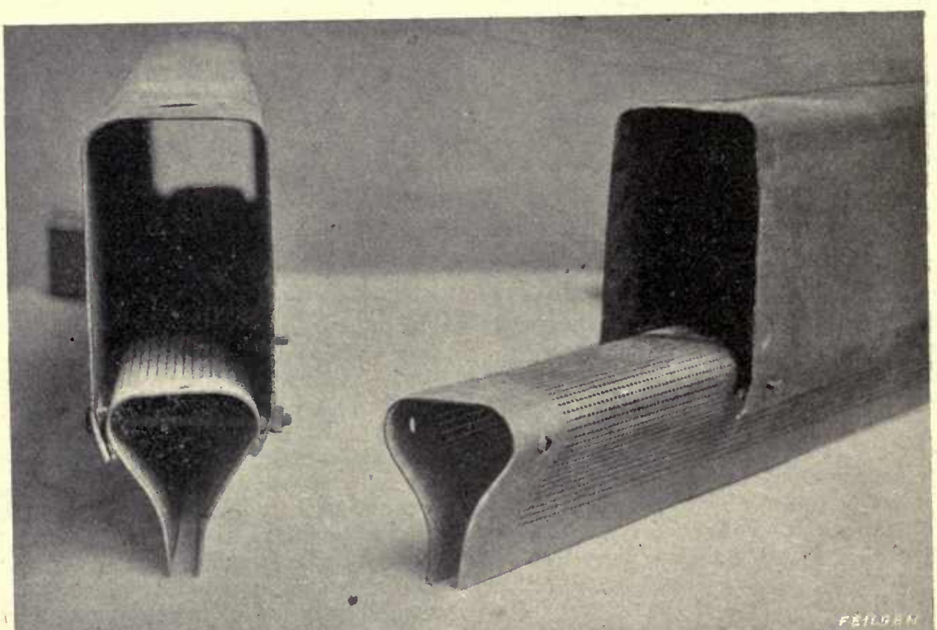


FIG. 49.—INVERTED U TUBES AND PERFORATED TUBES FOR LIVESEY WASHER.

is injurious to the illuminating power of gas) can be used, and the best results obtained in extracting other impurities and saving the work done in the purifiers themselves.

This plan has been adopted in the Grimesthorpe Station of the Sheffield Gas Company, the whole of the ammonia shown by the litmus paper test being removed by the use of about 0·33 gallon of water per 1,000 cub. ft. of gas, and an average of tests made showing the removal of other impurities to be as follows:—

	Grains per 100 cub. ft. of gas.		
	Inlet of scrubbers.	Outlet of scrubbers.	Absorbed by scrubbers.
Carbonic acid ...	1336	848	655
Sulphuretted hydrogen ...	765	655	113

The Tower scrubber is a circular vessel built up of cast-iron plates of a height from 40 to 70 ft., and diameter from 3 to 12 ft., both height and diameter varying in accordance with the quantity of gas to be dealt with, and somewhat with the idea of the engineer, as some advocate greater comparative height to diameter; but in any case a Tower scrubber is rarely more than 70 feet high by 12 feet diameter. The cast-iron vessel is merely a shell to contain the scrubbing material, which breaks up the gas into small streams, the surface of the material being kept constantly wetted with the liquid run in at the top. The scrubbing material used was at one time almost exclusively gas coke, but this was found to require frequent renewal, and it is now more general to use wood boards about ½ in. thick and 7 to 9 in. deep, with distance pieces about ½ in. thick, nailed on to keep them apart. The rows of boards on edge are set on each other so as to form a spiral in the scrubber, and one or two rows are omitted every 12 to 20 feet to allow the small streams of gas to unite, when they again break up to

FIG. 50.—WASHERS AND SCRUBBERS AT THE GRIMESTHORPE STATION OF THE SHEFFIELD GAS COMPANY.

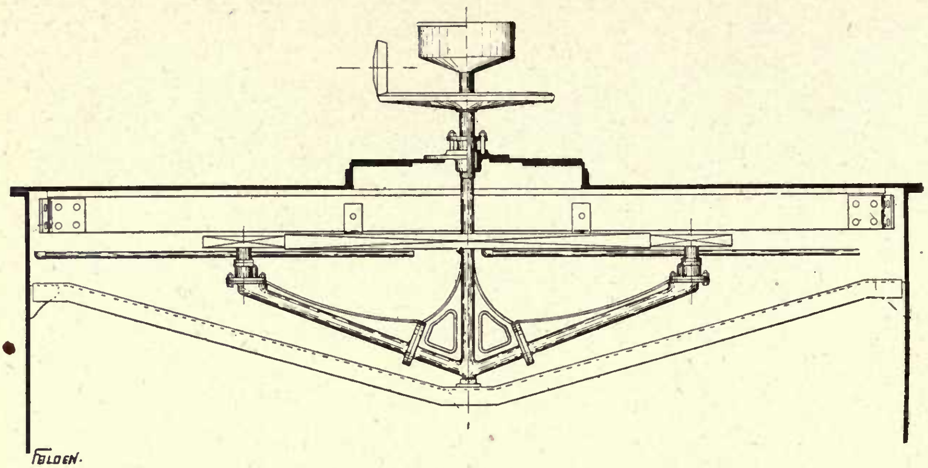


FIG. 51.—GREEN'S DISTRIBUTER FOR TOWER SCRUBBERS.

pass through another series of boards. In some cases canvas screens are used instead of boards and are said to be very efficient.

It will be seen that if the exposed surfaces of the scrubbing material are to be kept wetted, a very efficient means of distribution must be employed. If the liquid be run in through an open-ended stationary pipe it would find its way down in very few streams only, and a pipe having a number of small holes is unsatisfactory from the liability of the holes to choke.

Out of the many devices invented to attain this object of efficient distribution the author has adopted one invented by Mr. Harry Green of Preston. An open-ended pipe is used, being made to revolve while regulating the flow of liquid, so that an even distribution is ensured whether the quantity used be large or small. The following description, with illustration (Fig. 51), will make this clear.

In the centre of the scrubber and close under the top plate is a large fixed spur wheel. Passing through a stuffing box in the centre of the top plate and down through the spur wheel, but not attached to it, is a central supply pipe, having at its upper end a funnel, below which is keyed on to the supply pipe a bevel wheel. A rotary motion is conveyed to this wheel by bevel gearing from any convenient

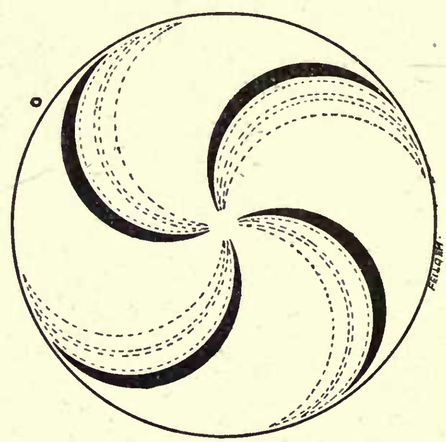


FIG. 52.—DIAGRAM SHOWING DISTRIBUTION OF WATER FROM GREEN'S DISTRIBUTER.

source of power. The central supply pipe rests in a footstep, and from it branch one or two pipes at a V-angle, thus forming a liquid trap to prevent the escape of gas. The branch pipe serves also as a bracket to carry a socket bearing, in which works as a swivel the axis of a small pinion, gearing into the large fixed spur wheel. The axis of the pinion has a passage or port formed through it communicating with a short discharging pipe. The central supply pipe revolving causes the branch pipe to revolve, but in addition the small pinion rotates, being geared into the fixed spur wheel. The number of teeth in the latter are such as not to be exactly divisible by the number in the pinion, thus ensuring a slight variation in the position of the discharging orifice of the arm each time it is to open.

Referring to Fig. 52, if the circular line *O* is taken to represent the circumference of scrubber, the four black curved lines will represent both the track and volume of liquid discharged at four separate points in the first revolution. The dotted lines a little in advance of them will represent the line of discharge at the second and third revolution, and so on, the discharge at each revolution being slightly in advance of the preceding one. The curves not only represent the course of the discharge, but the thickness represents a greater or less discharge to suit the variable area over which it is made.

Of the type of rotary scrubbers a very good example may be seen in the "Eclipse" washer scrubber made by Clapham Brothers, of Keighley (Figs. 53 and 54). It consists of a cast-iron case or shell with semi-circular top, the lower part of the shell being divided internally into compartments by means of cast-iron plates. A shaft runs the full length of the washer, upon which are keyed the revolving cylinders, one to each compartment. The outer edges of the cylinders are faced and run against corresponding facings inside the case, thus preventing gas slipping by the cylinders and passing direct from one compartment to another. The cylinders are filled with sycamore wood balls, $1\frac{1}{4}$ in. diameter, and perforated with $\frac{1}{2}$-in. diameter holes, kept in position by perforated steel plates. Perforated buckets are fixed upon the cylinders, which dip into the liquid at bottom of washer and thoroughly wet the surface of the balls at every revolution. The shaft is carried on bearings outside each end of the shell and on others fixed to each division plate. A tail pin is used to keep the facings on revolving cylinders and case in contact, the efficiency of the machine largely depending upon this to prevent any slip of gas.

The machine may be driven by strap, or geared down direct from crank shaft of a small steam engine.

In this and all other forms of washer scrubbers the principal object is to free the gas from ammonia, which being a valuable product is well worth some trouble to effect. Clean water only is necessary, ammonia being readily absorbed by it, but the gas must be broken into as small streams as possible and presented to ample wetted surface. The clean water, entering the washer scrubber at the end where the cleanest gas leaves, should take up the last traces of ammonia, becoming more and more impregnated as it travels through the machine until it leaves at the end where the gas enters.

As the water becomes impregnated with ammonia it also absorbs some portion of carbonic acid and sulphuretted hydrogen, and to such extent lightens the work of the purifiers proper.

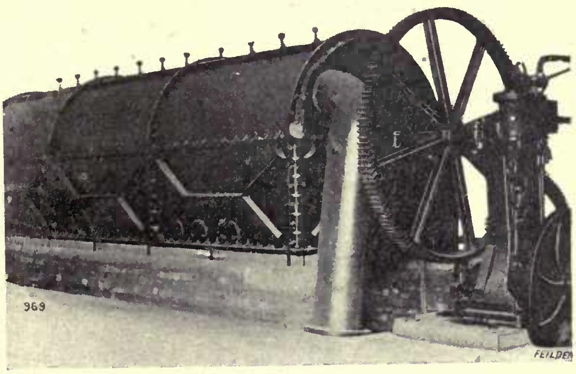


FIG. 53.—CLAPHAM BROTHERS' "ECLIPSE" WASHER SCRUBBER.

Another excellent type of the rotary scrubbers is the "New" washer scrubber manufactured by W. C. Holmes & Co., of Huddersfield (Figs. 55 & 56). It does away completely with the faced surfaces of metal running in contact, is lighter, requires less driving power, and offers an enormous washing surface. It is a cylindrical vessel composed of cast-iron plates, the length being twice or thrice the

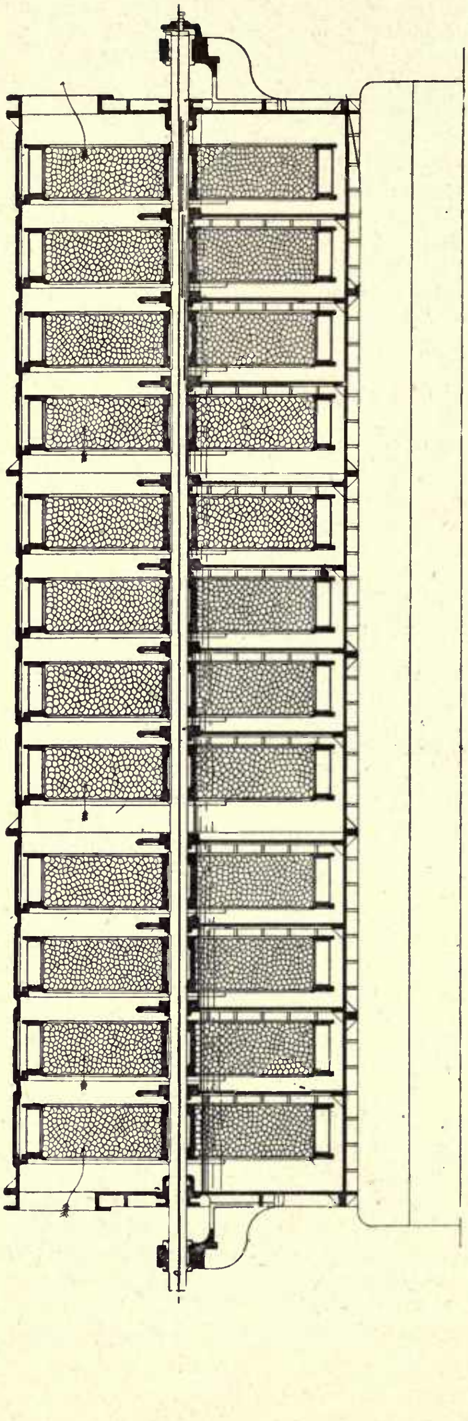


FIG. 54.—LONGITUDINAL SECTION THROUGH CLAPHAM'S "ECLIPSE" WASHER SCRUBBER.

diameter. Inside are ranged a series of wrought-iron plates $\frac{1}{4}$ in. thick, alternately fixed between the flanges of the cylinders and to the driving shaft running from end to end of the scrubber. The shaft is supported on brackets outside each end of the machine, and also midway on a cast-iron stand fixed to bottom of cylinder. To the iron plates attached to the shaft are fixed circular brushes (Fig. 58) made of South African Gaboon Piassava. These, continually revolving, dip into the liquid in the lower portion of the several chambers formed by the plates fixed between the flanges of the case, and supply freshly wetted surface through which the gas passes. The brushes are made to give a $\frac{1}{4}$-in. thrust on each of the division plates, to prevent slip of gas without passing through the brushes. Between the chambers and separating them one from another is a small "still" chamber, which in practice it is claimed enables the ammonia water to be worked up to a greater strength. The washer is driven with helical spur gearing by a small horizontal steam engine.

Where ground space is limited, this washer scrubber is made in vertical form (Fig. 58) and is stated to be equally efficient.

The "Standard" washer scrubber of Kirkham, Hulett & Chandler (Figs. 59 and 60) is one of the earliest of the rotary type, and has gone through a succession of alterations and improvements. In the form in which it is now made it consists of a cylindrical horizontal vessel divided into compartments by vertical division plates, which have circular openings at the centre to permit the passage of the gas. The shaft, which runs the length of the machine, is provided with *lignum vitæ* bearings. To it is keyed in each compartment a strong cast-iron collar, and to this is attached a wrought-iron frame carrying the scrubbing material, which consists of bundles of wood boards $\frac{1}{8}$ in. thick kept $\frac{3}{16}$ in. apart by wood deflector

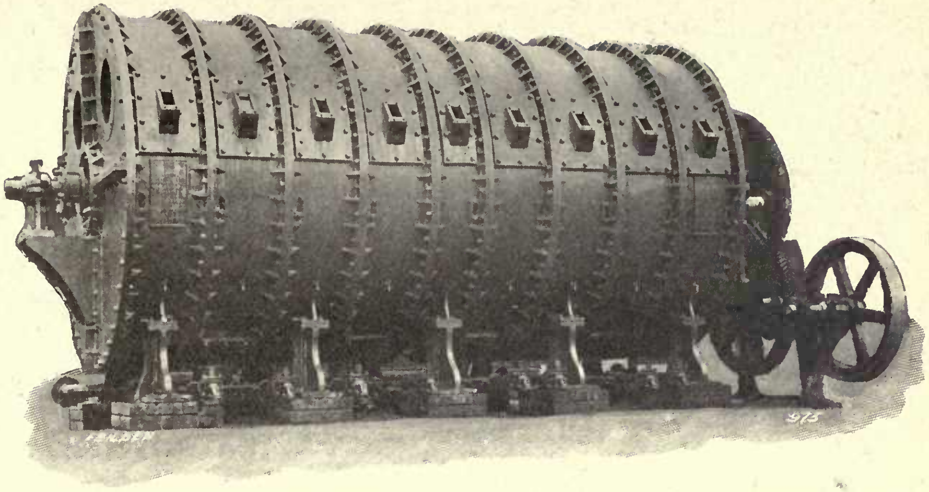


FIG 55.—HOLMES' "NEW" WASHER SCRUBBER.

pieces. In the latest devices these deflector pieces are notched out at one end, so as to pick up the washing liquid and distribute it over the wood boards at every revolution.

As in the "Eclipse" washer, the effectiveness of the machine largely depends upon the faced joint between the division plates and revolving collars. In this case, however, the faced joint is much nearer the shaft, and a felt ring (see Fig. 61) is attached to the division plate and presses against the facing on revolving collar, the faces of the metal being kept $\frac{1}{8}$ in. apart.

Special arrangements are made to ensure circulation of the liquid in the washer and prevent accumulation of tar, in addition to which a tar extractor can be fixed in the first chamber if necessary.

PURIFICATION.

The method of purification of coal gas depends upon the degree of purity aimed at, or the obligations laid by Parliament upon the owners of gasworks.

The Metropolitan gas companies are under restrictions to supply gas free from sulphuretted hydrogen, and which does

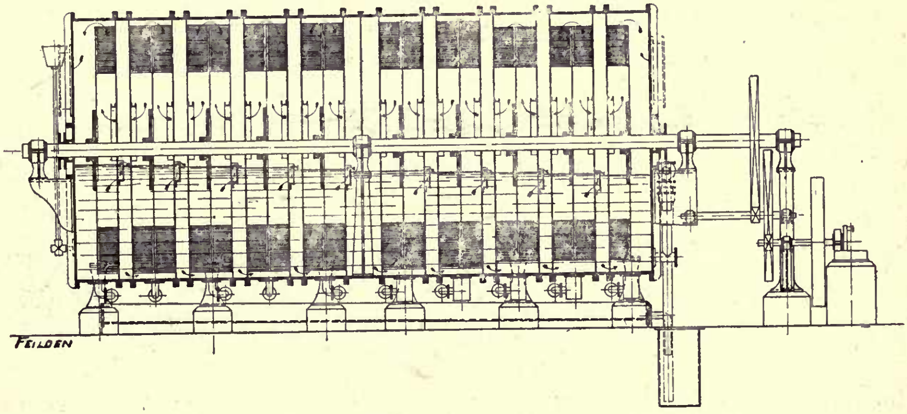


FIG. 56.—LONGITUDINAL SECTION OF HOLMES' "NEW" WASHER SCRUBBER.

