MODERN METHODS OF

SAVING LABOUR IN GASWORKS

C. E. BRACKENBURY, A.M.INST.C.E.

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BY

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PREFACE.

AT the time of writing there are not wanting signs of unrest and agitation in the ranks of gasworks labour, not only in England, but also in some Continental countries. Although the expiring year of the nineteenth century has not witnessed any widespread or general strike, there have been several isolated labour disturbances, many of which were organised by professional agitators, whose chief object, apparently, was to obtain official recognition for themselves and their Union. Apart from this also, there have been local conflicts, due, or nominally due, to the introduction and adoption at certain gasworks of some of the machinery which is mentioned in the following pages. It is not easy to understand the crass stupidity of such unreasonable outbursts on the part of gas-stokers, a class of men who are, and have been for years past in receipt of wages far in excess of those obtained by other unskilled, or semi-skilled workmen. Their work was admittedly, in some cases, physically onerous, and yet when mechanical ingenuity comes, in part, to their relief, they show their appreciation by refusing to work at all! This occurred, sometimes, even when the introduction of the particular machinery did not dispense with the services of a single man. Where the adoption of certain plant necessarily causes a reduction in the numbers employed, it may be that some instances of temporary individual hardship and grievance cannot be avoided. But the shortsightedness of withholding benefits from all because of the passing sufferings of the few is too obvious to be dwelt upon. Prosperity and progress are not developed on such lines. The well-being and comfort of the majority of the community must always be the deciding consideration and the goal to be attained. To this end, the duty of Capital is to be employed in the most beneficial and reproductive channels possible. To show, in a brief way and without undue technicality, what are some of the most important and remunerative of these channels in modern gasworks has been the object of the six articles contributed to the ENGINEERING TIMES, which are here collected together.

In these days, when fierce competition is found on all sides, when every effort is put forth by all industries toward improvement and economy, when enhanced prices have to be paid on raw material, when pretentious demands of workmen are frequent, and when other countries assail Great Britain's commercial position, it is surely time that all possible means should be sought and adopted in gasworks to ameliorate conditions, to increase production, to reduce cost, and to extend demand. The plants and appliances herein described will conduce to such results.

In conclusion, my thanks are due to many engineers, whose energies are being devoted, directly or indirectly, towards the attainment of these objects in the gas world, for the assistance they have so readily and so kindly afforded.

C. A. Brackenbury.

LONDON.
December, 1900.

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MODERN METHODS OF SAVING LABOUR IN GASWORKS.

CHAPTER I.

GENERAL.

IT is not unfitting in the closing year of the present century to call attention, in some particulars, to the principal developments which have taken place in an industry just one hundred years old. It may be interesting, as well as instructive, to glance from the first to the last year of the nineteenth century, and briefly to call to mind the birth, growth, and present stature of a business and art which has directly affected the prosperity and comfort of every individual, and in the management of which so many able men are engaged throughout the world.

The art of coal-gas manufacture was called into being by William Murdoch, the son of a millwright, who himself is entitled to remembrance as the designer of the first iron tooth gearing in England. It was while Murdoch, in 1792, was erecting engines at Redruth for Messrs. Boulton and Watt, of Birmingham, that he experimented with illuminating gas coming from coal, but it was about ten years later before any considerable application of gas lighting was carried out. The first installation was at the Soho Foundry, Birmingham, which to-day is still linked with the gas industry. During the next few years other factories in Lancashire, Yorkshire, and elsewhere adopted the new system of lighting, in spite of great prejudice, not only on the part of the general public, but also of eminent men of science. Sir Humphry Davy, for instance, ridiculed the idea of lighting a whole town by gas, and asked if it were intended to take the dome of St. Paul's Cathedral for a gasometer, as gasholders were then called. Architects insisted on gas pipes being put at a considerable distance from the walls to prevent fire, as it was firmly believed the pipes must be hot! A deputation from the Royal Society strongly recommended the Government to limit the size of gasholders to 6,000 cubic feet, and that they should be inclosed within buildings. Its members made a visit to the Peter Street Gasworks, Westminster, but remained unconvinced for the safety of gasholders, even after a workman had been ordered by the engineer to make a hole in one with a pickaxe, and light the issuing gas, with the natural result that it merely burnt away without any explosion occurring, as had been anticipated by the learned gentlemen. Thus there was a considerable amount of opposition to be overcome, as there is even to-day with any general innovation. The industry, however, grew, fostered by the care and ability of the inventor, and assisted by Winsor, Samuel Clegg, Dr. Henry, and many others. A Bill for the incorporation of the Chartered Gas Light and Coke Company, the forerunner of the present great London Company, was passed in 1810, after encountering various Parliamentary vicissitudes, which, curiously enough, seem to be the inherited misfortune of the descendant company to-day. Westminster Bridge was lighted by gas on the last day of the year 1813, and in the following year the parish of St. Margaret's, Westminster, obtained the distinction of being the first to have its streets so lighted. Provincial towns then commenced to build their gasworks, Bristol, Birmingham, and Chester being among the first. From that time to the present there has been a continual development, so that now there is hardly a small town or large village without its works. The annual consumption of coal for gas making has risen to 13,000,000 tons, the Gas Light and Coke Company, of London, alone using on the day of its largest make of gas no less than 12,000 tons. Gasworks coke to the amount of 9,000,000 tons is produced in the year, besides which there is an enormous quantity of lime and oxide of iron used for purifying purposes. Gasholders, from being small vessels but 30 ft. in diameter, have gradually increased in size, until we now have the South Metropolitan Gas Company's mammoth holder, at East Greenwich, 300 ft. in diameter, rising to a height of 180 ft., and containing 12,000,000 cubic feet of gas, while there are many gasholders in different parts of the country over 200 ft. in diameter, and 150 ft. high. The use of gas for motive purposes has largely increased with the cheapening of gas and the development of the gas-engine—from that of Lenoir in 1860 to the perfected "Otto" engines made by Messrs. Crossley Brothers, of Manchester, and the enormous engines up to 1,500 h.-p. made by the Westinghouse Electric and Manufacturing Company. Gas stoves of all kinds have become of domestic utility, and this comparatively recent branch industry is no doubt destined to make further strides. It will easily be understood that such growth, in all directions, as has been indicated, has carried in its train many new methods of procedure in the manufacture of coal-gas, and that, in consequence, the ever-increasing quantities of coal and coke and other materials to be dealt with have necessitated the improving of old ideas and the introduction of new ones.

Now, what where the old lines upon which a gasworks of average size was conducted but a few years ago? It may be that there was no railway communication into the works, so that the coal was brought in by carts. On entering the gasworks, it would be weighed and taken to the coal store, from which, as required, it would be brought in the stokers' barrows to the retort house. Here it would be thrown by shovels into the retorts, and after proper carbonisation, the residual coke would be drawn by hand-rakes, and carried away to be quenched, and then stacked in the coke-yard. Thus it will be seen that there were half-a-dozen or more different operations, from the arriving of the coal to the storing of the coke, all to be done by hand, and necessitating a large number of labourers and stokers. The demand for gas, the higher cost of labour, and the generally improved conditions of life, made it compulsory to lighten, expedite, and cheapen the primary process in the manufacture of illuminating gas. It is the object of this and succeeding chapters to indicate briefly some of the modern methods employed in gasworks to this end.

Of all materials to be dealt with in a gasworks, coal is, of course, the largest in quantity, and the first in importance.

