Description of the process of manufacturing coal gas

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Part IV.

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Form and dimensions of the Retorts originally employed for manufacturing Coal Gas.

The proper mode of constructing the retorts in which the coal is distilled, and the art of applying them form an object of primary importance in every gas-light establishment. According as the manufacture is conducted in these respects with a due regard to physical principles, depends the quantity of gas which can be obtained in any given time, from any given quantity of coal, the consumption of fuel requisite for the production of that quantity of gas, the degree of deterioration to which the distillatory vessel is subjected, the quality in some measure, of the gas itself; and, as the ultimate result of all these circumstances, the cheapness at which the gas light can be furnished to the consumer.

The essential influence of these various particulars on the value of the art of lighting with coal gas, has led to much assiduous enquiry to ascertain that sort of construction and mode of operation in respect to each of them which may be most advantageous. And in no branch of the new art of procuring light, has a greater variety of plans of improvement been submitted to the several directing boards of gas works, or more labour and expence been incurred in experiments conducted on a large scale, to ascertain the relative merits of these plans. Nor is there any part of the gas-light process in which a greater number of material alterations have been put in practice.

In the earlier periods of lighting with coal gas the retorts employed at some of the gas-light establishments in the metropolis, were hollow cast-iron cones from six to seven feet in length. The greatest diameter of the cone which formed the mouth of the retort, measured from twelve to fifteen inches, and its smallest diameter at the vertex from nine to ten inches.

At other gas works the form of the retort was a parallelopiped from six to seven feet long, the

horizontal, and vertical sides were respectively to each other, as 20 to 15 inches. The angles of these retorts were slightly rounded. Fig. 16, plate V. exhibits a vertical section of this retort.

Again at other establishments semi-cylindrical retorts, placed horizontally upon their flat surfaces were employed; fig. 18. pl. V. The length of these retorts was from five to six feet, and their vertical and horizontal diameters were to each other as 6 inches, to 18 inches. And at a few establishments, ellipsoidal retorts, fig. 17, plate V. were used; these measured from five feet and a half, to six feet in length, their major and minor axes bore different proportions to each other at different establishments. At the first adoption of these retorts, the proportions varied but little from the cylinder, but subsequently the difference between the major and minor axes became gradually increased till at last the major axis has become to the minor axis, as 20 to 10 inches, and at some gas works the proportions are as 25 to 10 inches.

With vessels of these forms the distillatory process was carried on for some years, and the quantity of fuel employed to decompose a given quantity of

coal by means of them, amounted to from thirty to thirty-six per cent.

When the dimensions of the retorts were increased, both the quantity of fuel and time required for the decomposition of a given quantity of coal was in a far greater ratio; and the operations of charging and discharging the retorts, very troublesome.

Retorts of smaller dimensions have likewise been tried, but the more frequent charging and discharging, which they require, occasioned such a waste of time and labour, and such intermissions, in the temperature necessary for the process of distillation, (besides being attended with other disadvantages which will be afterwards explained), that they were speedily discontinued at the gas works where they had been adopted.

The use of conical retorts, as well as of those of a semi-cylindrical and parallelopipedal form, has of late been discontinued in most establishments. The conical shape not only diminishes the capacity of the vessel, but also renders it incapable of being heated economically.

From two comparative series of operations

made on a large scale, and continued for upwards of six months with conical and cylindrical retorts, with a view to determine the comparative power of these vessels, it has been proved that the same quantity of gas which can be obtained by means of forty conical retorts, may be procured in the same time and with the same quantity of coal and fuel, by means of thirty-four cylindrical retorts.*

Similar experiments have been undertaken, to determine the comparative action of semi-cylindrical and parallelopipedal retorts.† The latter, when kept in action day and night, do not long retain their shape; their sides collapse, their capacity becomes diminished, their angular form causes the heat to act upon them unequally, in whatever manner it may be applied, in consequence of which they suffer more deterioration in some parts than in others. Besides, they require a much larger proportion of fuel for decomposing

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* These Experiments were made at the commencement of the new art of lighting with gas, at the Westminster Chartered Gas Works, by Messrs. Grant and Hargraves.

† At the Birmingham Gas Works.

a certain quantity of coal than the cylindrical retorts.