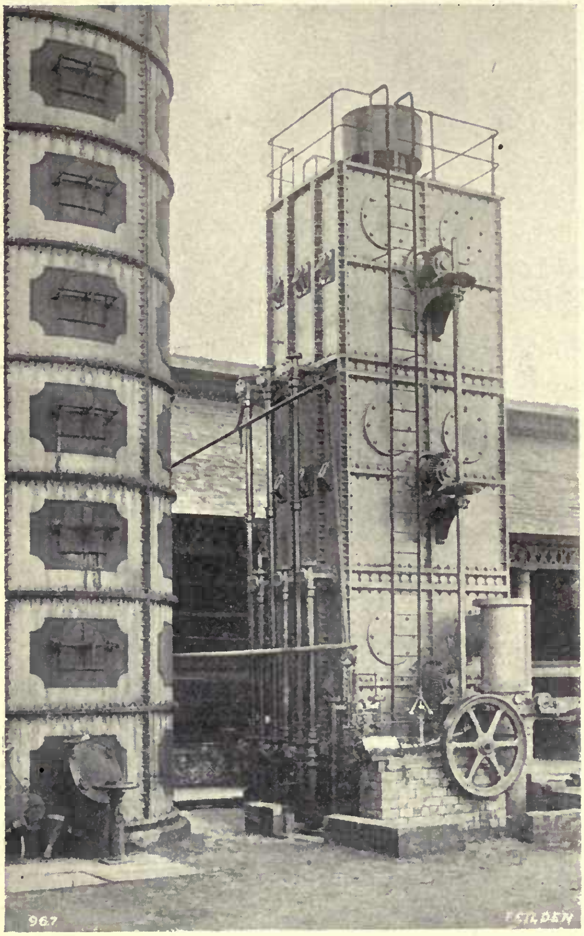


FIG. 57.—HOLMES' "NEW" VERTICAL WASHER SCRUBBER, FOR USE WHERE GROUND SPACE IS LIMITED.

not contain more than 4 grains of ammonia per 100 cubic feet of gas, nor more than 22 grains of sulphur (in other forms than sulphuretted hydrogen) in winter, and 17 grains in summer; and there are numerous testing stations at which daily tests are made to see that these restrictions are complied with. These restrictions apply also to most of the suburban and provincial gas companies, though there are a few notable exceptions. As a rule, local authorities who own gas works are not so restricted, though in most cases some form of sulphur purification is adopted, but, as may be supposed, not nearly so strictly adhered to as in the case of companies, who are rigidly tested and are liable to penalties for infringement.

Ammonia is easily eliminated to a much lower point than the legal limit by the use, as already stated, of clean water, and if the only other impurity to be removed were sulphuretted hydrogen, it could easily be accomplished by passing the gas through oxide of iron. But there still remains, in addition to the sulphur compounds, carbonic acid, which, though not injurious to health in the small quantities existing in coal gas, is yet very prejudicial to its illuminating quality, and is therefore almost always partially removed, the method generally adopted being to use sufficient lime for reducing the carbonic acid and then oxide of iron to completely remove the sulphuretted hydrogen.

So far purification of coal gas is simple enough, but in dealing with the sulphur compounds in other forms than sulphuretted

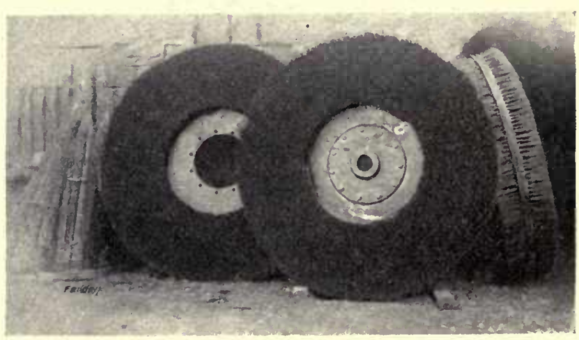


FIG. 58.—BRUSHES SECURED TO REVOLVING PLATES FOR HOLMES' "NEW" WASHER SCRUBBER.

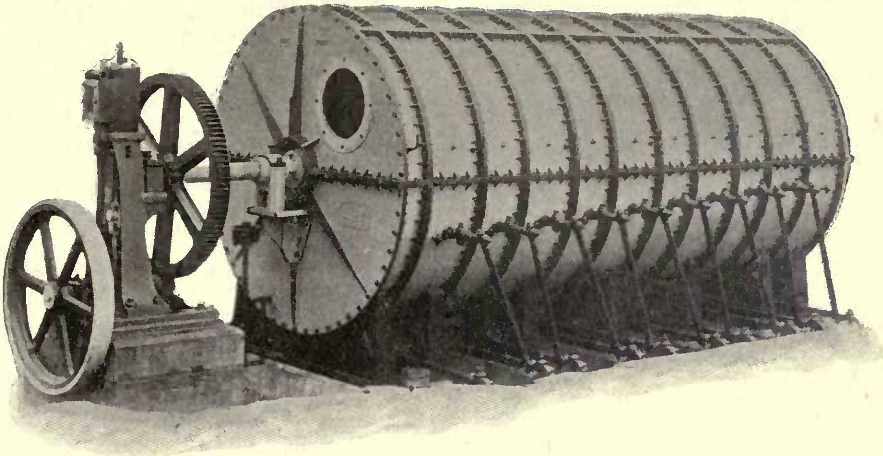


FIG. 59.—KIRKHAM, HULETT AND CHANDLER'S "STANDARD" WASHER SCRUBBER.

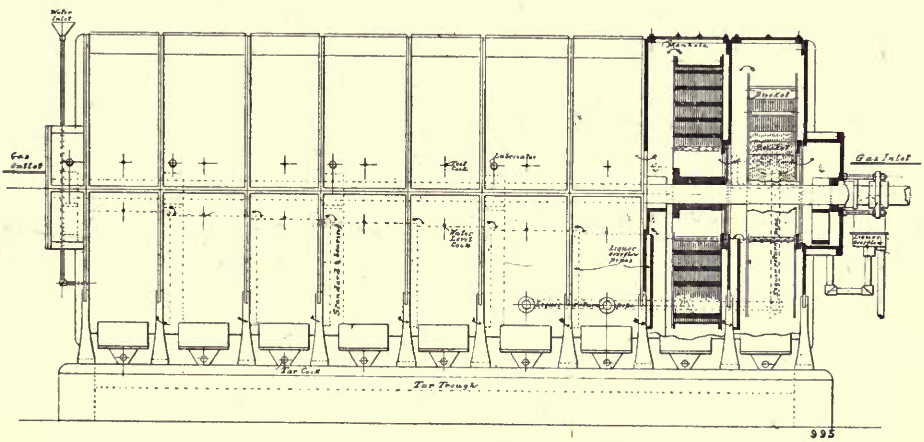


FIG. 60.—LONGITUDINAL SECTION OF KIRKHAM, HULETT AND CHANDLER'S "STANDARD" WASHER SCRUBBER.

hydrogen much more difficulty is experienced, and the purification must be accomplished practically with all lime—a process far more expensive than when a considerable quantity of oxide of iron can be used.

The outcry that was raised against sulphur and its deleterious influence upon health, which led to the stringent legislation limiting the quantity in purified coal gas, was a costly one in results to gas consumers, and, the author believes, without adequate benefit for the expense involved. The following extracts, from a recent report of a well-known chemist upon the subject, will show the very small amount of sulphurous acid produced in gas-lighted rooms from the combustion of sulphur in coal gas :—

"The practice of stating the quantity of sulphur remaining in purified gas in grains per 100 cubic feet of gas does not convey to the general mind a clear idea either of its relative amount or actual importance.

"Gas weighs approximately 240 grains per cubic

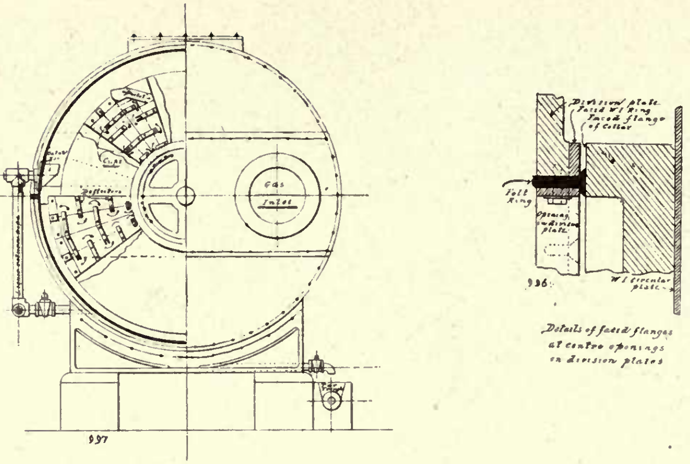


FIG. 61.—SECTIONS OF KIRKHAM, HULETT AND CHANDLER'S "STANDARD" WASHER SCRUBBER.

foot, therefore 40 grains are equivalent to one part in 600 parts. Expressed as volumes, the proportion is seen to be still more insignificant. In the gaseous form sulphur weighs about 1,200 grains per cubic foot, therefore 40 grains of sulphur equal one part in 3,000 parts by volume.

"The utter insignificance of a few grains more or less of sulphur is, however, best seen on considering the extent to which the atmosphere is vitiated by its combustion; and it is. of course, only on this account that the sulphur is objected to. Forty grains of sulphur yield on combustion 80 grains, or $\frac{1}{15}$ of a cubic foot, of sulphurous acid. But the combustion of 100 cubic feet of gas produces also 60 cubic feet of carbonic acid, so that the sulphurous acid forms only $\frac{1}{900}$ part of the whole gaseous products of combustion. Even where no special means of ventilation are provided, diffusion is constantly taking place through crevices and the porous walls of a gas-lighted room, so that the amount of those impurities actually existent in the atmosphere of a room is exceedingly small. The amount of sulphurous acid is altogether too minute to be directly estimated; but, knowing the ratio it bears to the carbonic acid, it is possible to arrive at the amount indirectly."

Referring to experiments made to determine the carbonic acid present in the air of gas-lighted rooms, the report goes on to say:—

"Under the worst conditions, this impurity never amounted to one part in 500 parts of air, and only rarely exceeded one part in 1,000 parts. From this it would seem that when gas is burnt containing 40 grains of sulphur the atmosphere may be contaminated with sulphurous acid to the extent of one part in 900,000 parts, but the proportion will certainly not amount to one part in 450,000 parts.

"It is quite probable that this minute trace of sulphurous acid is beneficial rather than otherwise, by reason of its destructive action on disease germs present in the air."

It must be remembered that it is not possible to remove all the sulphur present in coal gas, but only to reduce it about one-half—that is, instead of the air in unventilated gas-lighted rooms containing a possible one-half-millionth part of sulphurous acid, it can be reduced to a possible one-quarter-millionth part, and the cost of so reducing the sulphur is certainly not less than one halfpenny for every 1000 cubic feet sold. For such a paltry gain, therefore, the gas consumers of the Metropolis *only* pay the huge annual sum of upwards of *£68,000.*

Throughout Germany and most of the Continental gasworks oxide of iron only is used for purification, and the sulphur compounds are ignored altogether.

CHAPTER V.

PURIFIERS.

THE impurities present in unpurified gas, and the methods and materials used for their removal having been described, attention may now be directed to the purifier itself, and to improvements effected of late years in its construction, as well as to the appliances now in use for mechanically handling the purifying materials.

The body of the purifier (Fig. 62) is in form of an open cistern constructed of cast-iron plates, a lute for water being cast on to the side plates. It is provided with a movable cover of sheet iron, having angle and tee-iron framing inside to give the necessary rigidity. The cover has sides usually not less than two feet deep, and these dip into the water in lute, forming a seal and preventing escape of gas. Suitable fastenings are provided to hold the cover down and prevent the pressure of gas underneath from raising it.

Inside the purifier are grids made of wood or iron and supported on tee-iron bearing bars. Upon these grids the purifying material, which is sufficiently porous to allow gas to be forced through, is placed.

The purifiers are generally arranged in a series of four, connected with cast-iron pipes, and controlled by a centre valve by which one purifier can always be shut off during the operation of emptying the fouled material and refilling with fresh.

This is not however universal, various combinations being adopted. A frequent arrangement is to use six purifiers, the first four worked in rotation and doing the bulk of the work, while the last two are used as catches to ensure that foul gas shall not at any time pass. Again, six purifiers are sometimes used arranged in couplets, the valves being such that one purifier at a time of each couplet can be shut off.

Each time a purifier is to be emptied and refilled the cover must be lifted high enough to enable men to get under it easily and safely, or after being lifted

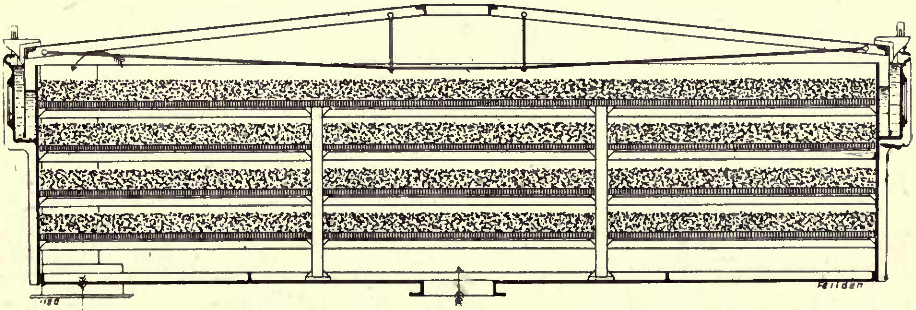


FIG. 62.—SECTION OF ORDINARY TYPE OF PURIFIER.

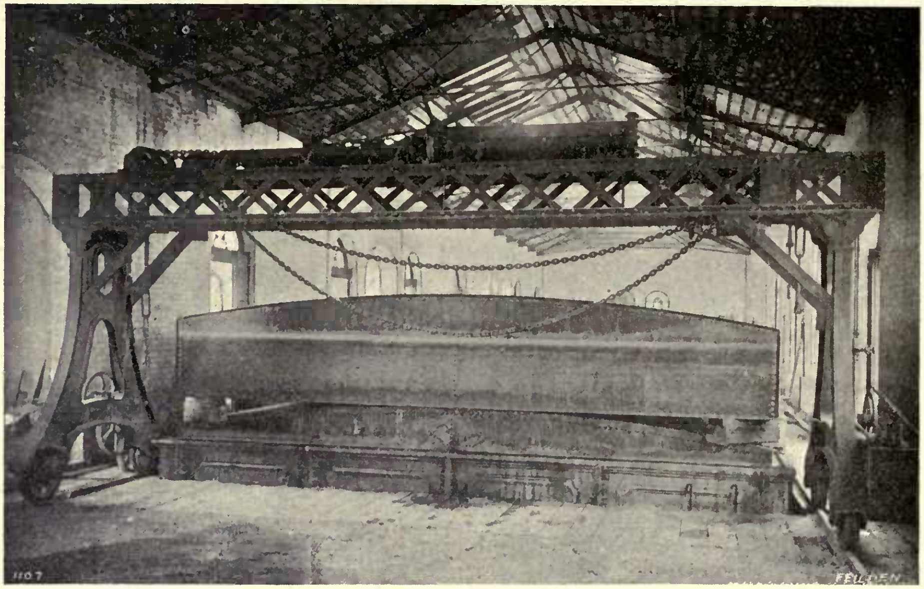


FIG. 63.—"GOLIATH" FOR LIFTING PURIFIER COVER, WEIGHING SIX TONS, BY HYDRAULIC POWER, MADE BY MESSRS. CLAPHAM BROS., KEIGHLEY.

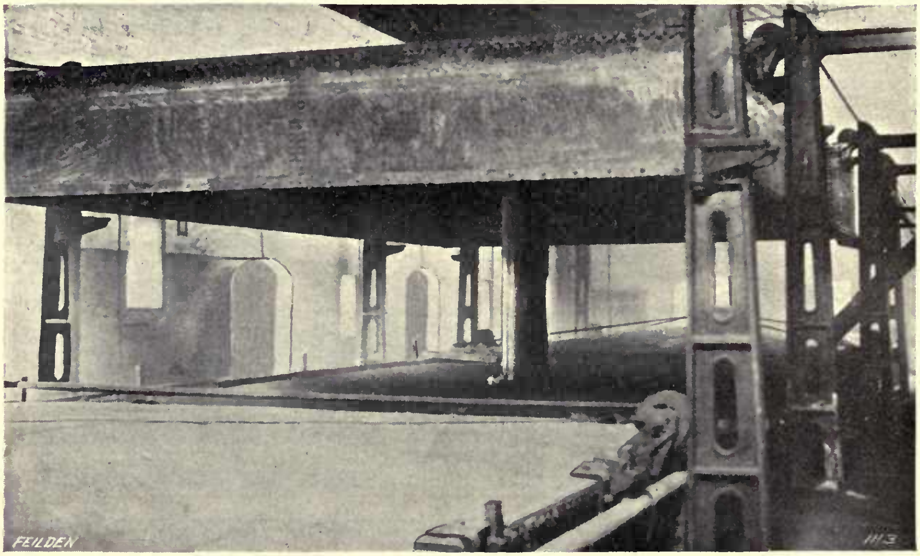


FIG. 64.—PURIFIER COVER, WEIGHING 6¼ TONS, RAISED BY HYDRAULIC POWER WITH CENTRAL RAM.

must be moved away during the operation of changing the material inside. As the size of the purifier increases so does the weight of the cover and the power of the apparatus for lifting it, which, when the size becomes considerable, is a serious addition to cost.