The conditions under which the problem of the economical carrying and storing of coal has to be solved by engineers naturally vary very much indeed, and it is, of course, impossible to lay down any general scheme that would in all cases be the most suitable to adopt. The local and particular circumstances must always be the deciding consideration. What is a successful arrangement in one gasworks may be found inadequate in another—even though the works be situated in the same town. There are, however, certain general features to be borne in mind. The force of gravity should be used as far as possible: the coal should be so deposited that once placed, it should be in the best possible position for future requirements: different means for similar operations should be avoided in the same works; and it should be remembered that the pulverizing of coal is detrimental to its gas-giving qualities. It is practicable nowadays to receive coal in a gasworks, carbonise it in the retorts, and stack the residual coke without once touching the materials by hand. But where the coal store intervenes, that is, when the coal has to be fetched from the stores to the retort house instead of being taken there

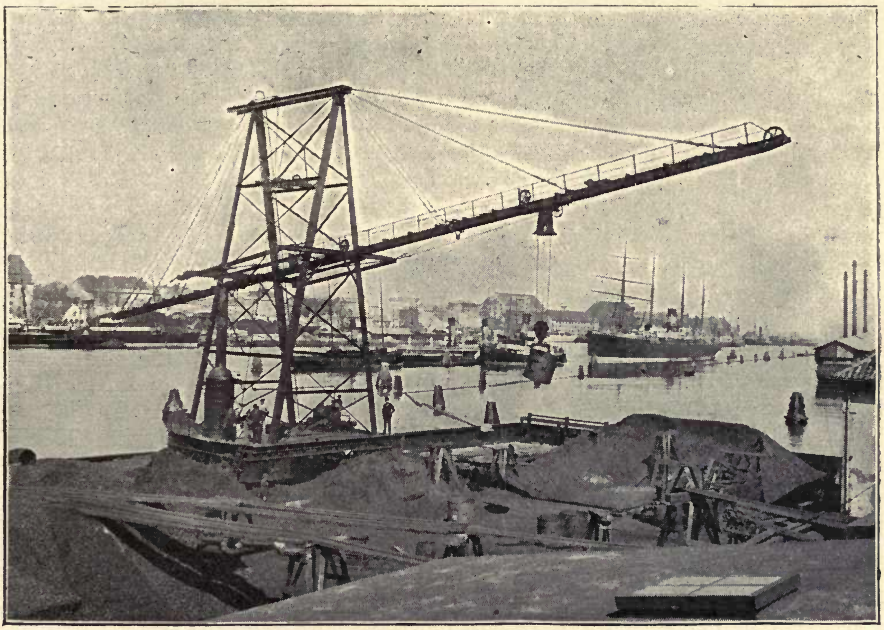


FIG. 2.—TRAVELLING TOWER TRANSPORTER AS USED FOR DISCHARGING COAL, ETC., FROM STEAMERS AND STACKING IN BULK.

direct, it is not so easy of accomplishment. In this country, with its wonderful wealth of mines, there is not the need for such extensive storage of coal as is found abroad. In many works in England, a month's supply of coal is all that is considered necessary to have in hand, though during the past period of scarcity it was hardly a comfortable reserve. On the Continent, however, there are many gasworks, established under a concession from the town, where a six months' storage is made compulsory, and where, therefore, the problem of economically filling and emptying the coal stores is more important than at home.

Among other methods of filling coal stores is that by means of an aerial wire ropeway, such as has been at work for some time past at the Metz gasworks and which has been recently described in an interesting paper by Monsieur Bouvier, of Lyons. This system of transporting coal and coke has been adopted in several instances on the Continent, but the writer is not aware of its application in an English gasworks. It certainly seems to offer advantages in some cases, owing to its simplicity, rapidity, small wear and tear, and low initial cost. At Metz the coal is discharged by hand from the railway wagons into twenty-ton hoppers of a V shape, from which it falls by gravity in regulated quantities into the buckets of the aerial ropeway passing underneath. The route taken has an incline of one in six, entering the coal stores just below the roof. When required for carbonisation, the coal is filled into small narrow-guage railway wagons, and so taken to the retort house. On entering, they are automatically weighed by a weighbridge, so constructed that only wagons of a specified weight can pass over it. The net result of this aerial installation has been a saving of about 4*d.* per ton of coal on the former cost of haulage by horses and tip wagons, and an economy in time of 66 per cent.

At Mayence there is a somewhat similar installation, the coal in this case, however, being supplied to the aerial wagons by cranes with jaw-grabs, which take it direct from barges. The coke from the retort house is also dealt with by a combination of travelling cranes and aerial ways, the motive power of which is electricity. It may here be remarked on the frequency with which one finds in gasworks abroad electricity serving as an auxiliary to gas. In this country the two illuminants are generally regarded as antagonistic, and the advantages to be gained from a judicious blending of the two, whether it be for motive or lighting purposes, have not perhaps been sufficiently recognised.

In recent new works that have been carried out at Geneva, the transmission of coal has received rather elaborate treatment. On the arrival at the gasworks of the ordinary railway wagons, they are placed upon trucks running upon a metre-gauge line, which leads to a funnel-shaped discharging tank, where the coal is thrown out. Below suitable openings in the trough are placed two conveyors, one above the other. The upper conveyor has two-inch diameter holes in the flat plates of which it is made, so as to allow the smaller coal to drop through to the lower one. Thus the top conveyor carries the large pieces along to a coal breaker, which feeds an elevator boot, as it is termed, while the bottom one conveys the fine coal direct to the boot. The coal is lifted by the usual elevator buckets, and is carried along the length of the stores by two spiral conveyors, supported from the roof, which deposit it as required. The stores are built with bottoms inclined at an angle of twenty-four degrees, though it may be noted that this is hardly found sufficient to cause the coal to find its way automatically to the two underground conveyors, placed along the whole length of the building. It has also been found that the spiral conveyors produce a considerable amount of friction, though working worked by electric motors, which, by subdividing the work to be done, undoubtedly save some friction and wear and tear.

Let us now take the case of some modern English gasworks, situated, say, on a water-way. The coal arrives in ships or barges, from which it may be taken by fixed cranes fitted

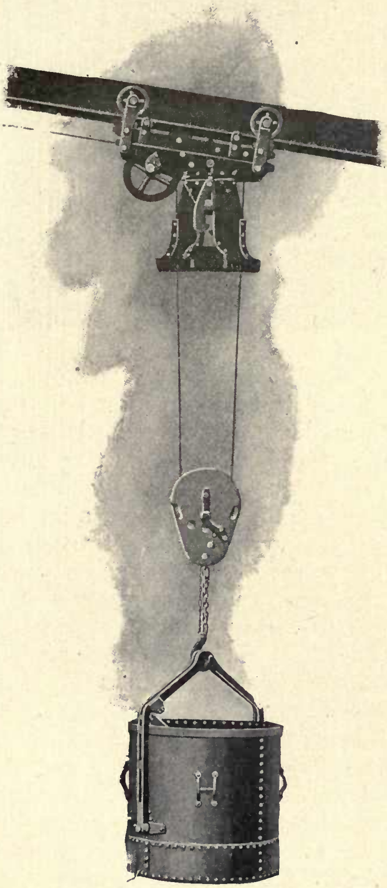


FIG 3.