Semi-cylindrical retorts, with the base of the retort bent inwards, so as to give the vessel a kidney-shaped form, have likewise been tried. But this shape is still less advantageous ; they could not be made to work uniform, they required more heat, and their deterioration was more rapid than cyiindrical retorts. They could not be kept fit for use when worked day and night, more than about five months. And with regard to ellipsoidal retorts, it must be confessed, that the experiments that have as yet been made upon a large scale to ascertain their powers, are not of a nature to enable us to decide on their merits. No experiments have been carried on with retorts of this description in the metropolis for a sufficient length of time, with that care and attention which the subject demands, to ascertain their comparative power. From what however has been done, there is reason to believe that ellipsoidal retorts, might be found more advantageous, than those of a cylindrical form now in use. An ellipsoidal retort, 20 inches by 10 in diameter, and six feet long, weighs 14 Cwt.

The reader will thus observe, that of all the forms of retorts which have been hitherto fairly tried, upon a large scale, it has been satisfactorily ascertained, (excepting only as to the ellipsoidal retorts), that the cylinder is the best form for decomposing coal in masses, from five to eight or ten inches in thickness.

It is perhaps needless to state that in making experiments on the comparative value of the best form of cast-iron retorts, it is obvious that the operations should be continued for some months uninterruptedly; no conclusion can be drawn that may become practically useful in the large way, from processes carried on for a few weeks only. It is absolutely essential that the comparative trials be continued for months together, and that the inferences be taken from the total quantity of coal used during that period, compared with the total quantity of gas obtained, the deterioration of the retorts, and the time and labour expended.

Proceeding on erroneous data, many have persuaded themselves of having noticed that parallelopipedal and semi-cylindrical retorts last

longer fit for use than those of a cylindrical shape, an assertion of which subsequent trials, conducted in the manner just stated, has clearly shown the fallacy. Enough has been done at the different gas works in the capital to settle this point, and there is now but one opinion amongst those who are best qualified to judge of the subject. Every body who has made the trial on a large scale, is convinced as already stated, that the best form of the retort for manufacturing coal gas where the process is conducted on the plan of decomposing coal in masses or layers of from four to eight inches in thickness, is a cylinder six and a half feet long, and one foot in diameter, and accordingly retorts of this shape and dimensions are now used in all the best regulated gas establishments in the metropolis.

A cylindrical retort of the description before named, weighs about nine and a half to ten hundred weight. These and all other shaped retorts are furnished with a moveable lid or cover having a conical edge to fit the mouth-piece ; the cover is rendered air-tight, not as formerly by grinding,

a mode which was costly, but by the interposition of a thin coat of loom, between the lid and the mouth of the retort.

The mouth-piece forms a separate part of the retort. It is bolted and screwed to a flanch which terminates the mouth of the retort, so that when the retort is worn out, the mouth-piece may be detached and applied to new retorts.

There are now in action 620 cylindrical retorts, at the two chartered Gas Works* in the metropolis; and the total number of retorts at all the London gas establishments amounts to 960.

Application of heat.—Flue Plan originally adopted.

It must be obvious that the durability of the distillatory apparatus, greatly depends on the manner in which the heat is applied, to effect the decomposition of the coal contained within the

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* Westminster Gas Works,	Westminster Station -	250 Retorts.
	Brick Lane ditto - -	190 ditto
	Norton Falgate ditto -	50 ditto
City of London Gas Works, -	Dorset Street, - - -	130 ditto
		620

retort. If the heat be very intense the whole vessel is rapidly destroyed. If it be too languid, the distillatory process is protracted, and much fuel, time, and labour wasted to no purpose; and the retort is speedily deteriorated, if the heat acts upon one part of it more than upon another.

The different kind of retorts of which a description has been given in the preceding pages, were originally heated by means of flues passing under and over them. The retorts were placed horizontally and fixed in brick-work. One fire-place at the extremity of the mouth of the retort where the coals are introduced, and whence the coke is withdrawn, was allotted to every two retorts in the series.

At the commencement of the new art of procuring light the quantity of fuel as before stated, necessary to decompose a given quantity of coal, amounted to from thirty to thirty-six per cent of the coal decomposed; that is to say, it required from thirty to thirty-six parts of fuel to decompose one hundred parts of coal. This quantity has been much lessened by a better mode of setting the retorts, and it is now the general opinion that

the operation of decomposing coal, by means of cylindrical, parallelopipedal, or semi-cylindrical retorts, must be considered as well conducted when one hundred parts of coal are decomposed by twenty or twenty-five parts of fuel. This appears to be the minimum quantity of fuel, that can be employed for the complete decomposition of coal by means of these retorts, and with the least deterioration of the distillatory vessel.

The following statement will exhibit what has been done in this branch of art.