For square purifiers of moderate size, where the cover is lifted at one central point, any form of travelling crane is suitable; but as the size increases, and especially when an oblong shape is employed, it is usual to lift from two points at each side, and in this case two cranes must be used, each lifting from two opposite points simultaneously.

A form frequently adopted for this purpose is a travelling goliath, the lifting being done by hydraulic power (Fig. 63). Such a crane consists of two end standards, each resting on the axle-pins of two grooved wheels running on rails. On the top of the standards are fixed two lattice girders which support the hydraulic cylinders and shafts on which the chain pulleys work. The covers are lifted by two chains, one for either side, each having a lifting hook at one end, while the other end is attached to the crosshead fixed on the end of piston rod. The power is applied by a pair of small force-pumps fixed on one of the standards over a small cistern, the capacity of which is a little larger than the cylinder. By an arrangement of taps the water can be sent to either end of the cylinder or back into the supply cistern. A train of gear wheels is attached to one of the grooved wheels on each standard by which the goliath with cover suspended can be travelled.

A very convenient method of lifting large covers is by hydraulic power with a central ram.

In the case illustrated (Fig. 64), the cover being lifted in this manner is one of a set of six. It is 34 ft. long by 19 ft. 6 in. wide by 3 ft. 2 in. deep, and weighs about $6\frac{1}{4}$ tons. It is lifted 5 ft. 6 in. clear above the purifier, and is guided in its ascent by four rollers fixed to the top edge of cover, and running against cast-iron standards. When reaching its full height, hinged brackets are turned out from the standards and the weight of the cover borne by them. The ram is 20 in. diameter, and the hydraulic pressure used 75 lbs. to the square inch. The ram case is utilised to form one of the columns supporting a girder floor on which the purifiers are erected. In cases where

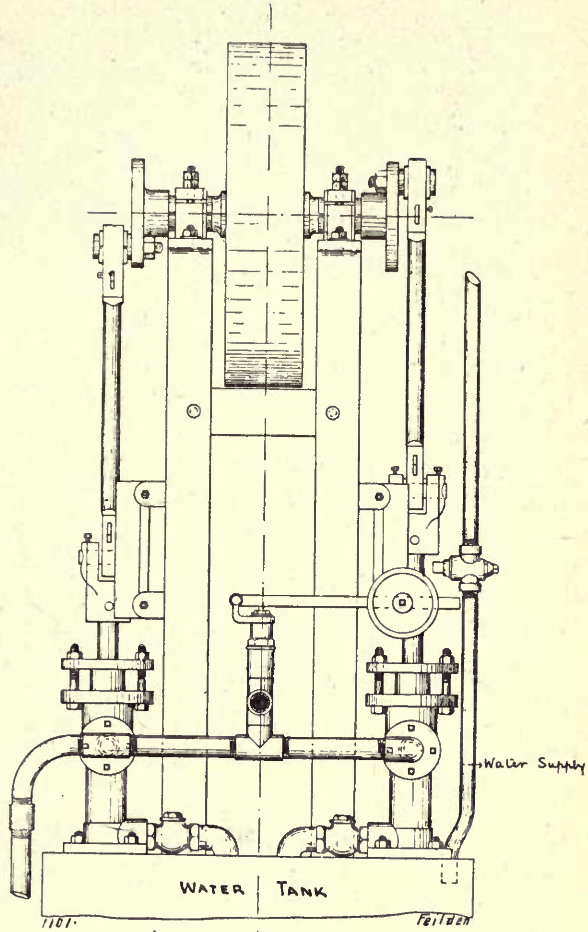


FIG. 65.—ELEVATION OF HYDRAULIC PUMPS FOR RAISING PURIFIER COVERS

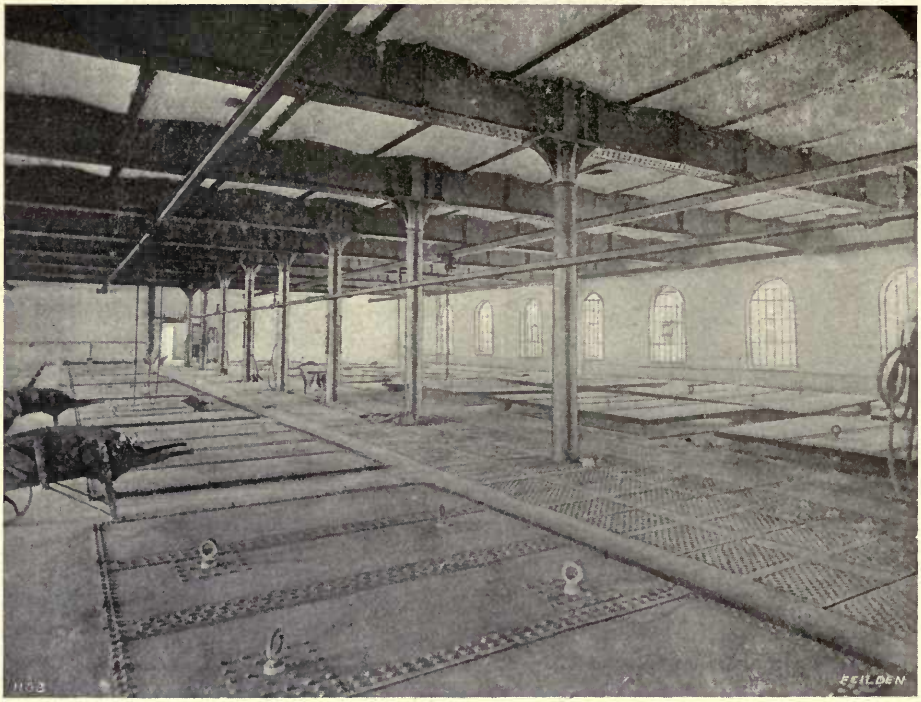


FIG. 66.—VIEW ON TOP OF GREEN'S TYPE OF PURIFIERS AT THE GRIMESTHORPE GASWORKS, SHEFFIELD.

hydraulic power of greater pressure is used the ram will be proportionately smaller, but in the case illustrated, as there was no existing installation of hydraulic power, a set of pumps was put down especially for the purpose, driven from an existing line of shaft and worked direct upon the rams without an accumulator; a very small air vessel being found sufficient to prevent shock and ensure the covers rising steadily.

The pumps (Fig. 65) are constructed upon a small cast-iron water tank, a pipe being laid back to it for return water from the rams. An anti-freezing mixture is used, and the water re-used over and over again. The pumps are fitted with 2 in. diameter by 6 in. stroke gun-metal plungers, connected to crossheads working in guides upon frames carrying the shaft and eccentrics. A safety valve and air vessel are fixed upon the outlet of pumps. The whole forms a very compact and cheap arrangement.

A form of purifier which very materially lessens the first cost, and dispenses with large cumbrous covers and costly lifting apparatus, and also permits of more floor space in the house being utilised by the purifiers themselves, is one originally designed by Mr. Henry Green of Preston.

A very complete installation of this type upon a large scale is in use at the Grimesthorpe Station of the Sheffield Gas Company (Figs. 66 and 67).

It consists of six purifiers, each 74 ft. long by 40 ft. wide, arranged in two lines. The three purifiers forming each line are joined together without a break, forming a box 210 ft. long; two cast-iron divisions being inserted to separate one purifier from another.

Instead of each purifier being provided with one large cover, the top is made of cast-iron plates having twelve openings, each 14 ft. 6 in. by 9 ft. 4 in., the covers for these being made of strong steel plates and angles. These are bolted to the top, and a gas-tight joint made with a strip of indiarubber $\frac{1}{16}$ in. thick. The covers are lifted with 30 cwt. chain blocks, having travelling gear and running on a steel joist attached to flanges of the girders forming floor above. The top of the purifiers form a floor upon which the men when changing the purifying material can work and wheel barrows.

The purifiers are connected together with 30 in. diameter pipes and valves.

The cost of these purifiers erected complete was as follows :

	Total Amount.	Amount per sup. ft. of area of purifiers.
	£	s. d.
Purifiers, including connecting pipes, valves, and lifting apparatus for covers	12,228	13 9
Columns and girders forming floor on which purifiers are carried	2,450	2 9
Total cost ...	14,678	16 6

The cost of purifiers of equal area with the usual water lutes and large covers, calculated at the same scale of prices at which the work for the above was carried out, would have been £18,825, or 21*s.* 2*d.* per sup. ft. of area—an increased cost of £4,147, while the house in which they were placed must have been made larger to permit access to the water lutes on all sides.

The only drawback to the use of Green's type of purifier has been the increased time taken, and consequent increased cost of labour, in removing the number of bolts required to secure the small covers in position, and this has been completely overcome by an ingenious invention of Messrs. Clapham Bros. of Keighley (Figs. 68 and 69).

This invention consists of attaching a cast-iron frame to the top of the purifier around each opening. Both top and bottom flanges of this frame are planed true, machine jointed and put together with bolts and steady pins. The bottom flange of the frame is bolted to a planed facing upon the top of the purifier. About 18 in. apart are cast in pairs, lugs

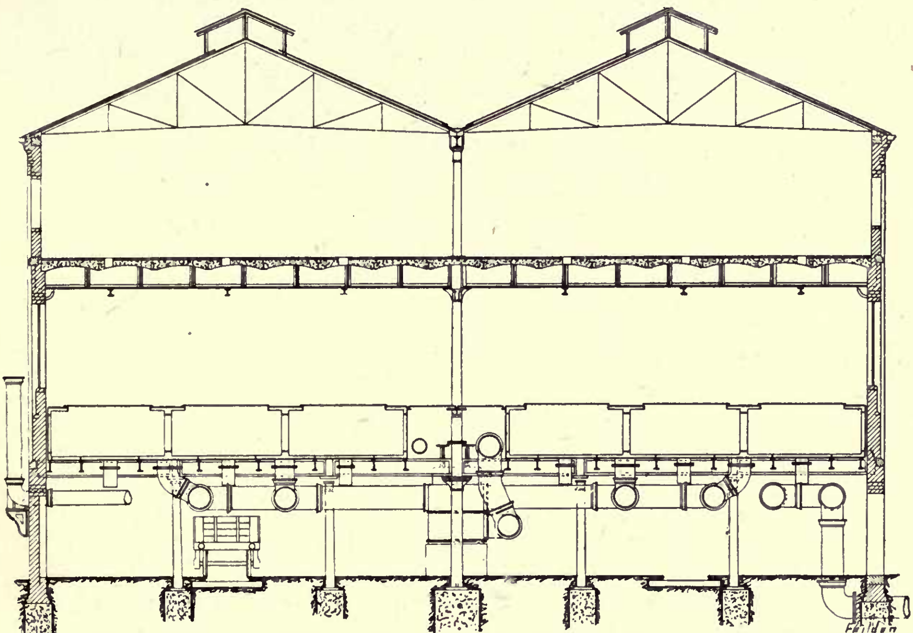


FIG. 67.—SECTION THROUGH PURIFIER HOUSE AT THE GRIMESTHORPE GASWORKS, SHEFFIELD.

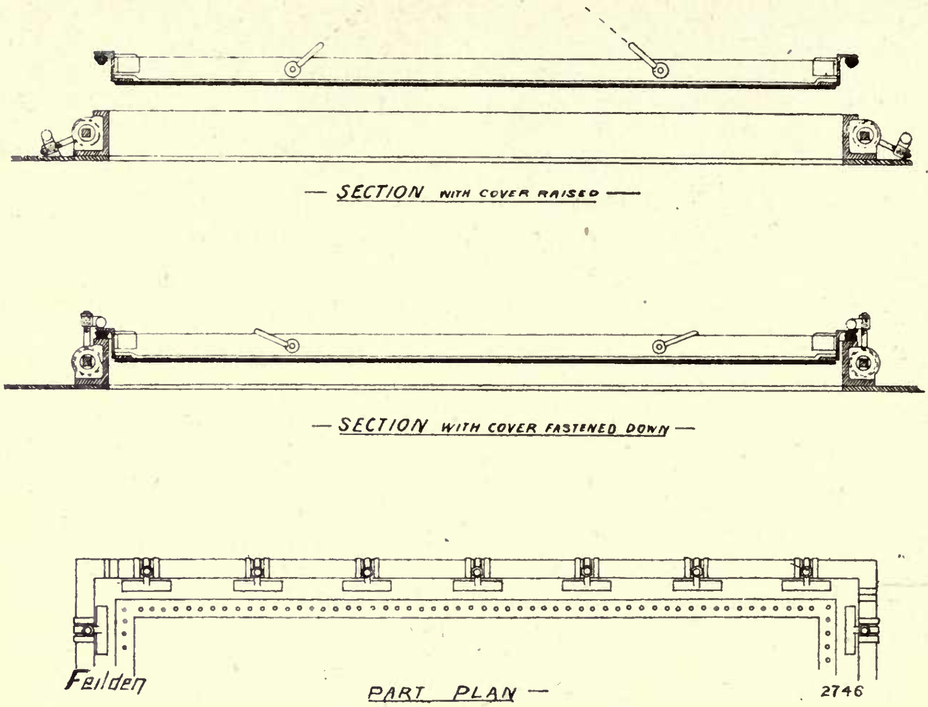


FIG. 68.—CLAPHAM'S PATENT 20TH CENTURY COVER AND ECLIPSE JOINT FOR GREEN'S TYPE OF PURIFIERS.

or brackets which stiffen the frame and form bearers for a shaft. Each of the brackets is bored to admit a turned collar in which is a square shaft.

The cover is of dish shape made of steel with an outer frame of Z section to which is riveted Tee-iron for stiffening and lifting the covers. The strong steel plates forming cover being riveted to these angles and to the Z-shaped frame. To the top rim of the Z section is fastened by countersunk screws a steel rim or clip, and into this is pressed the rubber forming joint between cover and purifier.

The square steel shaft runs the full length of each side of the cast-iron frame and passes through the collars fitted into the brackets on the frame. Between each pair of collars is a turned eccentric with square hole through which the shaft passes. To the eccentric is forged a loop bolt which is raised or drawn down by the eccentric. The square shaft, being turned with a powerful jaw spanner, acts upon all the eccentrics on one side simultaneously pressing the loop bolts upon the top of the cover and firmly pressing down the rubber joint. The direction of the shaft being reversed, the cover is liberated and ready for lifting. Adjustment of the loop bolts is obtained by tapping the head to suit screw on bolt, and after adjustment it is secured in position by a lock nut.

The house containing the purifiers at the Grimesthorpe Works is a three-storey building. The purifiers are erected upon the first or intermediate floor, while underneath are the valves and pipes, the latter being slung to the girders to give 10 ft. headway from the ground. The oxide of iron is discharged, through openings provided in the bottom of the purifier, on to the ground floor, where after treatment it is filled into small side-tip wagons, raised in a hydraulic lift to the top floor, and there piled in suitable positions for filling a purifier again.

The fresh lime is discharged into the side-tip wagons, raised to the top floor in the lift, and there prepared for use. An opening 12 in. square is provided in this floor over each of the small covers of purifiers, so that when the latter are removed and the purifier is to be refilled, a hose pipe is dropped through the hole and the fresh material shot down. Two sets of railway lines are provided on the ground floor to allow material, when required, to be discharged direct into trucks.

Mr. Thos. Holgate has recently designed, and is now erecting at Halifax, a set of four purifiers of Green's type, each 54 ft. by 38 ft. But in this case they are made 10 ft. deep, the gas being admitted to the centre of the purifier, where it divides and passes up and down through the purifying material.

In this arrangement there will be a tendency for the bulk of gas to pass upwards or downwards inversely, as the upper or lower material offers greater resistance to its passage, and to prevent this Mr. Holgate has placed valves, so that the stream of gas can be checked in either direction.

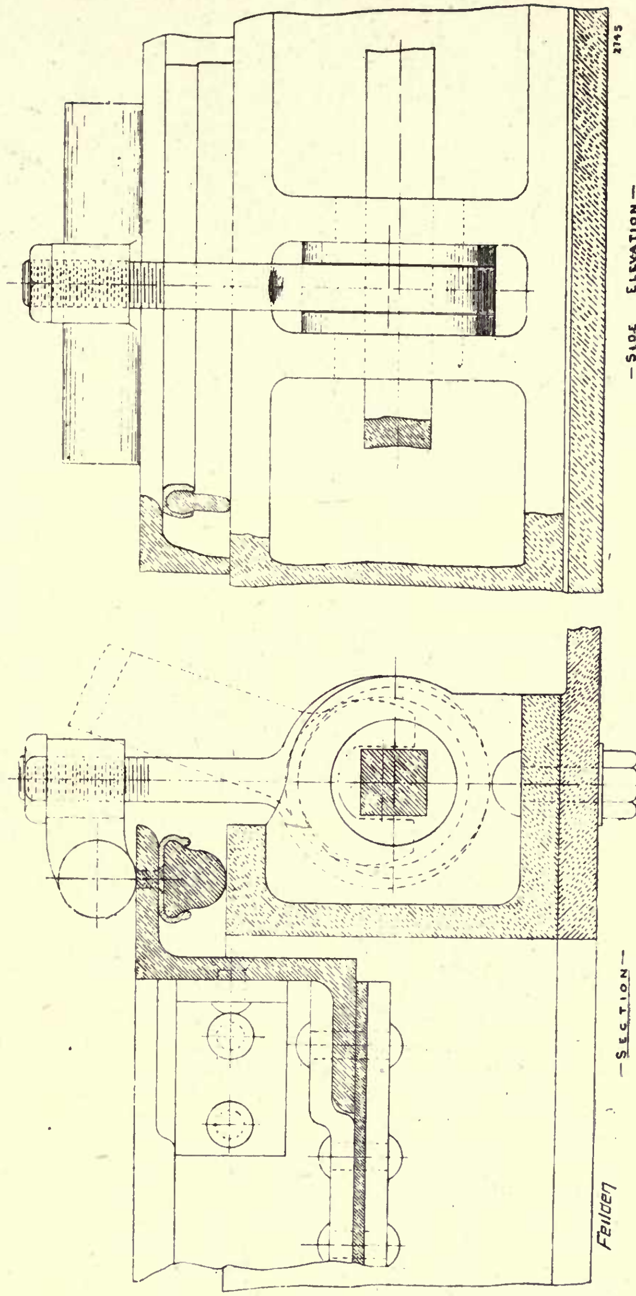
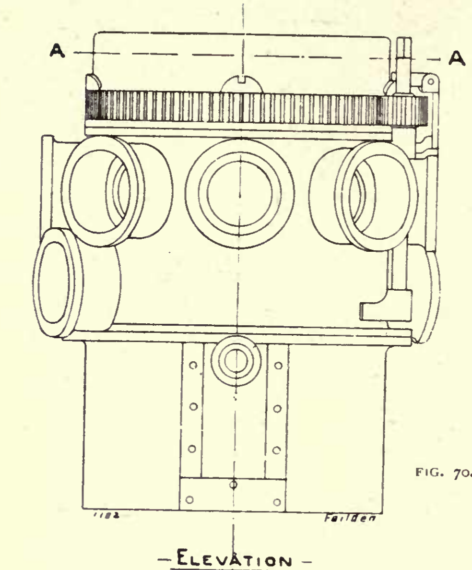


FIG. 69.—DETAILS OF CLAPHAM'S PATENT ECLIPSE JOINT FOR GREEN'S TYPE OF PURIFIER.