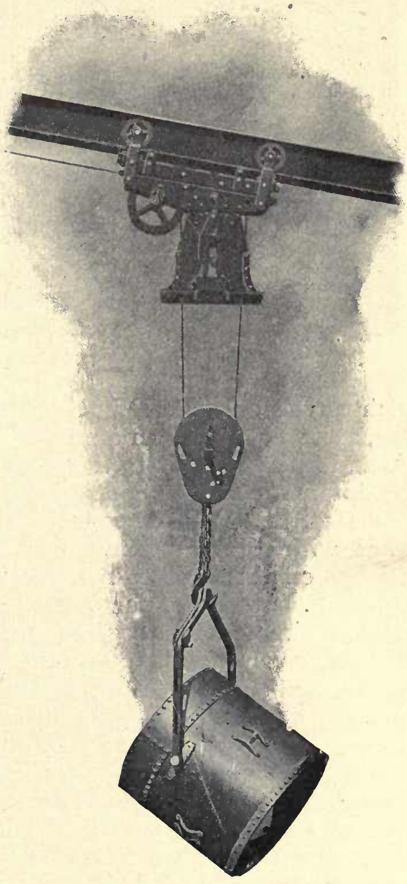


FIG. 4.

AUTOMATIC DUMPING FALL BLOCK AND SKIP.

admirably in other respects. The conveyors underneath the stores lead the coal to a second elevator, which fills a reservoir above the inclined retorts, so that the coal is received, stored and carbonised without any necessity for touching it by hand. At Geneva, also, all the plant is with self-acting grabs, as at the Beckton works of the Gas Light and Coke Company, or by such an arrangement as is shown in Fig. 2. This is a photograph of a travelling tower transporter, as made by the well-known Temperley Transporter Company. The view shows the transporter,

FIG. 5.—AUTOMATIC HOPPER WAGGON.

which travels on rails along the dock front, as it would work in discharging coal and in carrying it to the stores. The automatic skip is controlled by the driver, and thus dispenses altogether with the bankman usually stationed on the heap to release the skip-catch. It conforms to the last of the requirements for coal-handling plant previously mentioned—namely, that the coal should not be pulverized—inasmuch as the loaded skip can be upset close to the ground or coal stack without resting upon it. Fig. 3 shows the loaded skip being lowered, while in Fig. 4 it is seen in the act of righting itself after having been automatically upset. The Temperley transporter lends itself to a great variety of adaptations, and as the speed at which the apparatus works is considerable, it can easily deal with forty tons and more per hour.

Perhaps the most usual method of carrying and lifting coal in a works where, as is nowadays generally the case, there is railway communication, is by means of inclined railways, rising to twenty feet or so above the yard level. Hydraulic hoists for lifting coal wagons to the height required for economically utilizing the force of gravity have also been used in many works, but there can be no doubt of the superiority both as regards time and money of an inclined railway where practicable. To facilitate the automatic emptying of coal wagons, Mr. Charles Hunt, M.Inst.C.E., the engineer of the Windsor Street Gasworks of the Birmingham Corporation, and Mr. A. L. Shackleford, M.I.Mech.E., designed the hopper-wagon of which an illustration is given in Fig. 5. Each wagon holds about ten tons of coal, and is provided with bottom doors in half-inch steel plates, which can be quickly opened or shut by means of a hand wheel on each side. A large number of these wagons, first made by Messrs. Brown, Marshalls & Co., Limited, are now in use, and by their adoption, and the admirable network of railways at the Windsor Street works, Mr. Hunt is able to deal with the hauling and unloading of over 200,000 tons of coal in the year at a cost of less than 1¾*d*. per ton.

Undoubtedly the most important of all modern methods of saving labour in gasworks has been the introduction of the carbonising of coal by inclined retorts, instead of in retorts placed horizontally, as was the universally accepted system. As in many other instances, the modern arrangement of utilizing the force of gravity in charging and drawing gas retorts, by placing them at an angle of from thirty to thirty-four degrees, is merely a perfected revert to the ideas of the fathers of the gas-making industry. William Murdoch's first retort was a vertical one, used at Messrs. Boulton and Watts' Soho Foundry, Birmingham, in the year 1798, which he followed by one placed at an angle, and afterwards by the horizontal setting. The inclined retort system remained dormant until it was revived by Monsieur Emile Coze, when engineer of the Rheims Gasworks. Following in his steps, Mr. Frank Morris, M.Inst.C.E., introduced the principle into England at the Southall works of the Brentford Gas Company, in 1889. Since then the system has grown in favour, and has been vastly improved in many important details by English engineers, who have made it a practical working success, saving no less than 75 per cent. of the labour formerly employed in the retort house. It will easily be understood that there were many initial difficulties to be overcome, not the least being the unsatisfactory heating of the retorts, through the natural tendency of the heat to rise to the upper part of the setting. This drawback has now practically been surmounted, and the equal and efficient heating of inclined retorts twenty feet long, which, in part, is really the secret of a successful instal-

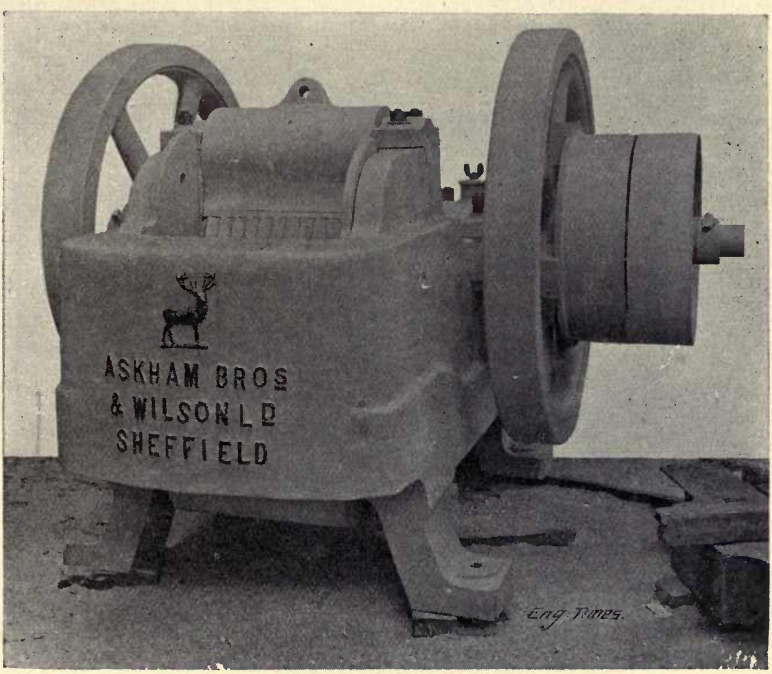


FIG. 6.—A JAW COAL CRUSHER.

lation, has been attained. It may be noted in this connection that there is now a suggestion, applicable to large works, of manufacturing producer gas for regenerative furnaces altogether apart from the general benches of retorts, and leading it to each setting as required for combustion, instead of, as at present, having a producer for each arch. This arrangement is applicable to all regenerative settings, whether "inclineds" or "horizontals," and would, among other advantages, save the constant labour of supplying coke to each separate furnace.