Report on a course of Operations, made with sets of 66, *of* 30, *of* 116, *and of* 64 *retorts, worked on the Flue Plan.*

In order to determine the relative value of the best method of setting cast-iron retorts, it was deemed necessary to ascertain whether three retorts might not be heated, instead of two, as before stated, by one fire-place and branching flues. To determine this the following processes were carried into effect.

Process I.

Sixty-six cast-iron cylindrical retorts, of the usual size, namely, six and a half feet long, (exclusive of the mouth-piece) and one foot in diameter, internal dimensions, where set on the plan of three retorts to one fire-place, at the Westminster gas-work station, and a series of 30 similar retorts were erected at another station belonging to the same company, at the East end of London.

The experiments were pursued with every degree of justice in the detail, the retorts were kept in action day and night for upwards of four months, and the results noted down with exactness. The final reports from the two establishments were found to concur in showing that nothing was to be gained by this method over that previously in use.

The time occupied for the distillatory process was not abridged. The consumption of fuel was greater—no larger quantity of gas was obtained from the quantity of coal carbonized. The produce with regard to coke was in the usual ratio, and the retorts were destroyed in about one third less time than when only two were heated by one fire-place.

Process II.

The apparently conclusive results of these experiments did not, however, prevent another set of experiments from being made on the same principle, extended even a degree farther. The problem now proposed to be solved, was, whether four retorts might not be heated with economy, in a manner which had been found already wasteful with respect to three, that is, whether four instead of two retorts might not be heated economically by means of one fire-place.

On this plan one hundred and sixteen cylindrical retorts of the usual dimensions were again erected at the Westminster gas establishment, and sixty-four at another station belonging to the same chartered company. These retorts were kept in action in the best possible manner night and day, and the results, as might have been anticipated, only served to confirm the facts already established by experiment with three retorts.

Nothing was found to be gained; and so far from their being any saving in respect of fuel and wear and tear of the retorts, the waste beyond that which takes place on the plan of two retorts to one

fire-place, was increased to nearly twenty-five per cent., accompanied by a corresponding acceleration of injury to the retorts.

It was still imagined, however, that the great waste of fuel and the ultimate unfavourable result of these proceedings, which were repeated with as little success at several other gas-works in the metropolis with parallelopipedal retorts, and at other works with retorts of a semi-cylindrical form, set in a way different from that pursued at the Westminster station, might probably have been owing to the unavoidable circumstance, that the heat was not made to act upon all the retorts employed uniformly in each series of four retorts, but in a manner so variable that one, or even two of the series would become destroyed and rendered useless, while the others continued uninjured in a sound and working state.

The excessive waste of fuel was occasioned, we are told, by the number of injured retorts, which became useless, and were nevertheless required to be kept red hot to no purpose ; for it was actually found that when one retort of a series of four became injured, the same fire which had heated

the whole four, still required to be kept up to maintain in action the remaining three of the series, and so on with respect to the whole range, till ultimately when there might remain only eighty retorts actually in use, as many fire-places were required to be in full action as would have been sufficient to serve for one hundred retorts.

Attempts accordingly were now made to get over this supposed cause of the losing results, already obtained from the plan of four retorts to one fire-place, by a new series of similar operations, in which the retorts were fixed in such a manner, that those which happened to become injured during the process, might easily and immediately be withdrawn without materially disturbing the rest, and replaced by new ones. The waste of fuel was, it is clear, greatly lessened by the expedient; yet still upon the whole there was no such variation from the general results obtained by the preceding experiments, as to justify the adoption of this plan of increasing the number of retorts worked by one fire-place, on any principle of sound economy.

The great obstacle, as the reader will at once perceive, to working more than two retorts,

no matter whether cylindrical, or of any of the other forms before named, with economy, by means of one fire-place, evidently arose from the difficulty of conducting the heat by means of flues around the series of retorts, in such a manner that the heat shall act with equal force on all the retorts.

It is almost needless to state, that the construction of the fire-places, and the direction of the flues for applying the heat to the retorts, were varied by different workmen, who prided themselves on being able to aid the object in view, but the result always showed even that when the draft of the fire-place was well obtained, the action of the heat upon the series of retorts could not be distributed equally and kept up uniformly, except at a great expence of fuel and vast deterioration of the distillatory vessels. The retorts always became injured more in some parts than in others. The concentration and rapidity of the draught of the fire, beyond a certain velocity was always found highly injurious to the retort, and this observation has been since amply confirmed.