The cost of these purifiers, including covers, lifting apparatus, grids, valves and connecting pipes, is £6,146, or 15*s*. per sup. ft. of purifier area. But in comparing with the former example at Sheffield, it must be remembered that



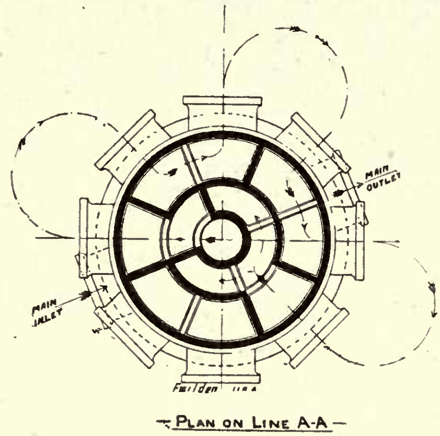


FIG. 70.—DRY-FACED CENTRE VALVE FOR SET OF FOUR PURIFIERS.

they are some 40 per cent. deeper, and the comparison on a 6 ft. deep basis would be:

Sheffield purifiers 13*s.* 9*d.* per sup. ft.

Halifax ditto 9*s.* 0*d.* ditto.

The stage purifying house has always been considered much more expensive than the arrangement of purifiers, on the ground protected by a light roof, and a stage house has hitherto only been adopted where ground space is limited. But by adopting Green's type of purifiers, this disparity of cost almost disappears. Moreover, in stage houses, the annual cost for labour is considerably reduced, as they give facilities for handling the purifying material very economically

At the Neepsend Station of the Sheffield Gas Company, where all the purifiers are in stage houses, elevators are used for raising the oxide of iron as it is thrown out of the purifiers to an overhead floor (Figs. 73 and 74), where, after revivification, it is shot down through a hose pipe into the purifier again.

A very complete arrangement of elevators and conveyors for

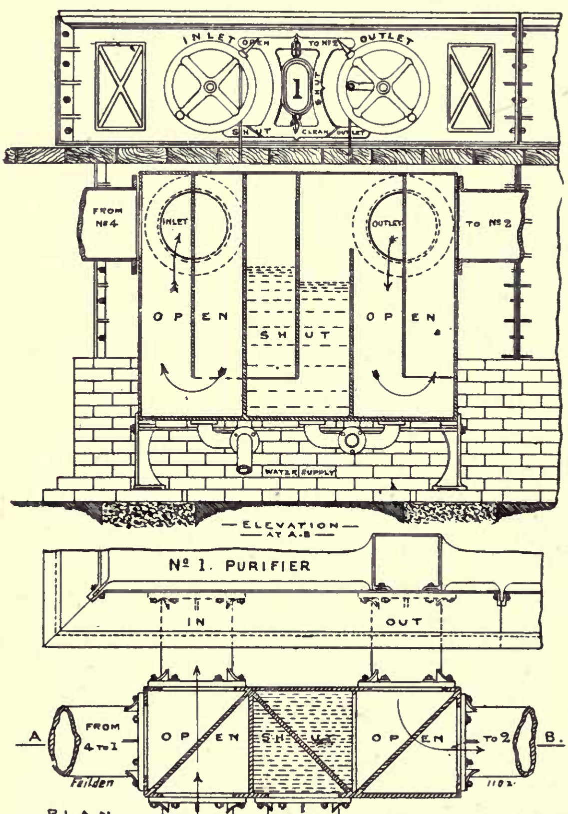


FIG. 71.—CUTLER'S WATER VALVE AS USED FOR WORKING PURIFIERS IN ROTATIVE ORDER, ONE SUCH VALVE REQUIRED FOR EACH PURIFIER.

mechanically handling the purifying material is in use at the Stafford Gas Works. Mr. J. Ferguson Bell, the Engineer, has placed the purifiers on the first floor of a stage house. The material, as it is taken out, is shot down on to the ground floor, and when ready again for use is shovelled into a trough conveyor, which carries it to the boot of an elevator, and by the latter it is raised into other conveyors fixed in the roof over the purifiers, and then dropped into the one being filled.

A very economical method of handling the material may be seen at the Nine Elms Station of the Gas Light and Coke Company, where the house is built over two canal docks, and the spent material is dropped direct from the purifiers into barges, which are then taken down the Thames to the dumping ground. The fresh material is also brought up by barges and raised with hydraulic cranes on to the floor above the purifiers, and there prepared for use.

At the East Greenwich Station of the South Metropolitan Gas Company, where the purifiers are in the open on the ground level, the material is economically handled by being filled into small tip trucks (Fig. 75) drawn by diminutive locomotives. The spent material is taken away in this manner, and also the fresh material brought to the purifiers.

VALVES FOR PURIFIERS.

It has already been stated that the most usual plan is to arrange the purifiers in groups of four, the direction of the gas and sequence of purifiers in action being controlled by a centre valve.

The ordinary type of dry-

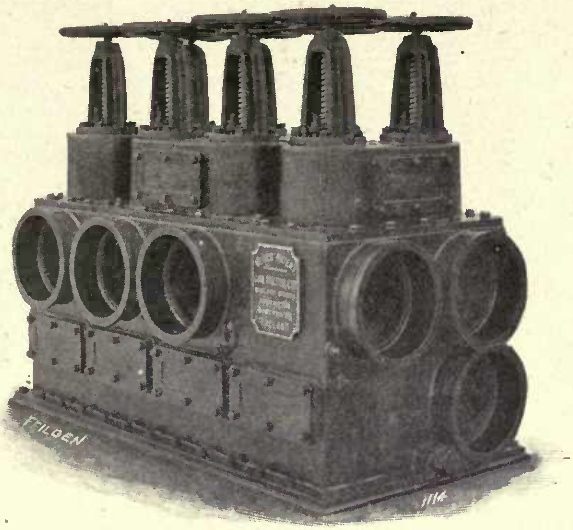


FIG. 72.—WECK'S PATENT CENTRE VALVE, BY WHICH ONE, TWO, THREE OR FOUR PURIFIERS MAY BE WORKED IN ROTATION. (MANUFACTURED BY C. AND W. WALKER.)

FIG. 73.—ELEVATORS FOR RAISING PURIFYING MATERIAL TO AN UPPER FLOOR AT THE NEEPSEND GASWORKS, SHEFFIELD.

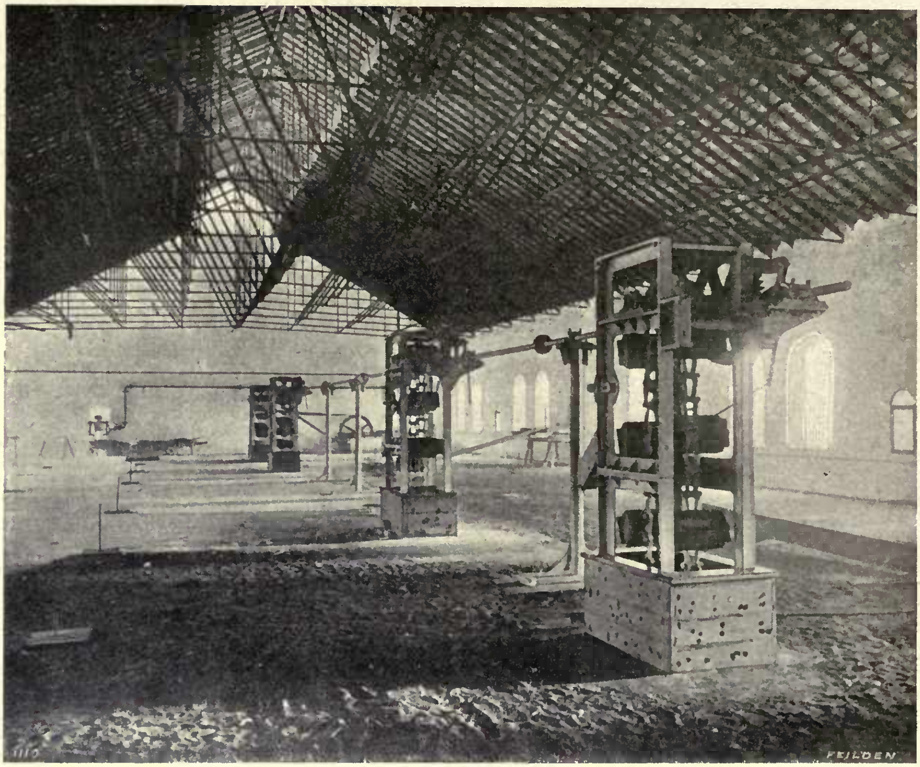


FIG. 74.—VIEW OF HEAD OF ELEVATORS ON THE UPPER FLOOR OF PURIFIER HOUSE AT THE NEEPSEND GASWORKS, SHEFFIELD.

faced valve for this purpose is circular, and consists of three main castings (Fig. 70). The centre one is divided into compartments, there being two concentric divisions in the centre, forming main inlet and outlet compartments; and radiating from the outer of these, a division forming a compartment for each of the inlets and outlets of the four purifiers. On the outside of this casting are provided sockets for connecting pipes, and these communicate with the interior compartments. The bottom casting forms a syphon into which a drain-pipe seals from each compartment of the valve. The top casting is a deep cover, having divisions in it forming five compartments. The first connects the main inlet with the first purifier, the next two connect the first, second, and third purifiers respectively in rotation, while the fourth connects the outlet of the third purifier with the main outlet of the valve. The fifth compartment forms a blank over the inlet and outlet of the fourth purifier, which is therefore shut off for refilling.

All the lower edges of the divisions in the cover and upper edges in the centre casting are carefully scraped up to a true surface to make gas-tight joints. On the periphery of the cover is cast a toothed spur wheel into which gears a pinion wheel. On rotating the cover by this means one quarter turn to the right, the blank compartment comes over the inlet and outlet of No. 1 purifier, which is thus shut off, while No. 4 is brought into use as the last of the series.

In large sizes this valve is very difficult to make and to keep perfectly gas-tight,

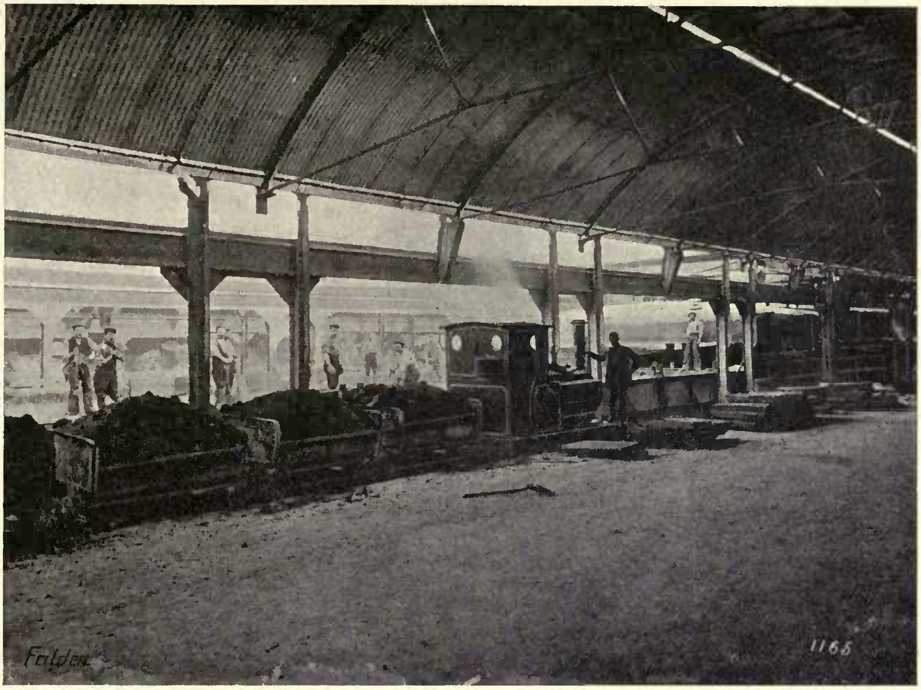


FIG. 75.—NARROW-GAUGE TRUCKS AND LOCOMOTIVE USED FOR MOVING PURIFYING MATERIALS AT THE EAST GREENWICH GASWORKS.

and for this reason is not often used now in large works. It is sometimes replaced by a number of independent slide valves, but as twelve of these is the minimum that can be used for working four purifiers in rotation, they often give rise to confusion, and mistakes may occur when changing unless great care is exercised.

A centre valve, having much to recommend it, is one invented by Weck and made by Messrs. C. & W. Walker, of Donnington (Fig. 72). It combines the advantages of a centre valve with the greater certainty from the use of slide valves. It is made rectangular in shape and horizontally is divided into a main inlet and outlet compartment. A disc valve—having faces on both upper and lower sides, and having outside screw for raising and lowering the discs—is used for inlet and outlet of each purifier. These when screwed up connect respectively to main inlet or outlet, and when screwed down connect by means of top hoods to inlet and outlet respectively of adjoining purifiers. It is therefore only necessary when working the valve to remember that the screw of inlet to first purifier and outlet of last must be up and all others down. Moreover, by this arrangement one, two, three or four purifiers can be in use at once. The disc valves are guided as they ascend and descend to prevent rotating, and their faces are made of a special mixture in which there is very little lead.

There is, however, with all dry-faced valves of whatever description, some risk of foul gas passing through leakage of valve faces, and the only absolutely certain valve is that formed by a water seal. Recognising this fact, Messrs. Cutler and Sons, of Millwall, have designed and patented a very compact and complete arrangement of water valves for purifiers which gives absolute assurance against this leakage (Fig. 71).

CHAPTER VI.

GASHOLDERS.

THOUGH gasholders do not strictly come under the heading of "appliances in gas manufacture," yet they play so important a part in the equipment of a gasworks that to omit a description of them would leave this article very incomplete. Moreover, there is no portion of the gasworks that offers such scope for engineering skill, and certainly in only one other branch of gas engineering has such a revolution in construction taken place in recent years.

The importance of gasholders to the gas manufacturer lies in the fact that he has in them a reserve of gas upon which he can draw during the few hours of maximum demand. And herein lies the assurance that an uninterrupted supply can be maintained, which the so-called opponent of gas—the electric light—does not possess.

A storage system for the latter has yet to be invented that will admit of the full energy being taken out of store that has been put in, and until this can be done the storage of electricity can never be

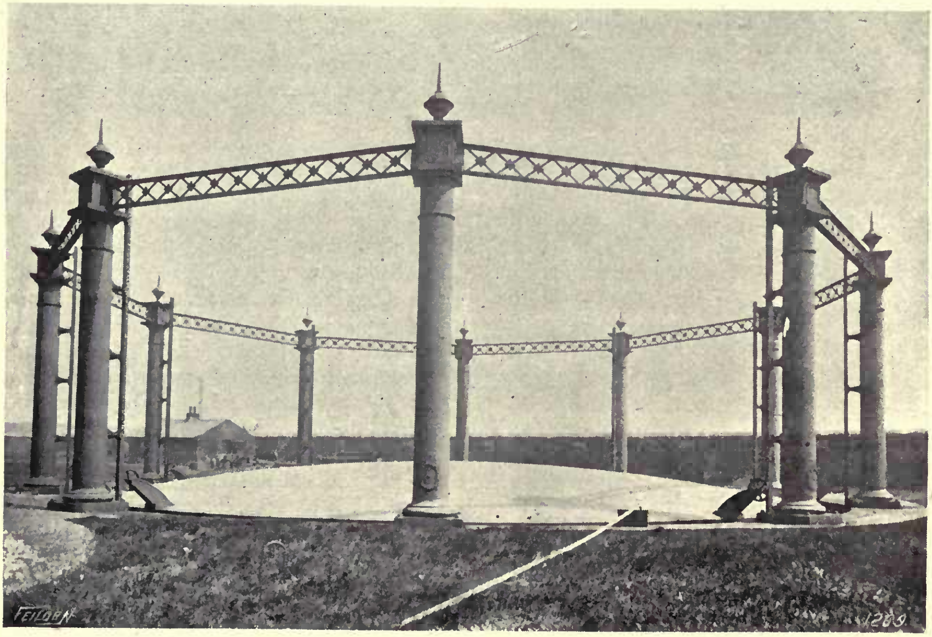


FIG. 76.—SINGLE-LIFT GASHOLDER AT THE DENTON GASWORKS, HAVING HEAVY CAST-IRON COLUMNS. SIZE 90 FT. DIAMETER BY 24 FT. DEEP. THIS GASHOLDER HAS NOW BEEN CONVERTED BY MESSRS. ASHMORE, BENSON AND PEASE, INTO ONE OF TWO LIFTS, THE COLUMNS BEING REMOVED AND THE GUIDING EFFECTED BY THEIR PATENT ARRANGEMENT OF STEEL CABLES.

economical, though to a certain extent it may be necessary. Unlike electricity, the storage of gas is simple and reliable, and every 1,000 cubic feet of gas put into store can be taken out when required.