The coal intended for distillation in inclined retorts is thrown from railway wagons direct into coal breakers, or into suitable hoppers or tanks, from which the breakers are supplied. The small coal is made to pass through a screen without entering the breakers, by which arrangement both the power required and the wear and tear are reduced. The breakers or crushers are of two kinds—either with jaws or rollers; the former being what are generally adopted on the Continent, while the latter are usually seen in England. A good example of the former, as made by Messrs. Askham Bros. & Wilson, Limited, of Sheffield, is shown in Fig. 6. The mouth is 20 in. by 10, and its jaws are made of specially toughened material, suitable for breaking the hardest coal, cannel, or boghead. The roller crusher, which is perhaps less simple in its working and takes more power, consists of two pairs of rollers, with strong claws in cast steel. From the breakers the coal falls into the trough or boot of the elevator which carries buckets for lifting the coal to the required height. There has been found a difficulty in regulating the proper amount of material for each bucket to take up, and often the elevator

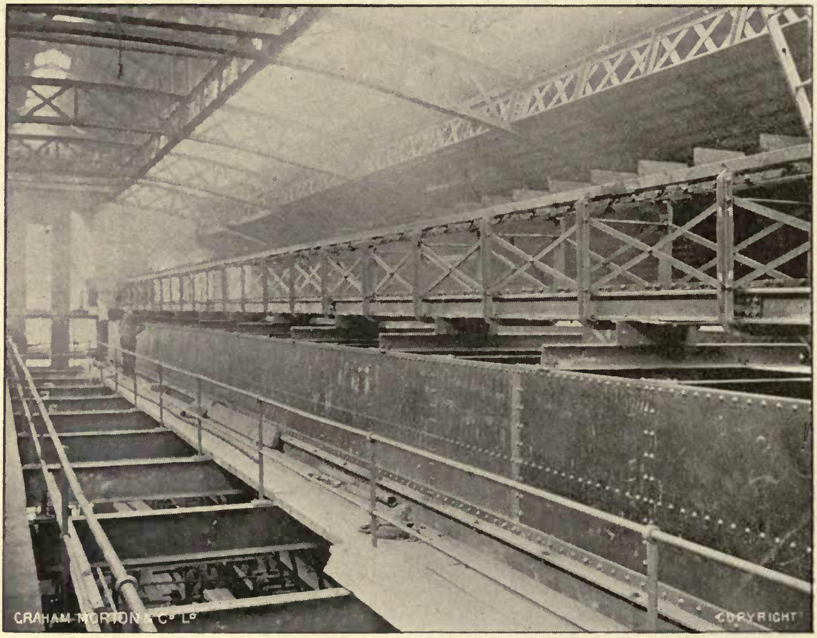


FIG. 7.—VIEW SHOWING A PUSHPLATE CONVEYOR FIXED IN POSITION OVER THE STORAGE TANKS FOR AUTOMATIC FEEDING.

boot becomes choked, with the consequent shocking, or stopping, of the elevating machinery. This means serious delay, when the important and continuous operations in the retort house are borne in mind. To obviate these dangers of breakdowns and to reduce manual labour still further, an ingenious arrangement has been carried out by Mr. Maurice Graham, Assoc.M.Inst.C.E., of Leeds. It consists of a revolving drum or feeder, placed immediately ingham, may be placed above the conveyor, so as to have an accurate record of the daily amount of coal passing into the retort house. The coal tanks, with the conveyor above them, are shown in Fig. 7. These tanks generally hold sufficient coal for a night's supply to the retorts, in order to avoid the working of the machinery except during the daytime. Underneath the storage tanks, and on the same vertical centre line as each row of retorts, are fixed

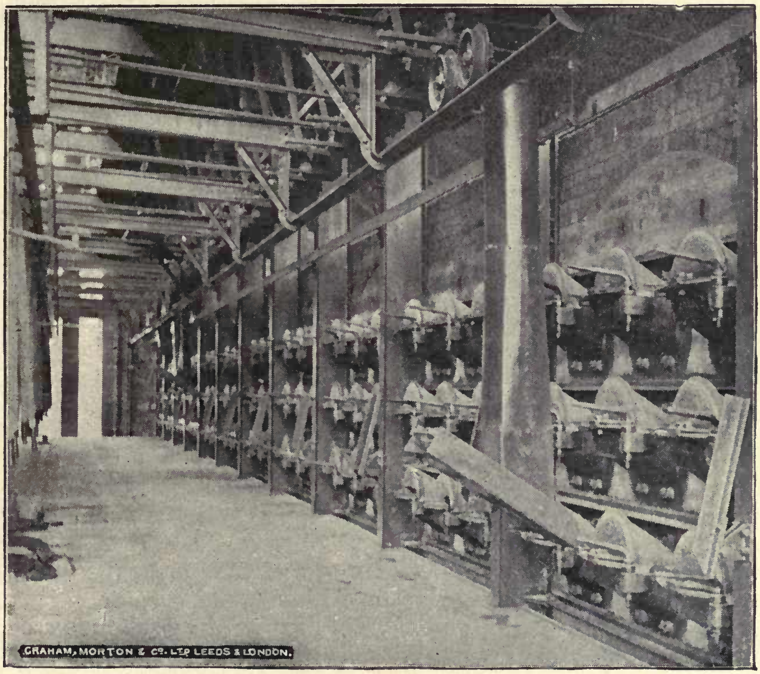


FIG. 8.—CHARGING STAGE OF AN INCLINED RETORT HOUSE, SHOWING THE CHARGING SHOOTS.

underneath the coal-breaker, over which the coal may be heaped in any quantity, as the feeder only allows just sufficient material to pass to load properly each elevator bucket. The coal at the top of the elevator is thrown on to a conveyor which supplies continuous overhead storage hoppers. If desired, an automatic weighing machine, such as is made by Messrs. W. and T. Avery, Limited, of the historic Soho Foundry, Birm- measuring chambers, which are opened and shut by levers, so arranged that it is impossible for the stoker to put into any retort either more or less coal than the required quantity. It will be remarked that as the measuring chambers are all at the same height, the drop of the coal will vary for each of the three tiers of retorts. To overcome the difficulties arising from this, baffle-plates have been introduced into the

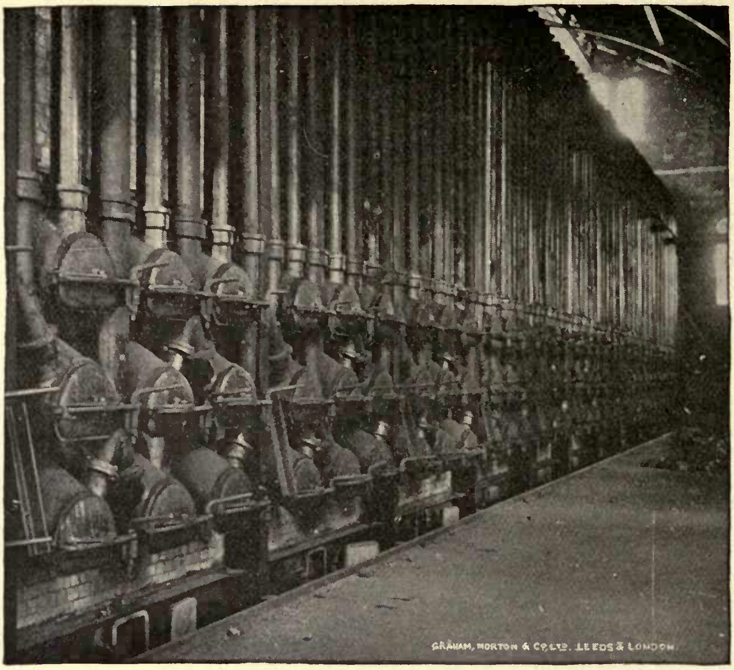


FIG. 9.—DRAWING STAGE OF AN INCLINED RETORT HOUSE.

charging shoots, which insure that the speed of the coal will be the same for all the retorts. This arrangement is superior to that sometimes adopted of having the charge of coal suspended in the three shoots, at the same height above each retort mouthpiece. For it must be remembered that the character of coal is very variable—being wet or dry, large or small. The baffle-plates may be adjusted to suit these variances, but such adjustment is not possible when the charge is suspended in the shoot. Another improvement, especially where cannel coal has sometimes to be used in inclined retorts, is to have a spring door on the shoe entering the mouthpiece, with a lever attached, so that the attendant can regulate to some extent the varying speeds of the descending material. An illustration is given in Fig. 8 of the charging floor of an inclined retort installation, showing the levers for working the measuring chambers, and the travelling shoots for charging the retorts. The coal on entering the retort is met at the lower end by a stopper or check plate, against which it forms itself into a regular layer along the bottom of the retort. After carbonisation, the lids on the drawing stage, shown in Fig. 9, are opened, the stopper removed, and the coke, with or without some slight assistance, discharged.