In a well constructed furnace, the deterioration of all the retorts in the series is uniform over the

whole vessel; no part of the retort is *burnt out*, as the workmen call it, sooner than another part; and whenever the contrary happens, we may pronounce the fire to be badly applied. When there is such misapplication of the heat, the manufacturer cannot depend upon the duration of the distillatory vessel; he is always in a state of uncertainty with regard to their wear and tear, and it not unfrequently has happened, under such circumstances, that a whole series of retorts have become suddenly deteriorated.

Oven plan lately adopted.

The results before detailed, with regard to the mode of setting cylindrical retorts suggested the propriety of an entire change in the mode of applying the heat, and this was at length fully carried into effect by the adoption of ovens, or air furnaces, in which the retorts are equally exposed to the action of heat on all sides. Mr. Rackhouse has the merit of having first carried into effect this method, since generally known by the name of the *oven plan*.

The first experiments with these ovens were made on only one retort, exposed in an oven to air intensely heated ; but they were afterwards repeated on two, three, four, and five retorts, successively. The retorts suffered the action of heat thus applied, exceedingly well ; their deterioration was uniform, and the quantity of fuel required to work them, was found always to be in a direct ratio to the number of retorts employed. These experiments were carried on for upwards of nine months, and it was found, that with five retorts in one oven, so that the heated air could act upon all of them equally, without the flame being directed forcibly upon them, this plan had a decided advantage, in point of economy, over every other method previously adopted. Each oven, containing five retorts, is heated by means of three fire-places, and although it is true that the number of retorts is less by one, than what could have been heated by three fire-places, on the original plan of two retorts to one fire, yet still this method has been found to be far more productive. The front wall of the oven may be readily taken down so that a retort, when damaged,

may be withdrawn, and replaced without materially disturbing the rest.

The oven plan of applying heat has been found equally advantageous for parallelopipedal and semi-cylindrical retorts.*

Description of the Retort Oven.

Fig. 1, plate IV., represents a transverse section of one of the retort ovens now in action at the Westminster Chartered Gas-Light Company's Works; similar ovens are likewise in use at the City of London Chartered Gas-Light Works, and in many other provincial gas establishments.

Fig. 2, plate IV., exhibits a longitudinal section, and fig. 1, plate V. shows the front elevation of the oven, built about ten feet above the ground, upon

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* The only gas-light establishment of great extent in the metropolis, at which parallelopipedal retorts are still in use, is the *South London Gas Works*. But it is solely owing to the very peculiar care and economy with which all the details of this establishment are conducted, under the immediate superintendence of a few active, skilful and scientific proprietors, that they are able to compensate for the loss, which in all ordinary cases is inseparable from the employment of vessels of that description.

piers or arches, which saves brick-work and allows a stage or platform to be erected in front of the fire-places of the ovens. See fig. 2, plate IV.

Between the back part of the ovens and the wall of the building in which they are erected, is left an empty space of a few inches to prevent the heat of the oven being communicated to the wall, as is seen at Y in fig. 2, plate IV.

The whole interior of the oven, as well as the horizontal flue which pass underneath the crown of it, near the upper tier of retorts, is lined with fire bricks. The uppermost part or crown of the arch is constructed of large fire bricks of such a shape as will allow to flatten the upper part of the arch as much as possible, in order to contract the space between the two upper retorts and the crown of the arch of the oven.

R. R. fig. 1, and 2, plate IV. and fig. 1, plate V. are cylindrical retorts, placed horizontally in the oven, the lower series are either supported by a large fire-brick, placed edgeways underneath the retort, or by means of a stout wrought-iron pillar, as shown in the design. The two upper retorts are supported by wrought iron straps, T, T,

T, fig. 1, and T, fig. 2, plate IV. The straps pass through the brick-work of the upper part of the oven, as shown in the designs, and they are secured with screws and nuts to an iron bearing bar, the extremities of which are supported by the outer walls of the oven. Each retort is furnished at the extremity opposite to the mouth-piece, with a short projecting piece or tail let into the brick-work of the oven, as seen in the design, fig. 2, plate IV.

M. Fig. 2, plate IV. shows the mouth-piece of the retort with its cross bar and hand-screw ; and fig. 6, plate V. shows the mouth-piece drawn to a larger scale. E. is the hand-screw, with its cross or bearing bar D, which passes through the projecting arms C. C. The lid of the mouth-piece has a conical edge, so that it fits close when pushed into its place by means of the hand-screw E. Fig. 7, plate V. is the lid which closes the mouth-piece ; the handscrew E, fig. 6, presses the lid close, to render it air-tight, a thin stratum of loom luting being first applied to the orifice of the mouth-piece.