It is usual to have storage equal to the maximum day's make of gas in mid-winter, and even a greater capacity is advocated by many engineers.

The gasholder in its simplest form, and as originally used, consists of a hollow cylinder closed at one end and inverted in a tank of water, the gas being brought into it by a pipe rising above the surface of the water inside. The pressure of the gas overcoming the weight of the cylinder raises the latter, and the weight of the cylinder maintains the pressure, so that as the gas is required it passes out through the standpipe inside and the cylinder descends.

To maintain the vertical position of the cylinder as it ascends and descends, columns are fixed around it having guide-bars attached to them, and pulleys are secured to the top and bottom of the cylinder and work in contact with these guides. The columns and guides, together with the bracing and ties to give them the

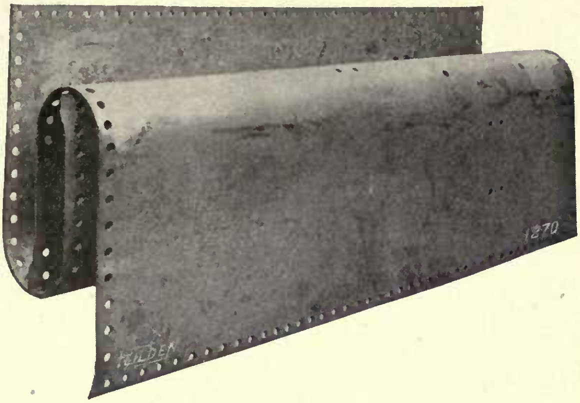


FIG. 77.—ONE LENGTH OF CUP AND DIP OF TELESCOPIC GASHOLDER READY FOR RIVETING UP TO ADJOINING LENGTHS.

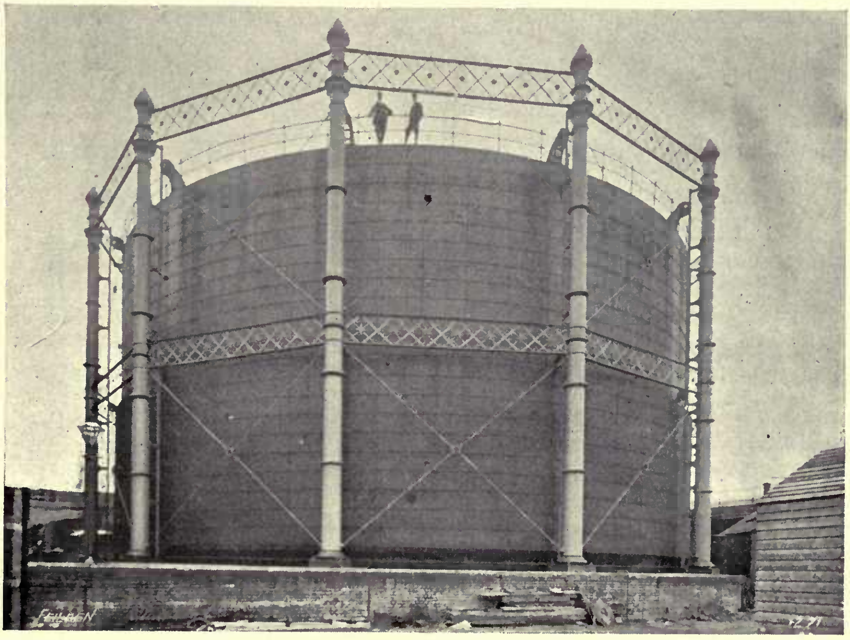


FIG. 78.—TWO-LIFT GASHOLDER AT THE CHESTER GASWORKS. SIZE, 90 FT. DIAMETER, EACH LIFT 24 FEET DEEP.

necessary rigidity, compose the guide framing, the cylinder being the bell or floating portion of the gasholder. (Fig. 76).

The next step in gasholder construction was to make a telescopic gasholder, so that in the same tank of water the capacity was increased nearly 100 per cent. In this form the hollow cylinder is retained, but the lower edge is turned up on the outside all round to form a cup. This may perhaps, be best likened to a man's tall hat, but with the brim turned up to U-shape, the brim forming the cup at bottom and the crown the top of the gas holder. Another cylinder, but open at both ends and rather larger than the first, is made outside the latter, and the top edge of this second one is turned down on the inside all round to such a size that it will fit into the cup at the bottom of the first cylinder (see Fig. 77).

The first or inner cylinder rising and becoming full of gas, the cup at the bottom (filled with water from the tank) grips into the inverted cup, or dip as it is called, on the outer cylinder, which it then raises, a liquid seal being thus made between the two preventing the escape of gas, and the now telescoped bell can rise to double the height of the single one.

In this form all telescopic gasholders are made, the only alteration (except in details) effected since their introduction being in the number of cylinders or lifts used. The largest telescopic gasholder now in existence has six lifts.

The advantage of the multiple-lift gasholder is simply one of economy, the cost of the tank remaining the same for any number of lifts, while each one adds materially to the capacity of the gasholder, and, therefore, the proportionate cost is reduced.

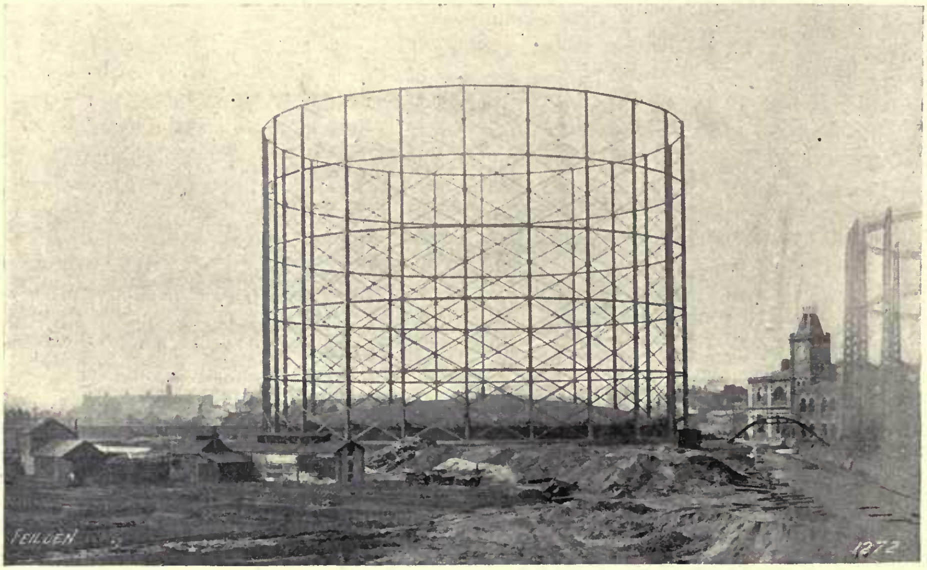


FIG. 79.—VIEW OF GUIDE-FRAMING OF TRIPLE-LIFT GASHOLDER ERECTED BY MESSRS. ASHMORE, BENSON AND PEASE, AT THE OLD KENT ROAD GASWORKS. GASHOLDER IS 210 FT. DIAMETER, AND RISES, WHEN FULL, 160 FT. HIGH, AND CONTAINS 5½ MILLION CUBIC FT. OF GAS.

The guide-framing originally was always made of cast-iron columns or standards, with suitable guides attached and tied together at the top with light girders. When the two-lift telescopic gasholder is used an additional girder is usually fixed between the columns at their centres to give additional rigidity.

Previous to the year 1881 there were

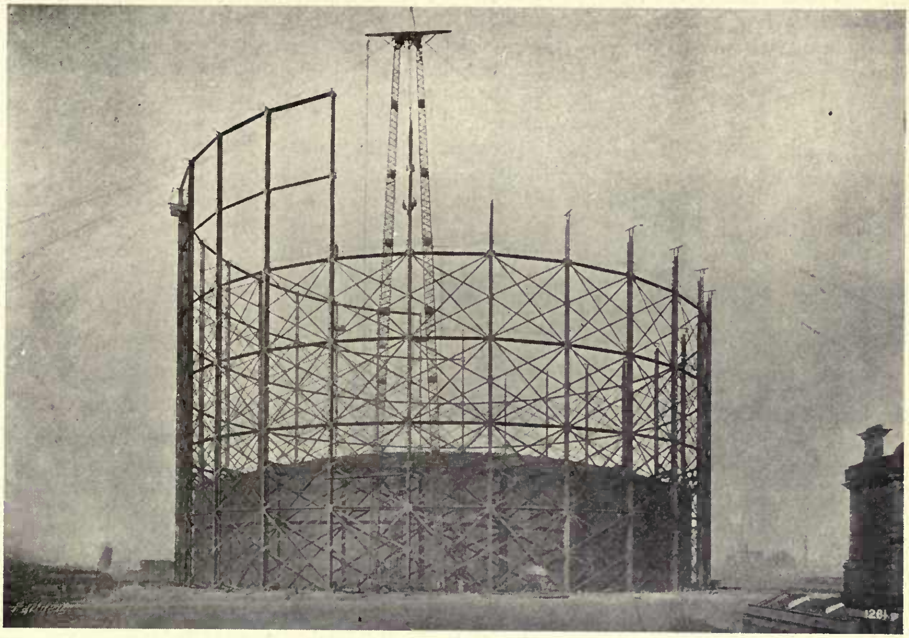


FIG. 80.—VIEW OF THE OLD KENT ROAD GASHOLDER, SHOWING GUIDE-FRAMING IN COURSE OF CONSTRUCTION, AND SHEAR-LEGS, 180 FT. HIGH, USED FOR ERECTING FRAMING.

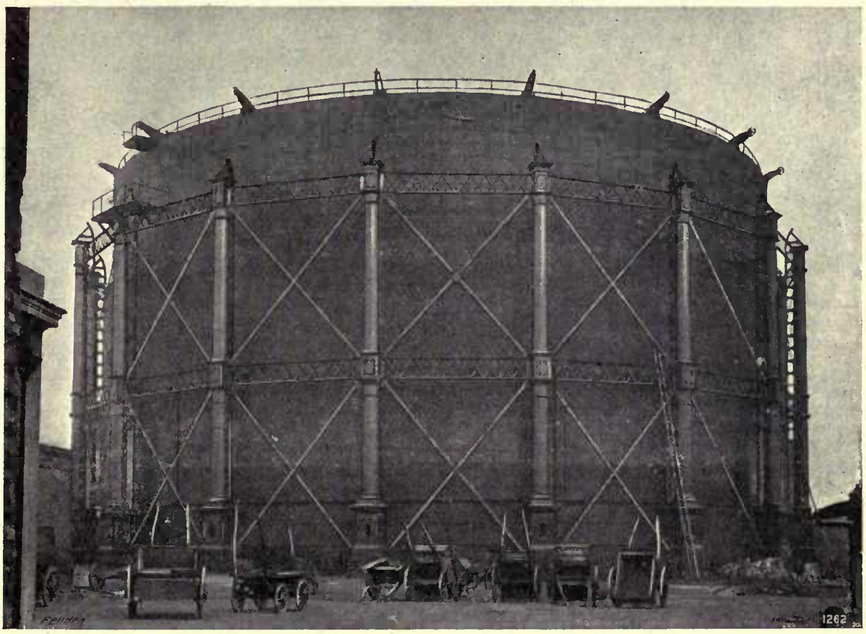


FIG. 81.—GASHOLDER AT THE ROTHERHITHE GASWORKS CONVERTED INTO A TRIPLE-LIFT ONE BY THE ADDITION, IN THE YEAR 1887, OF A FLYING LIFT.

only a very few examples of gasholders having more than two lifts, or that had standards for the guide-framing constructed of wrought-iron. But in that year Mr. George Livesey, then Engineer of the South Metropolitan Gas Company, made an entirely new departure by constructing the largest triple-lift gasholder up to that time in use, and adopting a very light framing of wrought-iron standards, but so securely braced with light horizontal girders and flat iron wind-stays, as to make the guide-framing practically into a remarkably stiff cylinder, having a circumference equal to that of the tank, to which, being bolted, it offered a greater resistance to overturning and distortion than anything that had previously been attained by the usual methods. (Figs. 79 and 80.)

On the completion of this gasholder, and probably due to his observation of its working, Mr. Livesey made the startling suggestion that the guide-framing of such a gasholder might be reduced in height by two-thirds; that is, it would be sufficient if carried up the height of one lift only, so that each of the first two lifts, as they picked up in turn the one below, would rise clear above the framing, and be securely held and maintained level by the lowest lift, which should remain in contact with the guide-framing.

In the year 1887, or nearly six years afterwards, Mr. Livesey applied in a modified form the suggestion he had made, by adding a third lift to a gasholder at Rotherhithe without raising the guide-framing; the new lift rising clear above it after the gasholder was two-thirds filled. (Fig. 81.) And again later, in the year 1892, he further applied it in the construction of the largest gasholder at present in existence, which has six lifts, the guide-framing in this case being raised to the height of four lifts only, two being allowed to rise clear above it. (Fig. 82.) Numbers

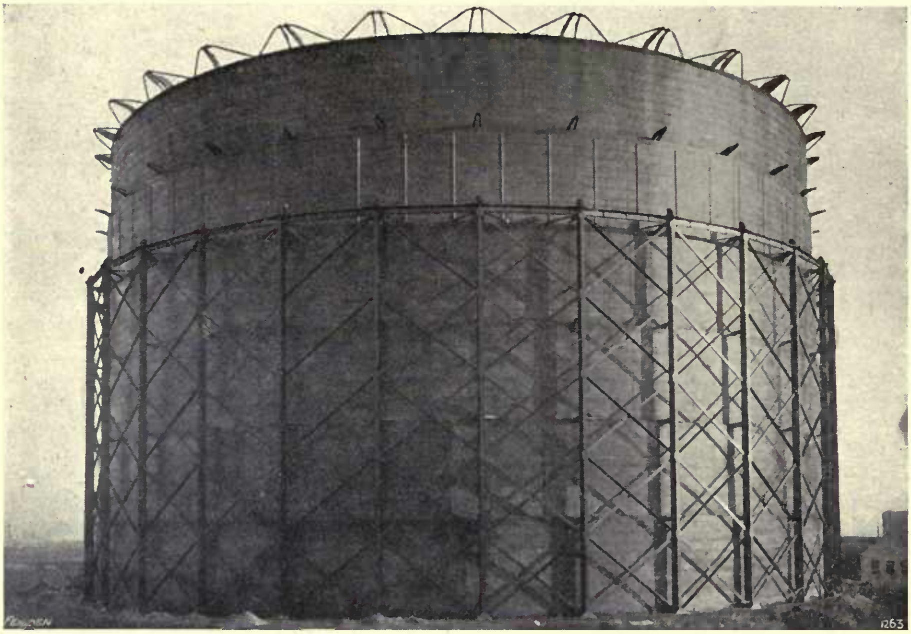


FIG. 82.—SIX-LIFT GASHOLDER AT THE EAST GREENWICH GASWORKS, HAVING TWO FLYING LIFTS. THIS GASHOLDER IS THE LARGEST IN THE WORLD, BEING 293 FT. DIAMETER, AND RISING, WHEN FULL, 180 FT. HIGH, CONTAINING 12 MILLION CUBIC FEET OF GAS, CONSTRUCTED BY MESSRS. CLAYTON, SON AND CO.

of gasholders upon this plan with one flying lift have since been erected.

While Mr. Livesey was adding the flying lift to the gasholder at Rotherhithe much discussion was taking place amongst engineers with regard to the question generally of guide-framing, and it was at this time that Mr. H. G. Webber suggested that it could be reduced to five or six feet high; in fact, only sufficiently high to insure that the lowest guide rollers on the bottom lift should be securely maintained in position, the lower stiffening ring on the botton lift being greatly strengthened to prevent as far as possible its distortion under the greatest stress to which it would be subjected. This plan was condemned by almost every engineer, and there can be no doubt that as proposed by Mr. Webber the idea could not have been successfully applied. Yet it was a most fruitful suggestion, for within two years from the time it was made two inventions had been patented for dispensing entirely with the guide-framing, and both have been successfully applied and are now extensively adopted.

The first was the invention of Mr. Wm. Gadd, of Manchester, and consisted in replacing the usual vertical guides in the tank and inside the outer lifts by spiral guides, in contact with which worked double rollers gripping the guides above and below. (Fig. 83.) In this manner a spiral or corkscrew motion is given to the bell as it rises and falls, and the same tendency is imparted to it when subject to wind-pressure on sides or top. Tilting is impossible, because immediately the tendency occurs, the guides—set at an angle of 45° or 60°—prevent the bell rising or dipping vertically and impart a rotating tendency, and the whole bottom curb of the bell is then held as firmly as if bolted to the tank wall.

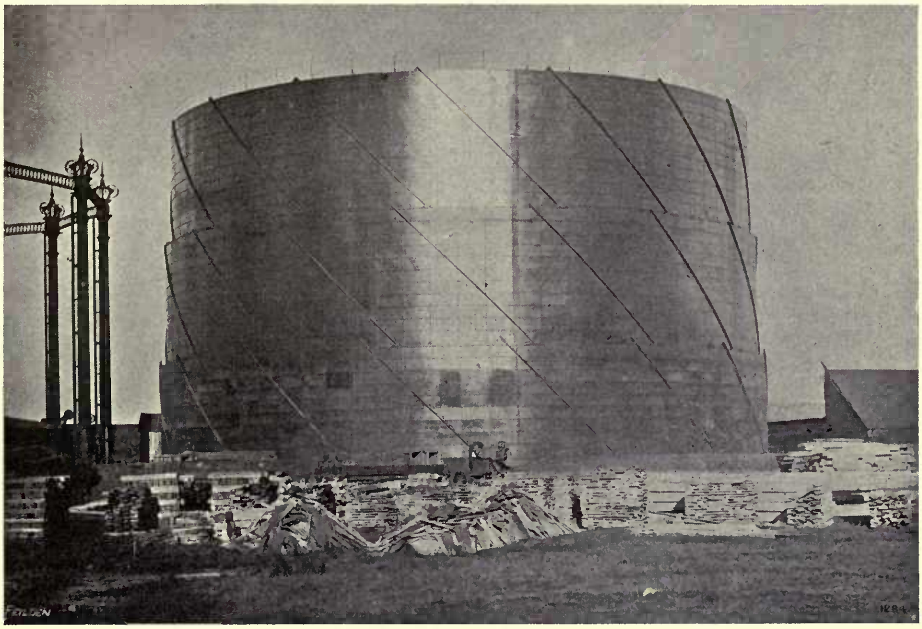


FIG. 83.—GADD'S PATENT SPIRAL-GUIDED TRIPLE-LIFT GASHOLDER AT THE WIDNES GASWORKS. SIZE 114 FT. DIAMETER, AND EACH LIFT 24 FT. DEEP.