We have followed, then, the course of the coal from the automatic emptying of the wagons, its breaking-up in the crushers, its elevating, weighing, conveying and storing in the overhead tanks, its passage through the measuring chambers and shoots to its resting-place in the inclined retorts.

CHAPTER II.

INCLINED RETORTS.

HAVING reviewed in a general way the system of carbonising coal by inclined retorts, it may be well, in view of the importance of this method of saving labour, to dwell in rather more detail on its development and working.

The adoption of inclined retorts has only developed within the last ten years. The revival of the idea of placing retorts at an angle was due, as previously stated, to Monsieur Coze, of Rheims. In 1885 an experimental arch of nine retorts, each 10 ft. 6 in. long, was put up there, the retorts being inclined at an angle of 29 degrees, and heated on the regenerative system. At the top, or charging end of the retorts, were fastened cast-iron bends, with vertical shafts, bedded into the brickwork, and into which the coal was dropped from small tip wagons, running on the top of the arch.

It was four years later before an experiment on similar lines was made in this country. In 1889 a "through" retort, 20 ft. long, was tried at the Southall Gasworks, by Mr. Morris, the late engineer of the Brentford Gas Company, assisted by Mr. Husband, the present engineer, who thus became the pioneers of the system on this side the Channel. Immediately after this a test on a larger scale was made at the same works, on a setting of seven similar retorts. The principle proved to be successful, although naturally enough the details were found open to improvement. The retorts received their coal from a small truck, fed from a storage tank, the coal passing from the truck to the upper ends of the retorts by means of a telescopic travelling shoot, which could be adapted to each of the three tiers of retorts. Further extensions for the Brentford Works were designed in 1890, consisting of eight arches of seven retorts each, 20 ft. long. In this installation the charging arrangement that has come to be known as the "shot-pouch" system, owing to its similarity to the old method of loading fowling-pieces with shot, was introduced, the coal passing in the same way from measuring chambers into the retorts below. Another great improvement was the adoption of continuous storage hoppers, from which the measuring chambers were supplied, along the whole length of the bench, and filled with coal by means of a conveyor. The telescopic travelling shoot of the previous installation was also discarded in favour of three separate shoots, one for each tier of retorts. The retorts were ⌂ in section, 21 in. wide and 13 in. deep. Some

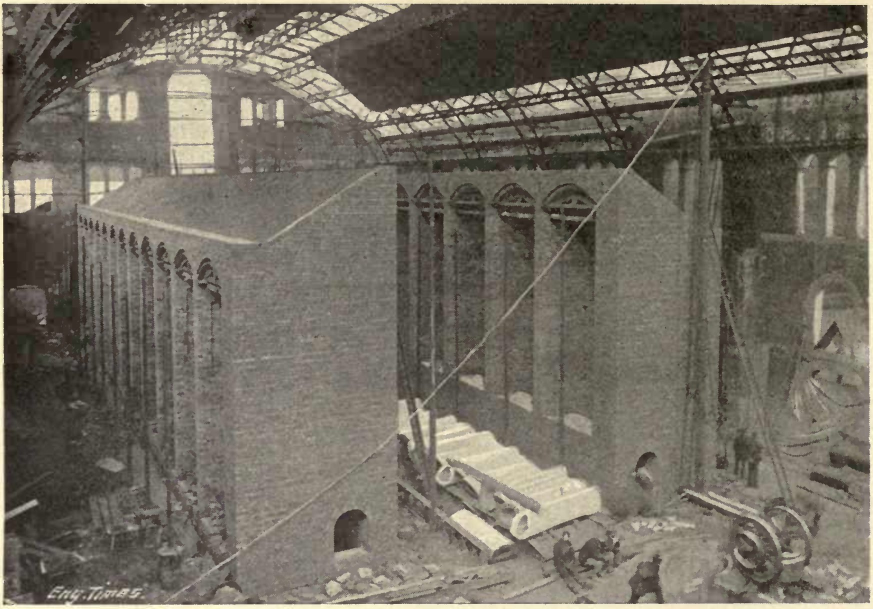


FIG. 10.—INCLINED RETORTS IN COURSE OF CONSTRUCTION.

difficulty was experienced in obtaining a regular heat for these settings, and so the middle retort was left out, and the remaining six increased in size to 24½ in. wide by 14 in. deep, in order to compensate for its loss. In the same year there were also put up at Rochdale five settings of inclined retorts, 15 ft. long. It was in this year also that a company bearing the title of the Automatic Coal-Gas Retort Company, Limited, was formed to work the English patent of M. Coze. This patent expired during last year, when an application for renewal was very properly refused, much to the benefit of the gas industry generally. It is only right, however, to recognise the abilities of Mr. Maurice Graham, who was for some years engineer to the company, and who has been personally connected, from the very first, with the majority of inclined retort benches put up in this country.

The London companies have been, and still are, peculiarly unfortunate in their experience of inclined retorts. At the Kensal Green Works of the Gas Light and Coke Company, in 1890, were put up sixty-eight beds of seven retorts, or 476 retorts in all, placed at an angle of 29½ degrees. They were built on the Coze system, with cast-iron bends for charging the retorts; but it was soon found that these shoots were impracticable, owing to their impeding the repairing or cleaning of the retorts, to their extent of surface, of use only while charging, and last, but not least, to the expense entailed. The heating of these settings also proved very defective, and consequently trouble was experienced in discharging the coke from the retorts, owing to the bad carbonisation of the coal.

It may be noticed that the angle most suitable for obtaining an even layer of coal in the retort is not the same as that most suitable for the automatic discharge of the residual coke. Were it possible, one would choose for charging a retort an angle of about 33 degrees, while for discharging the coke an angle of, say, 45 degrees. This, of course, is an impossibility, but at Beckton Gasworks, sixteen arches with nine retorts each, 15 ft. long, were set at an angle of 38 degrees, with the object of facilitating the discharge of the coke. In order that the coal might form a level layer upon the bottom of a retort placed at such an angle, a flat steel plate was let into the retort before charging, so as to allow the layer of coal to be about 5 in. deep. As might have been expected, the arrangement was not a success, and is now non-existent, the plate, besides becoming warped from the heat, also necessitating additional machinery and labour for working it.

Seeing that more may be learnt from failure than from success, it is somewhat curious that, after the experience gained from these installations, London gasworks do not possess to-day any eminently successful examples of the inclined retort system. It is to the provincial towns that one has to look in this, as in other departments of gasworks, for the best arrangements and ideas.