F. fig. 2, plate IV., is the fire-place, with the

ash-pit E of the oven. The door of the ash-pit is provided with three slits covered within by a register slide, to regulate the admission of air as occasion may require.

The fire passes freely and uniformly round all the retorts, and the whole cavity of the oven acquires an equable temperature, which it retains, if the workman takes care to admit as little air as possible, through the register door of the ash pit, when the upper part of the arch, or crown of the oven has acquired a bright cherry red heat.

We have stated already that in front of the oven is a platform, as represented in the sketch, fig. 2, plate IV. In the floor of this platform, and directly underneath the mouth-piece of the retorts, all of which project beyond the brick-work of the oven, is an opening covered with an iron trap door; through this door the red hot coke, discharged from the retorts, is suffered to fall below the stage or platform into a cellar, or other fire-proof place, that it may not annoy the workmen. O, O, fig. 1, plate V. denotes this opening through which the coke falls.

P, fig. 2, plate IV., and P. P. fig. 1, plate V. is a

pipe proceeding perpendicularly from the upper part of the mouth-piece of each retort, the other extremity of which descends into the horizontal hydraulic main H, which is shown in fig. 2, plate IV. and plate V., supported upon iron columns. This pipe serves to convey away the liquid and gaseous products which become disengaged from the coal in the retort during the distillatory process.

The liquid substances, namely the tar and ammoniacal fluid, collect in the hydraulic main H, plate IV. and V., which is furnished with a perpendicular diaphragm or partition plate to cause a certain quantity of the liquid deposited in it to accumulate to a certain height, and thus to seal the perpendicular pipe P. The liquid cannot flow out of the horizontal pipe H, till it rises to the level of the diaphragm. This arrangement is distinctly shewn at H. fig. 2, plate IV., where the diaphragm or partition plate is seen in the section of the hydraulic main, together with the extremity of the perpendicular pipe P., descending into the fluid contained in the hydraulic main.

K, Fig. 1, plate V. is the discharging pipe, con-

nected with the upper part of the horizontal main H : it serves to convey away the gaseous and liquid products from the hydraulic main H. By means of this pipe the tar and ammoniacal fluids are conveyed into any convenient reservoir, called the tar cistern, which is perfectly air-tight, and from this vessel the liquid may be drawn of by means of a pipe or stop-cock. The extremity of the pipe which communicates with the liquid, is bent downwards, so that no air can enter the vessel : this arrangement is shown at fig. 3, plate II.

It is essential that the condensation of the vaporous fluids should be fully completed before they reach the tar cistern. To effect this, there is usually allowed a considerable distance to intervene between the discharging pipe K, fig. 1, plate V., and the reservoir destined to receive the condensible products ; or the pipe is made to pass through a vessel containing water, called the condenser, which acts in a similar manner as the refrigeratory of a common still. It is obvious that it is immaterial how the condensation of the vaporous fluid is effected ; it is essential, however, that the condensation should be complete before the liquid tar and am-

moniacal fluid reach the reservoir destined to receive these products.

The gaseous fluid which accompanies the condensible products, are then made to pass into the lime machine, of which we shall speak hereafter, in order to be deprived by means of quick-lime and water, from the portion of sulphuretted hydrogen and carbonic acid gas which was combined with the gas. And when this has been accomplished, the purified gas is conveyed into the gas-holder, where it is stored up for use. This part of the operation will be rendered more obvious hereafter. In some establishments, the hydraulic main is furnished with two discharging pipes, the one carries away the condensible fluid, into which the perpendicular pipes P, fig. 2, plate IV. dip, whilst the other serves to convey away the gaseous fluids to a condensor, in order to deposit the vaporous portion of condensible liquid it may contain, and from thence the gas passes into the purifying apparatus, or lime machine. X, fig. 2, plate IV., is a small screw plug, which, when opened, restores the equilibrium of the air within and without the retort previous to the lid being taken off, to pre-

vent the loud report, which otherwise happens when the lid or cover of the retort is suddenly removed. To avoid these explosive reports which had become a nuisance to the neighbourhood of gas works, the practice of gradually withdrawing the lid of the retort, and at the same time presenting a lighted torch has been adopted at some works, which fully remedies the evil.

The number of retort ovens at the Westminster Chartered Gas Works' Stations, amounts to four hundred and ninety.