In the more recent examples the spiral guides are attached to the outside of the lifts and the rollers fixed to the tank wall and to the dips respectively.

It will be understood that with a gas-

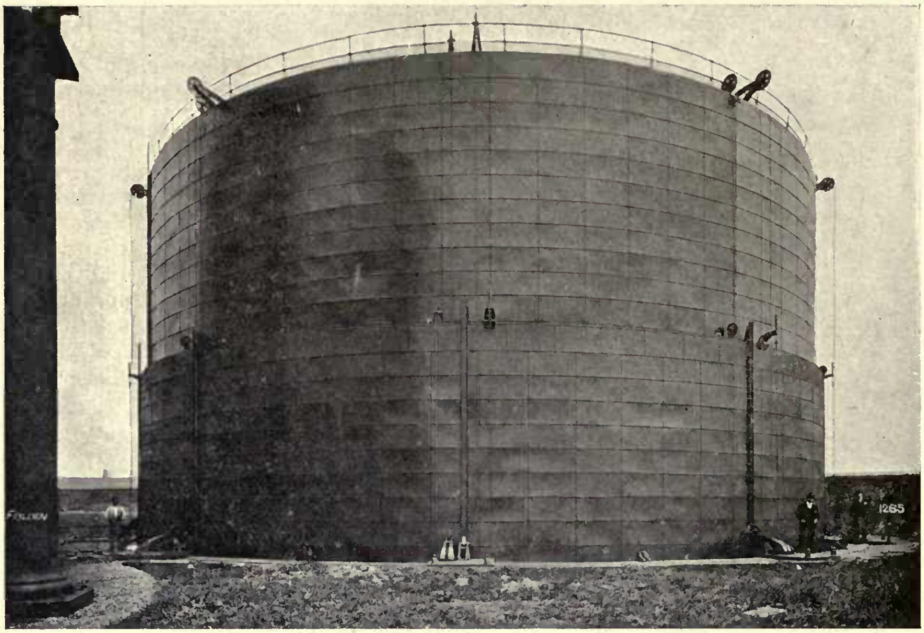


FIG. 84.—PEASE'S PATENT CABLE-GUIDED TWO-LIFT GASHOLDER AT THE DENTON GASWORKS. THIS WAS ORIGINALLY A SINGLE-LIFT GASHOLDER, WITH HEAVY CAST-IRON COLUMNS, BUT WAS CONVERTED BY MESSRS. ASHMORE, BENSON AND PEASE, IN THE YEAR 1899.

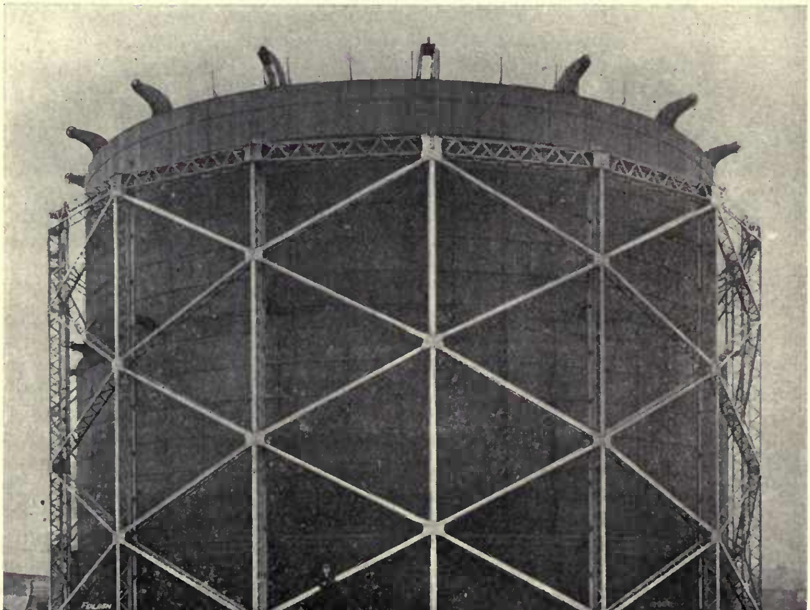


FIG. 85.—TRIPLE-LIFT GASHOLDER (82 FT. DIAMETER) AT THE ALDERSHOT GASWORKS, WITH CUTLER'S PATENT GUIDE-FRAMING RISING TO TOP OF SECOND LIFT. TOP LIFT RISES CLEAR OF GUIDE-FRAMING.

holder guided as described, the stress on the bottom curve of the bell and the guide rollers is very great when the bell is fully inflated and its whole leverage exerted ; and a much greater stress is also thrown upon the thin sheets forming the skin of the bell. In these gasholders therefore, the bottom curb is made much stronger, and the sides of the bell are considerably strengthened with stiffeners.

The second invention referred to is that of Mr. Lloyd Pease, of the firm of Messrs. Ashmore, Benson & Pease, in which cables or wire ropes are used to replace the external guide-framing. (Fig. 84.) At the first glance the system seems very complicated, but it is really extremely simple, and consists in substituting a cable for each column ; the cables being worked in pairs and arranged to withstand pressure coming from opposite sides.

Taking the example of a single-lift gasholder, and considering the one pair of cables which replace two columns—one on each side at points opposite to each other—one cable is secured to the tank wall and is taken up and over the crown on pulleys, then down the opposite side, passing under a pulley fixed to the curb of the bell, up again, and terminating at a bracket fixed upon the tank wall. A force now acting upon the bell on the side from which the cable started wouid tend to tilt the bell from that side. To tilt, however, the bell must rise on the side from which the force acts and dip on the opposite side, and this the cable prevents, as the first side can only rise as sufficient cable is paid out by the other side rising. The second cable of the pair being now fixed in the reverse direction, neither side can rise or fall without the opposite side doing so to the same extent, and the bell is therefore kept perfectly level so long as the cables remain taut, and this is provided for by fixing a strong spring upon each one. The pairs of cables are fixed about 30 feet apart around the periphery of the bell.

In the case of telescopic gasholders the cables are similarly arranged in pairs, each cable being trained over pulleys on the respective lifts to guide them in turn in their ascent and descent.

The stress upon the bottom curb of the bell is not very greatly increased under this system of guiding as the stresses are chiefly in vertical directions. The thin sheets of the skin, are, however, subjected to compression, but as there is a great surplus of tension stress due to the pressure of the gas within, this is unimportant.

Assuming that spiral and cable-guided gasholders are as safe as those having external guide-framing, it is hardly to be

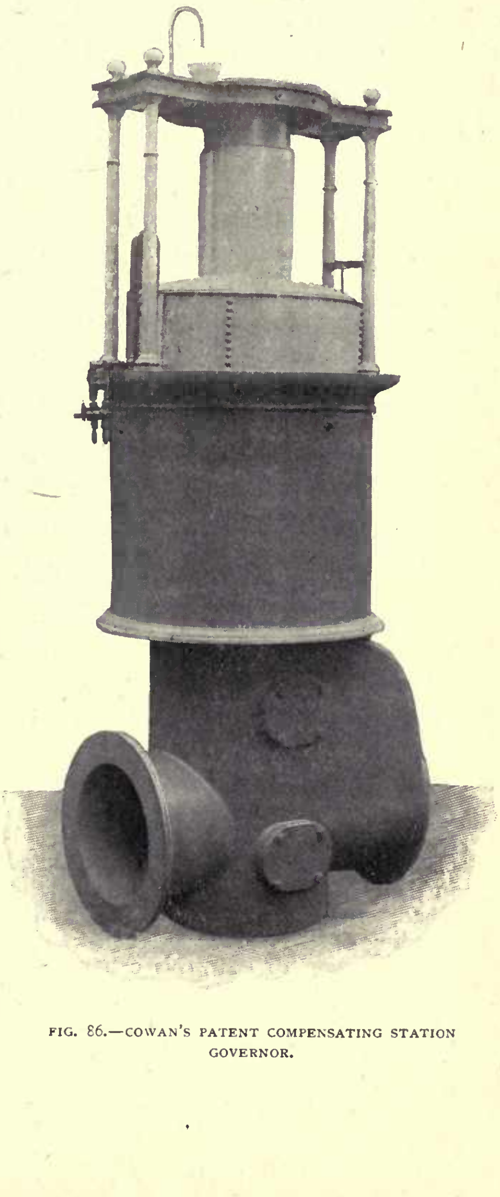


FIG. 86.—COWAN'S PATENT COMPENSATING STATION GOVERNOR.

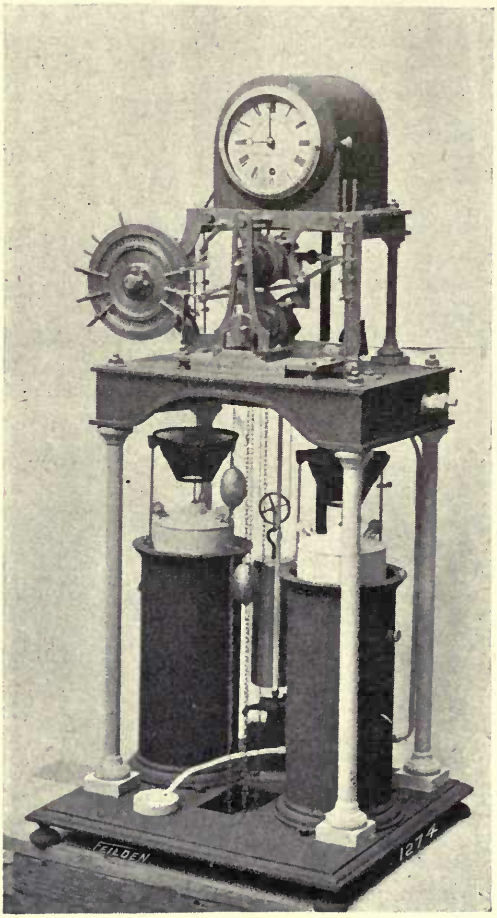


FIG. 87.—COWAN'S PATENT AUTOMATIC PRESSURE CHANGER.

supposed that engineers would prefer to adopt the former except on the grounds of economy in construction. That these methods are cheaper far than the old heavy guide-framings of former years cannot be disputed. But there can be no doubt that, first, by Mr. Livesey's example of the light, stiff framing adopted in the large gasholder at the Old Kent Road, and second, by the better understanding of the duty the guide-framing is called upon to bear, this can now, by a judicious placing of material, be immensely lightened and cheapened, so that the difference in cost between gasholders with external guide-framing and the two methods described of dispensing with it has been so greatly reduced that it is very questionable whether the latter will hold their own, much less that the practice in future years will be altogether in favour of gasholders without external guide-framing.

A guide-framing for gasholders (Fig. 85) has been patented and very successfully applied by Messrs. Cutler & Sons, of Millwall, in which the horizontal ties—except at the top—are omitted, and the stiffness of the uprights depends entirely upon the stays. The same firm have designed an arrangement, which is now largely in use, for carrying the hose-pipe which conveys steam to the cups of telescopic gasholders to prevent the water freezing.

GOVERNORS.

In conclusion of this article, reference must be made to the plan adopted for reducing the heavy pressures thrown by gasholders to such pressure that gas can be suitably supplied to consumers.

The pressure of gas can be controlled, of course, by simply opening or closing a valve by hand as the demand increases or decreases, but this would be a clumsy plan, depending entirely upon the attention of the operator. To obviate this the governor was invented, in which a valve is supported by the pressure of gas acting underneath the bell of a small gasholder. The pressure of the gas supplied to consumers can then be increased by weighting the crown of the small gasholder. As long at the pressure of the gas at the inlet of the governor is uniform, as it would be when a single-lift gasholder is used, nothing further is required ; but when it varies, as it does with multiple-lift gasholders, it is altogether inadequate, and will not insure a uniform outlet pressure. A compensated governor then becomes necessary ; that is, the inlet pressure of gas which acts upon the valve must be made to act upon a portion of the bell of the small gasholder of equal area to the valve and in an opposite direction.

Of this description is the Cowan patent governor (Fig. 86). It consists of the usual bell, or small gasholder, floating in a tank of water, and having a valve suspended from its crown. Into communication with this bell is put the gas after it has passed through the valve. As the gas increases or decreases in pressure beyond what the bell has been weighted to give, so this rises or falls, at the same time closing or opening the suspended valve, the desired pressure being thus automatically maintained. The compensation for changes of inlet pressure is obtained by having a chamber on the top of the bell, into which the inlet gas is introduced through the hollow rod suspending the valve from the crown. This chamber has an equal area to the valve base, so that whatever the upward pressure of gas may be on the valve a similar pressure acts downwards upon the crown of the bell, thus rendering the valve insensible to changes of pressure. It will be seen that when weight is added to the bell the valve will be opened wider, thus increasing the pressure of the gas, and the reverse occurs when the bell is lightened. In the Cowan governor the weight is increased by loading with water, which may be run on as slowly as desired and syphoned off again slowly. By this means the addition or reduction of pressure is imperceptible.

A very ingenious piece of apparatus (Fig. 87) for automatically changing the pressure of gas has been invented by the maker of the Cowan governor, and is largely used in connection therewith. It consists of a clock, having geared to it a disc, which it revolves once in 24 hours. Attached to this disc are two series of tappets, which can be so fixed as to come into operation at any desired period of the disc's daily revolution. One set of tappets controls a cock supplying water to the loading tank on the governor, the other set controls a similar cock withdrawing water therefrom. Shutting off the flow of water, when the required addition or reduction of pressure has been attained, is effected by means of two small gasholders in communication with the outlet gas from the governor. One of these in rising causes the water-supply cock to close; the other, in falling, the syphon cock. The small gasholders can be weighted to rise or fall at any desired pressure.

FIG. 88.—BRADDOCK'S PATENT 30-IN. DIAMETER COMPENSATING STATION GOVERNOR, WITH AUTOMATIC SELF-LOADING ARRANGEMENT, AT THE EFFINGHAM-STREET GASWORKS, SHEFFIELD.

Another device for loading governors which, within certain ranges, is absolutely automatic, has been invented by Messrs. J. & J. Braddock, of Oldham (Fig. 88).

Unlike Cowan's "pressure changer," it does not load and unload the governor at any set times of the day, but the loading commences automatically whenever the consumption of gas increases, and unloading when it decreases again. This is effected by fixing alongside the governor a water tank, which acts just as the balance cistern of a low-pressure kitchen boiler does, in maintaining a uniform level of water in the boiler; with this difference, that in the latter case the water in the boiler is reduced in level by being drawn out of the boiler, while in the former the water on the governor is lowered by the bell sinking as the valve of the governor opens to allow an increased quantity of gas to pass. In other words, the governor being set to give a minimum pressure. then, when the consumption of gas increases, the valve must open further to maintain this minimum, and the bell descends, water from the balance cistern is syphoned into the loading tank, thereby increasing the load on the bell, and the pressure is increased. As the consumption of gas reduces, the reverse action takes place, with the result that the pressure is reduced. A difficulty, however, occurs, owing to changes of inlet pressure, which causes an alteration in the level of the bell even with a uniform consumption. This, to a considerable extent, is overcome by placing the balance cistern upon the bell of a small gasholder which is similarly affected by the changes of inlet pressure. The arrangement, however, is not perfect where these changes are extreme, and the application of the system is therefore somewhat limited.

APPENDIX.

Samuel Cutler, Junr., Partner in the firm of Messrs. S. Cutler and Sons, Contracting Gas Engineers, Millwall, London, was educated at Clifton College and the Technical University, Mittweida, Germany. As a member of a firm that has a world-wide reputation in gasworks construction he is well known in English and Continental gas circles. He has given especial attention to the development of the Carburetted Water Gas industry, and in this connection has visited many of the principal gasworks in the United States and Canada.

APPENDIX.

Carburetted Water Gas.

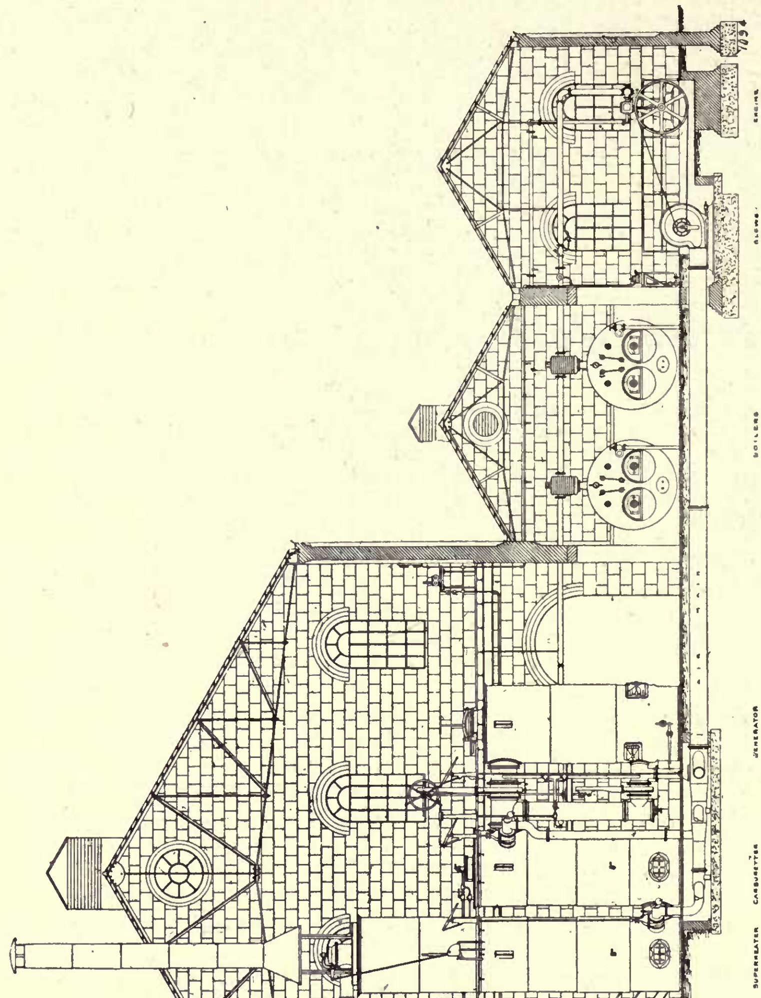
CARBURETTED water gas is now manufactured at over 60 important gasworks in the United Kingdom, and the number of installations is rapidly increasing. Plants are at work or under construction capable of producing over 100 million cubic feet of gas per diem, a quantity equal to two-thirds of London's maximum daily consumption, and four times greater than is required to supply the whole of Manchester. Yet, so recently as ten years ago, no gas of this kind was produced in England, and the purpose of the present article is to briefly describe the method of its production, and to refer to some of the more salient points which have contributed to its rapid progress and general success.