Mr. W. R. Herring, now chief engineer and manager of the Edinburgh and Leith Gas Commissioners' Works, who is at present engaged upon building large new works, where the whole of the carbonising will be done by means of inclined retorts, when occupying a similar position to the Huddersfield Corporation, put up, in 1895, in that town the very

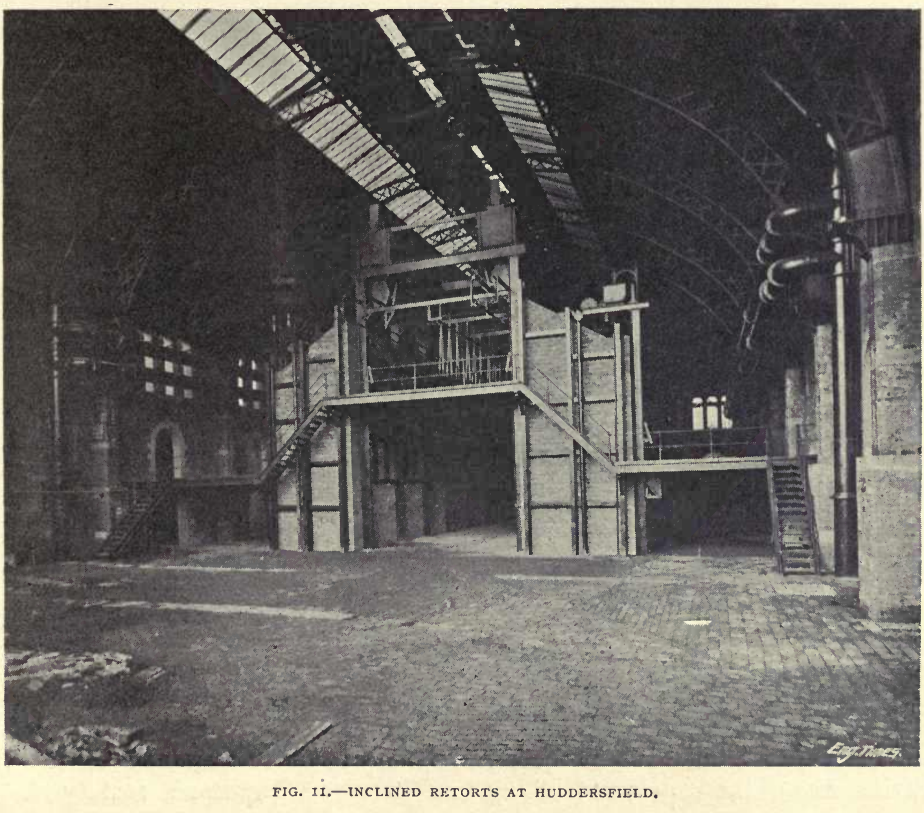


FIG. II.—INCLINED RETORTS AT HUDDERSFIELD.

admirable retort house and benches of inclined retorts, which are shown in course of construction in Fig. 10, and as completed in Fig. 11. The retort house, which is 90 ft. wide, and covered with a semicircular lattice-girder roof, contains a double bench of 24 beds of nine 15 ft. long retorts. Everything was done to make the installation as automatic as possible. The coal was brought to the works in carts, and was tipped into a pair of breakers, lifted up thence by elevators, carried along by conveyors, which filled the overhead continuous storage hoppers. All the measuring chambers were fitted with what is known as Graham's Patent Sure-Feed, a simple arrangement which compels the operator to put in the whole of the charge required, thereby making the retort house work largely independent of the goodwill and skill of the workman. This installation has the floor for the drawing of the retorts raised above the ground level, which is the general arrangement adopted, as it gives increased facility for

FIG. 12.—VIEW SHOWING TWO ELEVATORS FOR COAL; AND COKE HOPPER AND ELEVATOR FOR SUPPLYING COKE TO THE FURNACE SIDE OF BENCH.

discharging the coke and for attending to the furnaces underneath. Three years previously, however, Mr. Herring had put up some settings of inclined retorts, having the discharging floor on the ground level. Such an arrangement necessitates providing for the coke required for the furnaces to be carried round to the charging side of the bench, where they are placed. Fig. 12 shows the hopper and elevator buckets which perform this duty, as well as the two elevators used for supplying the coal. Though this system cannot, of course, be compared for a moment with the more practical arrangement of two stage floorings, one for charging and the other for drawing the retorts, yet it, nevertheless, seems to offer, by its reduced initial cost and the less height required, some advantages which might lead, in certain cases, to its adoption in small works. Monsieur Derval, a well-known furnace builder of Paris, has recently patented a furnace and other accessory details, specially adapted to meet the requirements of such installations.

We have seen, then, that the progress made from the original Coze type of inclined retort to that generally followed at the present time consists principally in improvements to the heating arrangements, to the adoption of the straight-through and tapered retort, dispensing with the fixed cast-iron charging bends in favour of independent travelling shoots, to the employment of continuous overhead storage tanks, with measuring chambers and sure-feeds, and, generally, in the plant for mechanically breaking, elevating and conveying the coal.

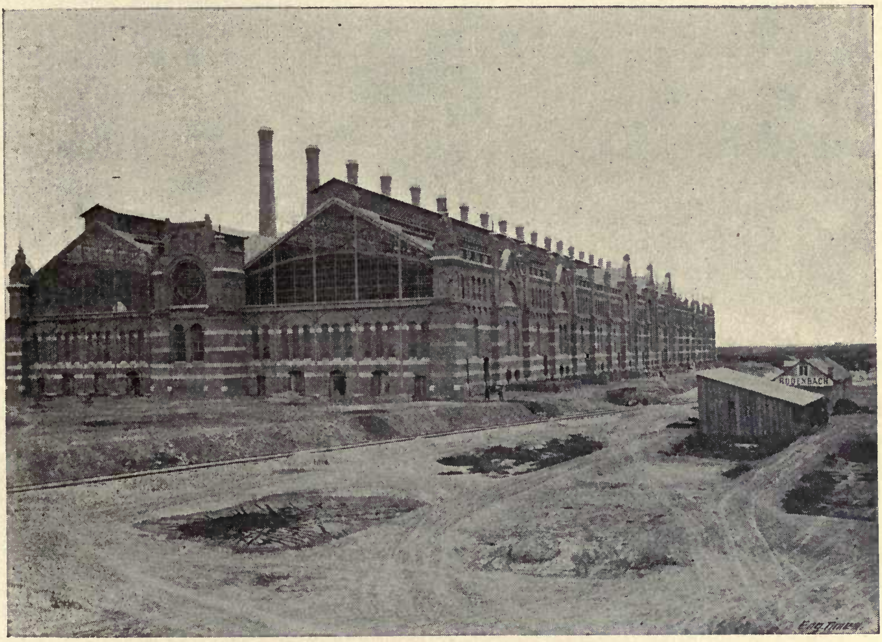


FIG. 13.—EXTERIOR OF VIENNA RETORT HOUSE.

Let us now see on what lines progress has been made on the Continent from the same starting-point of the Rheims plant. Incidentally, it may be remarked that during the ten years since their practical introduction into England, there have been erected in this country no less than 96,000 lineal feet of inclined retorts, representing a value of about £700,000. France, the country of the modern birth of the idea, can count to-day, after fifteen years, only about 1,400 lineal feet, though, with the expiration in June, 1900, of the Coze French patent, some greater development may be expected, although the industrial characteristics of the country, and the concessionary conditions of the gas industry there, prohibit any great extension being looked for. Germany to-day has 40,200 lineal feet, Austria 23,100, Switzerland 6,700, Italy 3,300, Denmark 3,100, and other European countries together 6,400, while in the United States of America there are but 640 lineal feet. In England, then, more coal is carbonised in inclined retorts in gasworks than throughout the whole of the rest of the world.