In most towns and districts of the United Kingdom the supply of illuminating gas is a monopoly granted by Parliament to statutory companies, corporations, or local authorities, each having a prescribed district to supply with gas of a specified illuminating power at a stipulated price. The nature of the gas to be furnished is not usually further defined, but until recently coal gas was almost invariably supplied.

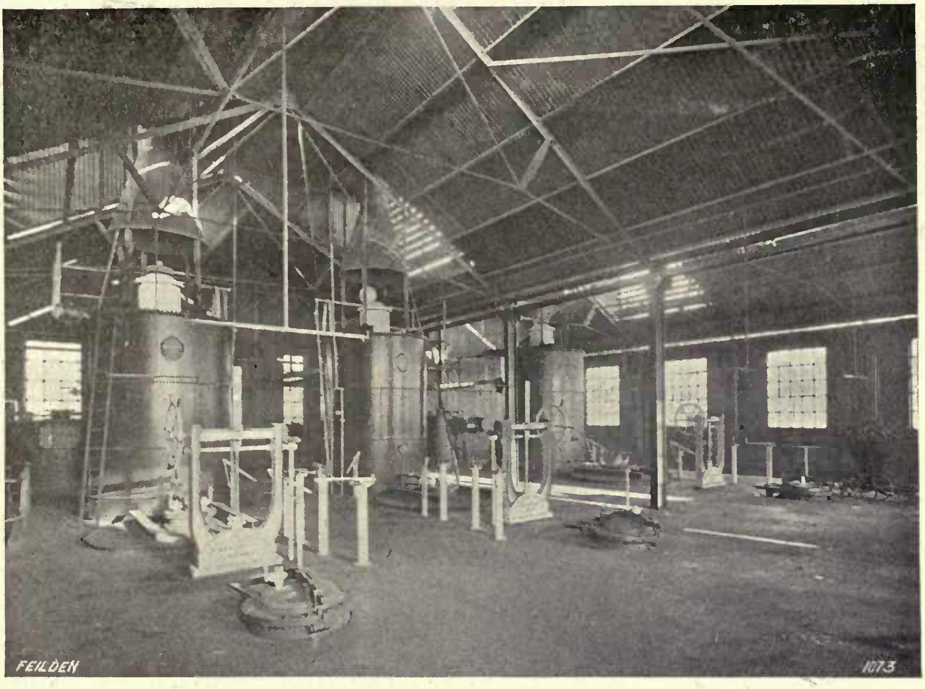
Coal gas, as is generally known, is the volatile product of the destructive distillation of bituminous coal in closed retorts, and its luminosity is derived from the hydro-carbons present in the coal. Carburetted water gas, as its name implies, is "water-gas" carburetted or enriched with extraneous hydro-carbons, usually derived from petroleum distillates.

Water gas is made by passing superheated steam through incandescent carbon; it consists of about equal volumes of hydrogen and carbon monoxide, and is a combustible non-luminous gas. It is carburetted by the admixture of gasified petroleum, which imparts to it the required degree of luminosity, and the combined gases are then passed through heated fire-brick chambers termed "fixers" or "super-heaters" to give permanence and uniformity to their illuminating power. The whole operation is carried out in closed vessels, and is rapid and convenient.

An important feature of the process is the few operatives required, compared with the number necessary in coal-gas production, and the comparatively light and cleanly nature of the duties to be performed. Perhaps the best proof of this is the fact that where such plants have been installed the coal-gas operatives



A MODERN CARBURETTED WATERGAS PLANT.



THE OPERATING FLOOR AT SOUTHALL.

are generally anxious to be transferred to the water gas staff.

Carburetted water gas has had a long and chequered history. Its potentialities were early recognised by English gas engineers, but the impossibility of securing a suitable carburetting material long delayed its successful utilisation. Many enrichers were tried, but the difficulty was never really surmounted until the discovery of petroleum oils—which are particularly suitable for the purpose, being rich in the required hydro-carbons, volatile and readily convertible into a permanent gas. The petroleum supply is now drawn from an area wide enough to afford reasonable security that oil of a sufficiently uniform character will be continuously obtainable at reasonable prices.

To chronicle even briefly the names and methods of all the early investigators is not possible within the limits of the present article, but the patent of John and Thomas Kirkham in 1854 deserves especial notice as introducing the vertical or "cupola" form of generator now almost exclusively adopted; also mention should be made of the useful and exhaustive experimental work of Robert Paulson Spice some twenty years later.

The historical side of the question is interesting reading, and an excellent review of the earlier processes will be found in "The Chemistry of Illuminating Gas" by Norton Humphreys, a gentleman whose writings are familiar on both sides of the Atlantic.

In the United States the advantage of utilising petroleum for gas-making purposes was early recognised, and numerous types of apparatus were devised and tried with varying success. Many of these are now entirely obsolete, the "survival of the fittest" being represented by the "Lowe" plant, which is now almost exclusively adopted as being the most economical, efficient, and convenient.

The "Lowe" type of plant largely predominates in England, and was first introduced here by the Gas Light and Coke Company, of London, on the recommendation of their Engineer, Mr. G. C. Trewby, who had inspected the various systems available. Some parts of this first plant were imported from America, and others were constructed by Messrs. S. Cutler & Sons.

GROUND FLOOR VIEW OF SOUTHALL PLANT.

The illustration opposite shows a sectional view of the generating vessels of a Carburetted Water Gas Plant. The exterior casings are of steel, and have a diameter of from 4 ft. to 10 ft., according to the output of gas required.

The first vessel, or generator, is lined with a special description of firebrick to withstand very high temperatures and contains the coke fuel bed, usually 5 ft. to 6 ft. deep. It is provided with a charging door from the renewal of fuel, clinkering doors, and ash hopper.

The second vessel, or carburetter, is also lined with fire-brick and has its interior stacked with small rectangular fire blocks placed checker fashion to form narrow conduits, through which the gases pass in close contact with the heated surfaces. The carburetting oil is admitted at the top of this vessel in the form of a fine spray, and becomes vaporised by contact with the heated checker blocks.

The third vessel, or superheater, is lined and stacked in a similar way to the carburetter, and has at its upper extremity a stack valve, by means of which communication can be made with the chimney. Each of these three vessels has an air inlet with a regulating valve, and is supplied from a general air blast main, in which a pressure of 10 in. to 12 in.

water column is maintained by means of a high-speed fan.

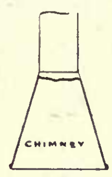
Sight glasses are fixed at various points to allow the operator to observe the interior condition of the hot vessels as occasion requires, and a battery of pressure gauges indicates the gas, air, steam, and oil pressures at all times.

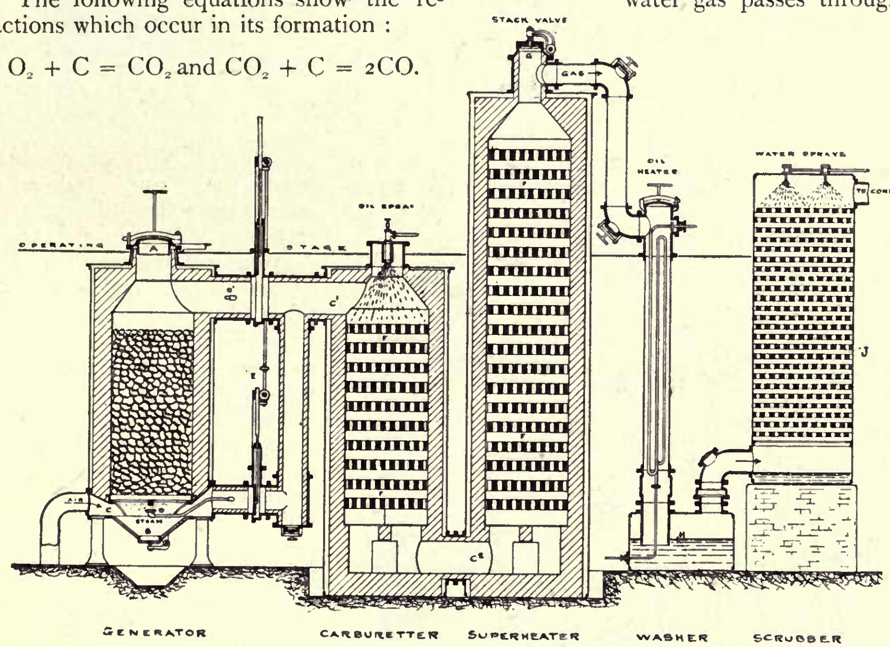
In the operation of gas-making the primary air is admitted at the bottom of the generator for a period of three or four minutes, during which time the fuel is raised to a high state of incandescence, and large volumes of producer gas are formed. The gas consists chiefly of nitrogen and carbon monoxide, the nitrogen is derived from the primary air, the oxygen of which combines with the carbon of the fuel in such a manner that 25 to 30 per cent. of the ultimate product is almost wholly carbon monoxide.

The following equations show the reactions which occur in its formation :

$$O_2 + C = CO_2 \text{ and } CO_2 + C = 2CO.$$

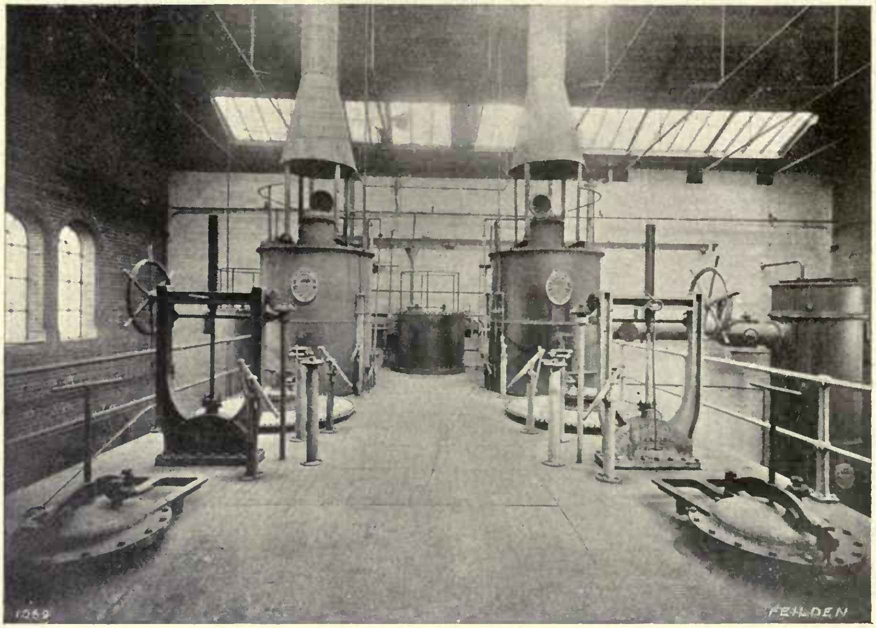
This producer gas passes into the succeeding vessels, where, by the admission of secondary air, it is burnt, the heat being absorbed by the fire-brick checker work, which has to be maintained at a bright cherry red. The stack valve on the superheater is meanwhile open, and the products of combustion pass into the chimney. At the end of this operation, termed the "blow," the coke fuel in the generator should have attained a temperature of over 2,000 degrees Fahr., and therefore be in condition for making water gas. The air valves are accordingly closed, and steam at a pressure of 100 lbs. per square inch is admitted below the heated fuel, the stack valve is closed, oil is sprayed into the carburetter, and the resulting carburetted water gas passes through the





SECTION OF A CARBURETTED WATER GAS PLANT.

A Fuel charging door on generator.
B Ash door on generator.
C Air blast supply to generator.
*C*¹ Do. do. carburetter.
*C*² Do. do. superheater.
D Steam inlet for up runs.
*D*¹ Do. down runs.
E Coupled reversing valves for up and down runs.
F Checker fire-bricks in carburetter and superheater.
G Stack valve operated from stage by lever.
H Water sea to prevent gas returning when stack valve is open.
J Wood grids in scrubber.

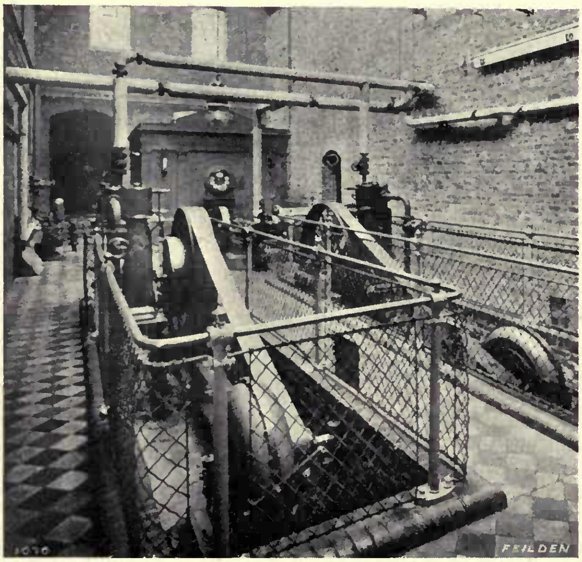


THE OPERATING FLOOR AT FOLKESTONE.

duct at the head of the superheater into the wash box, and thence to the purifying vessels and gasholders. This gas-making period is termed the "run," and lasts six or seven minutes, at the end of which time the temperature of the fuel in the generator will be decreased several hundred degrees. The "run" is then "taken off" and succeeded by the "blow" as before, and this alternation proceeds continuously, except for a short interval every six or eight hours, when any accumulation of clinker is removed from the bottom of the generator fire. The action of the steam on the carbon of the incandescent fuel is shown by the following equation:

$$C + H_2O = CO + H_2$$

The product of the action consists, therefore, of equal volumes of carbon monoxide and hydrogen, and this mixture constitutes the water gas, which is enriched with oil



THE ENGINE ROOM AT HARROW.

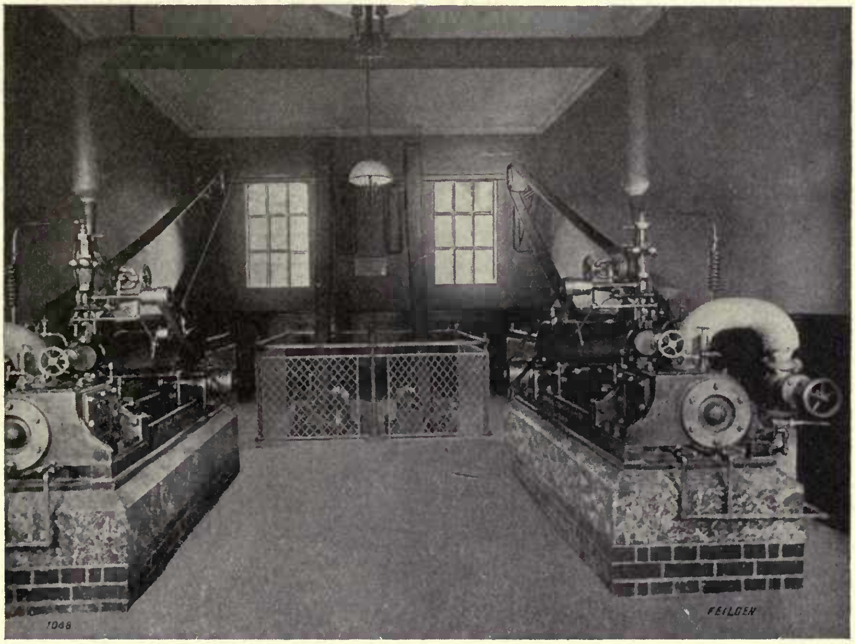
vapours in the carburetter, as already described.

The fuel is charged into the generator by means of hopper wagons at regular intervals, and hot coke direct from the coal gas retorts may be used with advantage. The intermittent nature of the process renders it important that the operator should be punctual and alert, but in a well-designed plant the various valves are adjacent and easy to manipulate, and the change over from "blow" to "run," or *vice versâ*, is accomplished in a few seconds.

It is most essential that dry high-pressure steam and a hot generator should always be maintained, as with too low a temperature in the generators the carbon consumed is not wholly converted into carbon monoxide, but forms some carbonic acid, until a point is reached at which carbonic acid is formed to the entire exclusion of carbon monoxide, as shown by the equation:

$$C + 2H_2O = CO_2 + 2H_2$$

As carbonic acid is an incombustible gas which reduces the temperature and luminosity of the flames of other gases when mixed with them, it is most desirable to restrict the formation of this impurity, and, although it cannot be wholly avoided, the proportion made should not exceed 3 or 4 per cent. This may afterwards be removed by passing the gas through lime, or its depreciative effect may be compensated for by the use of a little additional carburetting material.



ENGINE ROOM AT HORSHAM.

The temperature necessary in the carburetter and superheater for volatilising and fixing the oil is much less than that required in the generator, and variations are sometimes desirable to suit particular descriptions of oil; but such adjustment may be made with ease and precision by suitably regulating the supply of secondary air. Too great a heat produces lamp-black, and too low a heat an undue proportion of tar. The object of the operator should be to avoid both extremes and to produce neither lamp-black nor an excess of tar. It is of course impossible in any process in which mineral oils or coal are gasified to avoid the production of a certain amount of tar owing to the difference in chemical composition of the gas and the oil or tar, but in carburetted water gas manufacture the ready means that exist of controlling the temperatures make it possible to reduce this residual to a minimum.

The absence of residuals is a striking feature of the carburetted water gas process, there being only a small quantity of ash or oil tar in this category, while in coal gas manufacture the residuals amount to some 70 per cent. of the weight of coal used and include items of fluctuating and uncertain value.

The following analyses of gas and tar produced in plants erected by the writer's firm were recently made by Mr. W. Atkinson Butterfield. The proportion of the various constituents will vary according to the illuminating power of the gas, which in this case was about 23 candle-power.

Mean Composition of Unpurified Carburetted Water Gas taken from one of Messrs. Cutler's Plants, January, 1900.

	Percentage of volume.
Hydrogen (H_2)	37·60
Carbonic Oxide (CO) (Carbon monoxide)	32·50
Marsh gas (CH_4) (Methane)	11·60
Illuminating Hydrocarbons (C_nH_m) (chiefly ethylene and benzene) ...	10·00
Nitrogen (N_2)	4·52
Carbonic Acid (CO_2), (Carbon dioxide)	3·67
Sulphuretted Hydrogen (SH_2) (=72 grains per 100 cubic feet of gas)...	0·115
Oxygen (O_2)	trace
	100·00

The proportion of sulphur impurities present in the crude carburetted water gas will vary somewhat, according to the description of coke and oil used in its manufacture; but the percentage is invariably far below what is present in ordinary coal gas, and purification is therefore more cheaply and simply effected.

Composition of Separated Tar from one of Messrs. Cutler's Plants, April, 1899.

The specific gravity of the tar at 60 degrees Fahr. was 1 089, and on distillation it yielded the following products:

	Specific gravity.	Percentage by weight.
Light oils collected between 171° and 338° Fahr. ...	0·8905	5·72
Middle oils collected between 338° and 518° Fahr. ...	0·9920	27·30
Heavy oils collected between 518° and 662° Fahr. ...	1·0620	28·28
Pitch...	1·2750	33·88
Water	1·0000	4·82
		100·00

Tests of some average Carburetting Oils as used in various Plants erected by Messrs. Cutler & Sons.

	Sample 1.	Sample 2.	Sample 3.
Specific gravity at 60° Fah.	·8720	·8767	·8657
Flash point by close test	233° F.	216° F.	196° F.
Temperature at which distillation began to proceed freely	480° F.	446° F.	410° F.
Percentage, by volume, of the oil distilled below 662° Fah.	81	93	87
Temperature at which distillation entirely ceased	735° F.	707° F.	707° F.
Percentage, by weight, of solid residue left after distillation	0·450	0·190	0·230
Percentage of water, by weight...	0·100	none	none

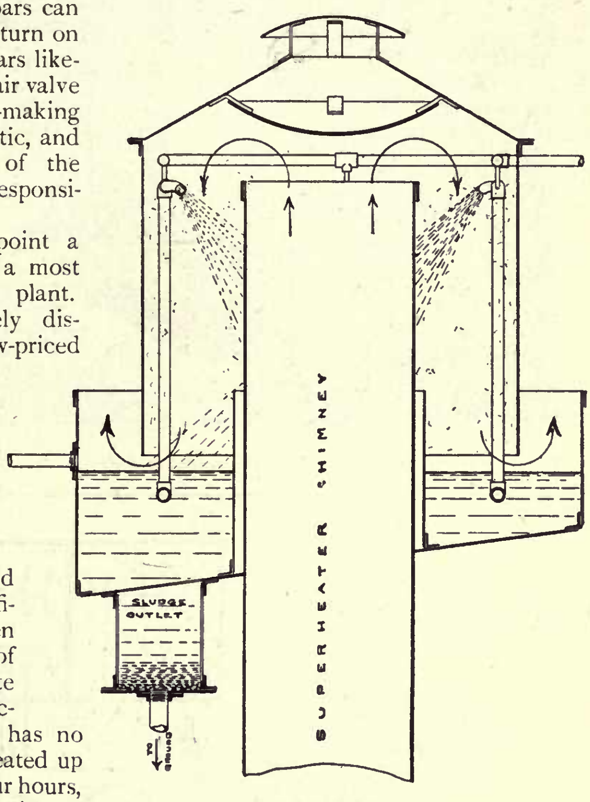
It is important to effectually isolate the air mains from the gas producers during the gas-making periods, so as to avoid the formation of explosive mixtures, and to this end the writer's firm interlock the steam and air valves so that they cannot be wrongly manipulated. Normally, during gas-making all the air valves are closed, but if in an uninterlocked plant the operator inadvertently opens one of these valves before turning off the steam, the gas will probably enter the air main and may form an explosive mixture, which, if fired from the hot vessels, will cause damage. This is a matter well known to users of water gas apparatus, but apart from plants erected by the writer's firm interlocking is rare. The system adopted by Messrs. Cutler, and applied to all their plants, consists primarily of a series of cottar bars (carried on friction rollers under the operating floor), which are projected into slots in the air valve spindles by the action of turning on the steam to the generator. Thus, until all the air valves are closed, and the cottar bars can enter the slots, it is impossible to turn on steam and make gas, and the cottars likewise prevent the opening of any air valve until steam is turned off and gas-making has ceased. The gear is automatic, and does not increase the work of the operator, while it relieves him of responsibility.

From a gas manager's standpoint a carburetted water gas plant is a most useful auxiliary to a coal gas plant. Expensive cannel coal is entirely dispensed with, and variable and low-priced coals can be used, the quality of the gas being readily adjusted by the use of more or less oil in the carburetted water gas. The price and stock of coke become controllable, a portion being used profitably in the manufacture of water gas, and the remainder sold at enhanced prices. Labour difficulties are decreased, as fewer men are required, and any workman of ordinary intelligence can operate the plant after a few days' instruction. As an emergency plant it has no equal, for a set of vessels can be heated up and put to full work in three or four hours, and can be let down again without deterioration—a quite impossible condition for any description of coal gas producer.

This facility of production reduces the necessity for the large storage otherwise imperative in districts subject to sudden demands, and the insignificance of this will be apparent when it is stated that 25,000*l*. is by no means an unusual figure for a storage holder and tank suitable for a large industrial town.

Although the original introduction of carburetted water gas into England was due in a large degree to the difficulty of obtaining cannel coal at a reasonable price, its many merits, other than that of an enricher, are now appreciated, and less surprise is felt that 70 per cent. of the whole of the gas output of the United States is produced by this process.

There are but few points in carburetted

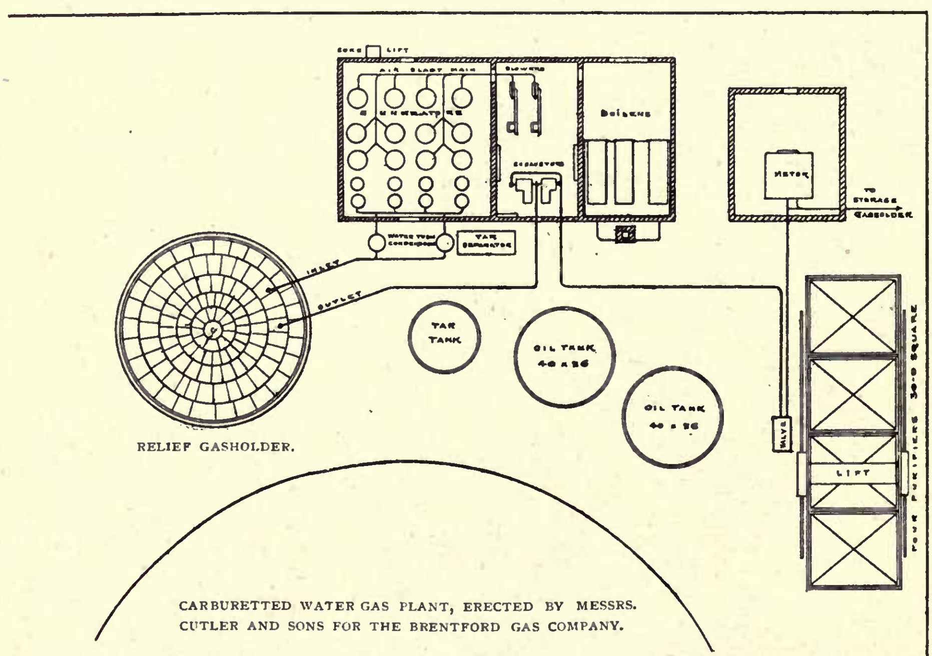


DUST INTERCEPTOR.
(CUTLER'S PATENT.)

water-gas manufacture that can cause nuisance or difficulty, but one or two matters should be mentioned in this connection. During the "blow" fine coke dust is frequently carried through the vessels with the air blast, and is liable to deposit upon surrounding property. In a large or isolated works this is of no importance, but under some circumstances it may cause nuisance. A case

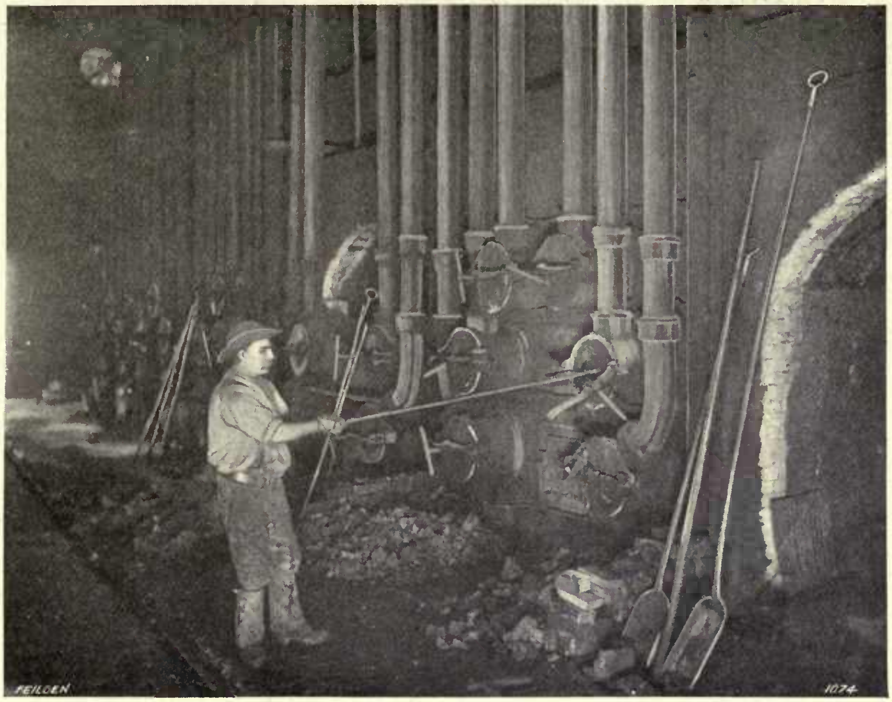
THE GENERATING PLANT AT FOLKESTONE.

of this kind arose in connection with a large plant erected by the writer's firm in a provincial town and caused some temporary concern, but the difficulty was entirely overcome by adding dust interceptors of the design shown on p. 77 to the superheater chimneys, and similar ones have since been fitted with every success at other places. The dust is precipitated by means of a series of water or steam sprays, and forms a sludge which is readily withdrawn at ground level through suitable connections. Another matter that has engaged a good deal of attention is the separation of water from the residual tar; the small difference in their specific gravities renders the operation more difficult than is the case with the heavier coal gas tar, but



CARBURETTED WATER GAS PLANT, ERECTED BY MESSRS. CUTLER AND SONS FOR THE BRENTFORD GAS COMPANY.

The above illustration shows the whole of the apparatus necessary for the production and purification of Carburetted Water Gas. The gas passes through the various vessels in the following order:—producers, carburetters, superheaters, washers, scrubbers, condensers, relief gasholder, exhausters, purifiers, meter, storage gasholder. The relief gasholder is interposed between the condensers and exhausters to temporarily store the varying and intermittent volume of gas discharged from the producers and deliver it in constant quantity to the exhausting and purifying plant.

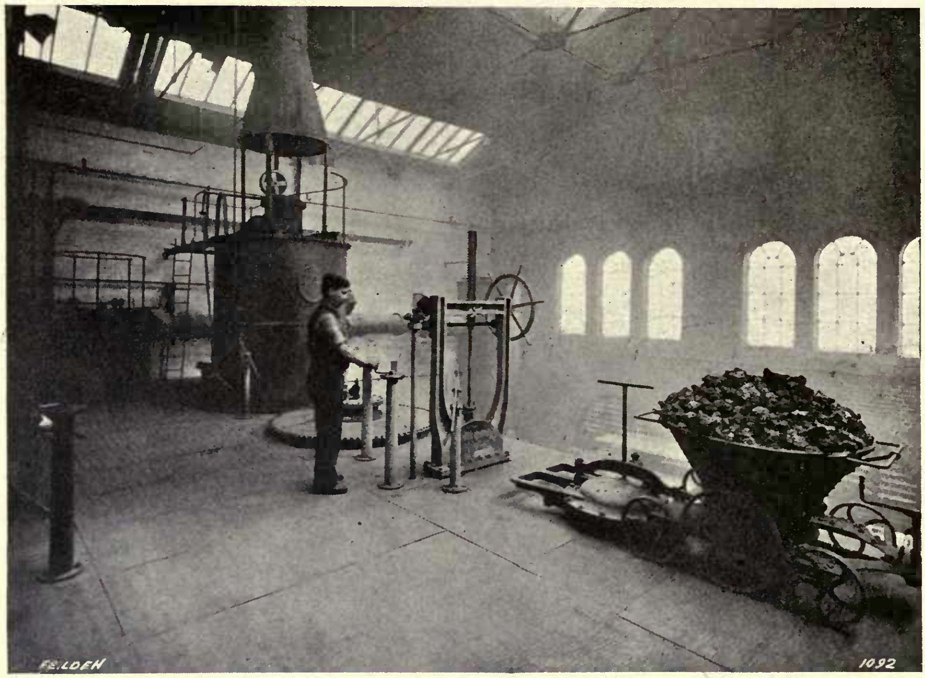


"THE OLD."

there is nothing insuperable about it if a suitable separator is provided.

The last, and in some respects the most important aspect of the carburetted water gas question is the composition of the gas and its suitability for the various purposes to which illuminating gas is now applied. Water gas *per se* obtained considerable notoriety in the eighties in consequence of the proceedings of certain well-advertised companies, and it is probable that the public do not appreciate the great difference between the gas then exploited and the illuminant which is now under consideration. It may, therefore, be well to explain that the water gas of these companies was uncarburetted, inodorous, and non-luminous, and when used for lighting purposes it had to be burnt under magnesium or other mantles, whereas the carburetted water gas of the present day is as luminous and odorous as ordinary coal gas. The important point of difference between carburetted water gas and coal gas is only perceptible by analysis, and consists in the former containing a much larger proportion of carbon monoxide than the latter, the proportion being about 4 to 1.

On the initiative of some prominent medical men, the Home Office, early in 1898, appointed a Departmental Committee to investigate the probable effects of an extended use of carburetted water gas, and a good deal of expert evidence was collected. The Committee recognised the utility of the process, especially for emergencies, but reported in favour of a somewhat stringent limitation of the percentage allowed to be supplied for illuminating purposes. No legislation has yet ensued. The American system of supplying undiluted water gas is, however, not likely to be followed in England, as it is necessary to make at least 25 per cent. of coal gas to produce the coke



"THE NEW."

required to make the remaining 75 per cent. of carburetted water gas. Also, as coke is a marketable commodity that helps to swell the revenue of gas concerns, the output is not likely to be reduced to the extent of leaving no saleable surplus. In this respect, English practice will naturally diverge from American, as in the United States anthracite coal is abundant, and is used for most purposes to which gas coke is applied in England. A natural limitation therefore exists, and taking all these matters into consideration it is unlikely that English gas companies will desire to make any excessive use of carburetted water gas, as they will find their interests best served by using a moderate proportion. The fact that Corporations such as Birmingham, Manchester, Halifax, and Leicester, and many other elective representative bodies have adopted the process, and have in several instances extended their initial installations, should prove that it brings advantages to both producer and consumer.

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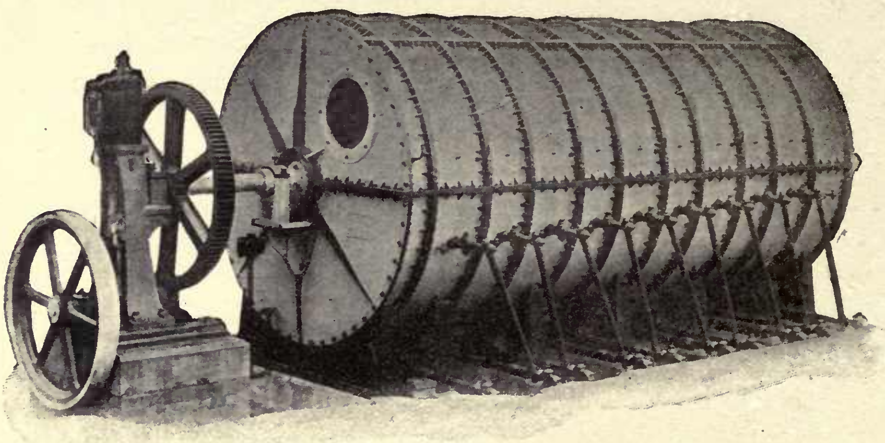

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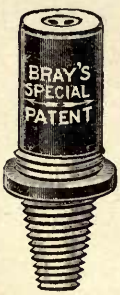

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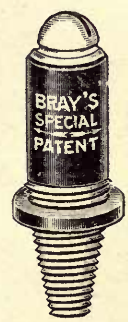

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