But to return to the Continent. If one were asked generally to state the distinctive features between English and Continental practice as regards inclined retorts, one might say that the Continental installations excel in the brickwork and furnaces, while the English are greatly superior in having longer retorts, and in the ironwork and mechanical details. A Continental engineer is generally prepared to sink more capital in his furnaces than his English colleague, no doubt largely owing to fuel being dearer. The proper heating of inclined retorts is of fundamental importance to their successful working, and consequently it was very soon found out that heating on the regenerative, or recuperative, principle was the only one applicable, the direct firing system having been tried at Oxford Gasworks and found wanting. The regenerative system of firing consists, briefly, in the passing of air through incandescent coke, and converting carbonic oxide into carbonic acid gas by mixing with it, in a combustion chamber, secondary air, which has been heated on its passage by the waste gases of the furnace. Generally, on the Continent this process is extended by the heating of the primary air in addition to the secondary, the system then being known as that of double recuperation. But although this leads to a slight increased economy in fuel, it may be questioned whether the extra economy is worth purchasing at increased complication in and first cost of the furnace.

An important point in the construction of inclined retort arches, upon which there can be no doubt of the superiority of Continental practice, is the width allowed from centre to centre of pier. In England the average width is about 10 ft. 6 in., while on the Continent in many cases it is 14 ft. 6 in. for a setting of nine retorts. The result is that there is a more effective slow current of heating in the setting instead of a rapid imperfect one. The solidity of the main piers is also on the Continent much greater, being made 2 ft. 6 in. thick, instead of, as in England, about 1 ft. 6 in. Again, it is a common custom on the Continent to grind up old fireclay material, and to re-manufacture it into new blocks, which in consequence reduces shrinkage to a minimum, and thus increases the life of the whole setting. Abroad, also, blocks are used to a greater extent in building a setting than at home, which results in increased general

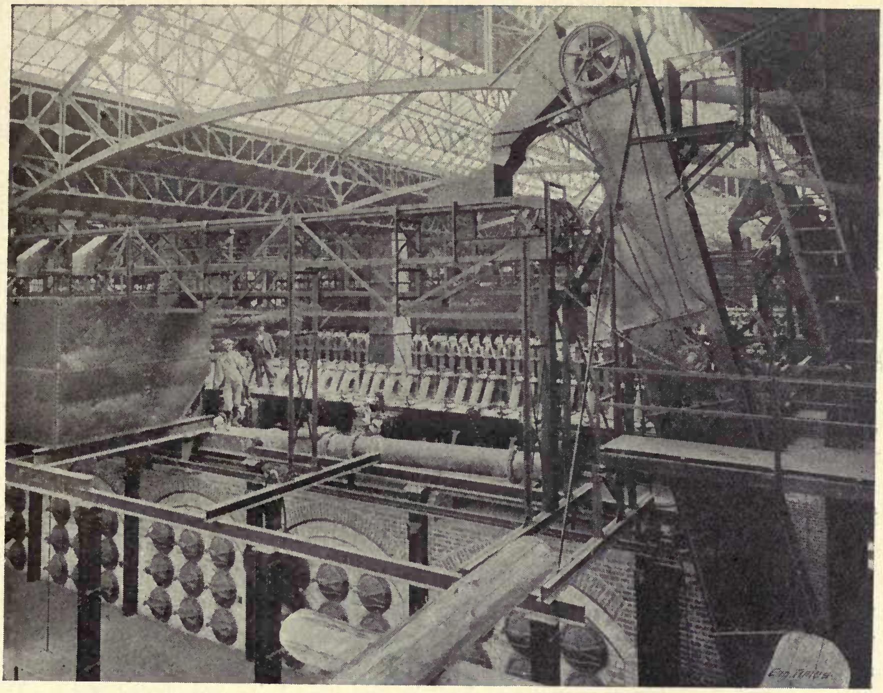


FIG. 14.—INTERIOR OF VIENNA RETORT HOUSE.

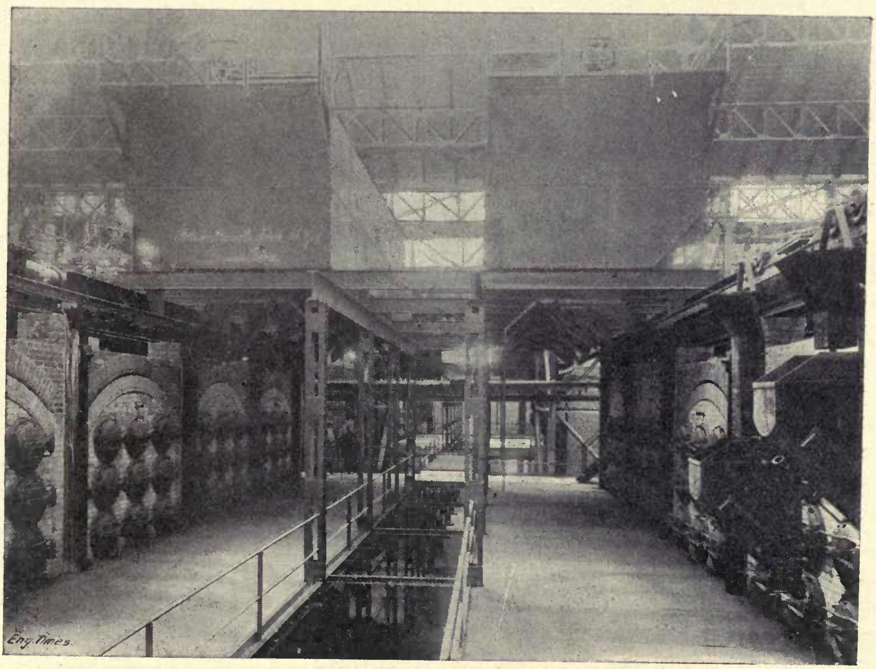


FIG. 15.—VIEW OF CHARGING STAGE AND SHOOTS AT VIENNA.

solidity throughout the work. During the building of inclined retorts, money is more willingly spent on the Continent on thoroughly drying the setting, for when the regenerator and the furnace have been built up to the level of the bottom retort, temporary walls are put up both back and front of the arch, and a slow fire kept up, so that the expensive regenerators find their proper settlement before the retorts themselves are set in the arch. This reduces also the liability of the short-circuiting of the secondary air taking place through any flaws in the joints of the passages, and adds considerably to the life of the furnace. Another point that may be noted in constructing furnaces is the advantage of heating the secondary air by means of induction through baffle bricks placed between vertical flues for the waste gases, and other vertical flues for the secondary air. Such an arrangement has the advantage over the usual horizontal flues, that it necessitates less pressure in working the setting. The only point on which Continental engineers still insist, and which the writer believes to be inferior to English practice, is the placing of the producers outside instead of within the bench. English engineers, nevertheless, may profit in many ways from the study of Continental practice with regard to the scientific construction of furnaces for heating gas retorts, and would do well to avoid repeating the errors of old designs. When we turn, however, to the machinery for automatically charging inclined retorts, we find that the case is reversed. An illustration from Vienna will show this. In the imposing retort house which is shown in Fig. 13, is the general arrangement of which some idea can be obtained from Fig. 14. It will be seen that the house contains a number of short benches, with nine retorts in an arch, each having its elevator, conveyor, and storage tank. The drawback of such a system will be at once apparent, though one cannot help being struck by the finish and perfection of the workmanship. Instead of having the coal in continuous hoppers above the charging stage, so that it may be dropped directly into each retort, it is necessary to push the travelling shoot under the fixed tank to receive the supply of coal required for the charge, and then to return to the particular retort for which it is wanted. This can be regarded as anything but a perfect labour-saving method. A better view of the charging stage and coal-scuttle-like shoots is obtained from Fig. 15. It is difficult to understand the reason for the adoption of such a system, necessitating the labour of pushing to and fro the heavy shoots, with their charge in suspension, when this might easily be avoided by the adoption of continuous hoppers with measuring chambers over each vertical line of retorts, as in England.

Here again, however, the excellent finish of the work, and the admirable arrangements for ventilation, deserve commendation, and praise should accordingly be given to the Stettiner Chamotte Fabrik Company, who put up the whole installation.

Recently the same contractors have also put up sixteen beds of nine retorts, placed at an angle of 33 degrees, and having a length of 15 ft., and being $15\frac{1}{2}$ in. deep and 18 in. wide at the top, tapering in the width to $21\frac{1}{4}$ in. at the bottom, to facilitate discharging the coke. They are in two benches, each of eight arches, treated on the double regenerative principle. Each furnace also has two boilers for generating steam, which is led under the fire bars, so as to prevent the formation of hard clinker. The boilers are heated by the waste gases of the furnace on their way to the chimney.

The arrangements for dealing with the coal consist of two jaw crushers, with grids for by-passing the smaller pieces, two elevators for lifting, either of which can supply two parallel conveyors, one of which is for the nearer eight arches, and the other for the farther. The continuous overhead hoppers have only two discharge measuring chambers per arch, one over each outer vertical line of retorts. The same criticism that was made on the Vienna arrangements for charging the retorts applies also to some extent in this case, for to charge the middle retorts on the vertical line, it is necessary to move the travelling shoot under the adjacent measuring chamber, and then to run back the shoot, containing its supply of coal, to the retort. Having got the shoot in position, the operator lifts a lever attached to the shoot, which allows the coal to fall into the retort. It is to be noted that neither in the Vienna nor this installation is there any arrangement, as is often found in England, as already mentioned, for absolutely guaranteeing that the whole of the charge will be placed in the retort. A negligent or lazy stoker could, if he wished, lift the lever only sufficiently to drop in but a small amount of coal. Nor at the Brentford Works has any "sure-feed" been adopted, and for the charging of each retort the stoker has two levers to operate, which seems unreasonable when the work

FIG. 16.—VIEW OF TRAVELLING SHOOTS AND OPERATING LEVERS ON CHARGING STAGE.

can be even better done with one only. Apart from the saving in time by connecting the two slides of the measuring chamber to one lever, there is also the advantage of lessening the amount of superintendence required. Fig. 16 gives a view of the travelling shoots and levers upon the charging stage of a thoroughly complete automatic retort house, with measuring chambers and sure-feeds, as erected by Messrs. Graham, Morton & Co., Limited, of Leeds. The drawing stage of the same installation, showing the screen for protecting the men from the falling coke, and for throwing it down through suitable openings in the flooring, is shown in Fig. 17.

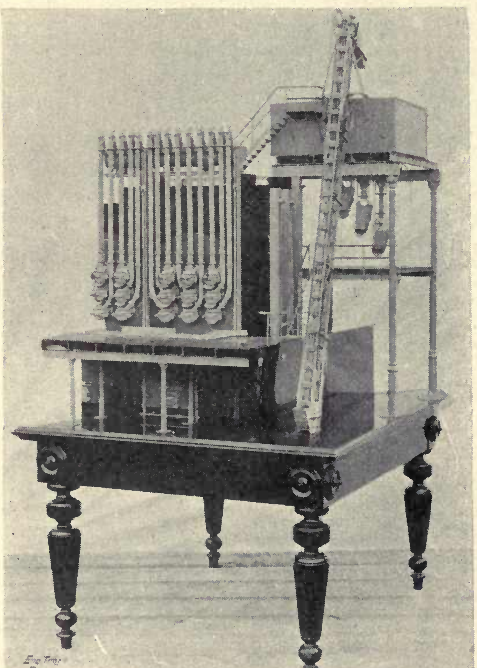
FIG. 17.—VIEW SHOWING COKE SCREEN AND DRAWING STAGE.

No retorts 20 ft. long have as yet been put up on the Continent, and there are some engineers in this country who still prefer the 15 ft. length. It is not easy to understand this hesitation to adopt the longer retort; for the 20 ft. retort, containing 7 cwt. of coal, can be charged equally easily, with the same machinery, and with the same effort expended by the operator, as a 15 ft. retort, containing only 5 cwt., while the initial cost of the installation per ton of coal carbonised is considerably reduced. The objection to it that has been raised is founded on the supposed difficulty of repairing such a long retort under fire, but this has not been found to be the experience of those who have actually worked them. They have also found the wear and tear of the 20 ft. inclined retorts to be less than those placed horizontally, which is only natural, remembering that the coal runs into the retort automatically by gravity.

Some engineers, whose experience with inclined retorts has perhaps been unfortunate, have endeavoured to depreciate the advantages of this system of carbonising. They have called in question the quality of the gas produced from inclined retorts as compared with that from horizontal, and have also made a mountain out of the molehill difficulty of the slipping, or "creeping," as it has been termed, of some coals towards the lower end of the retort during distillation. The former complaint is not based upon recognised and accepted facts, and the latter is only applicable to certain qualities of coal, or to defective installations, and is also contrary to the experience of many engineers using Durham coal, against which particular class of coal the objection has been principally urged.

The cost in England of erecting inclined retorts, including machinery, varies from £100 to £150 per retort, which is rather more than for horizontal settings, with stoking machines. The economy made, however, in carbonising wages per ton of coal by the former over the latter system may be taken, generally speaking, at about 2*d*. or 3*d*., while it should also be remembered that, per square yard of floor space, a greater quantity of gas can be made with inclined retorts than with those horizontally placed. Without going into details that might not be of interest to the general reader, it may be stated that the saving in labour by the adoption of inclined retorts may be taken, roughly, at 75 per cent., compared with the number of men required for horizontal hand-stoking; while the cost per ton of coal carbonised amounts to about 10*d*., in comparison with a former cost for hand-stoking of 2*s*. and more, though this figure, of course, varies very much indeed in different localities and under different circumstances. Bearing in mind the laborious and expensive old methods of carbonising coal for gas-making, and the time taken in doing what should be as nearly as possible a continuous process, the extensive adoption of inclined retorts for saving labour and cheapening the cost of gas production is not to be wondered at, and still further extensions may be looked for.

The succeeding chapter will deal with the different types of machines for charging and drawing horizontal settings of retorts.



CHAPTER III.

STOKING MACHINERY FOR HORIZONTAL RETORTS.

IT has already been seen that up to the year 1890 the universal practice in gasworks was to set the retorts for the carbonisation of coal horizontally. It will therefore be easily understood that from a comparatively early date in the history of gas manufacture methods were sought to perform mechanically the operations of putting coal into the retorts, and of withdrawing the residual coke. The work of the retort house was naturally of a very hard description, and tended always to become still more so from the increasing sizes and charges of the retorts used, the higher heats at which they were worked, and generally, from the continually growing quantity of material to be handled. The charging shovel of the old stoker could not keep pace with these requirements. The use of a long trough or scoop, into which the coal was filled, and thus carried to the retort, was therefore adopted, and is still employed in many works, but it has also, in turn, become inadequate. There was, and is, therefore, a large field for machinery for charging and drawing gas retorts.

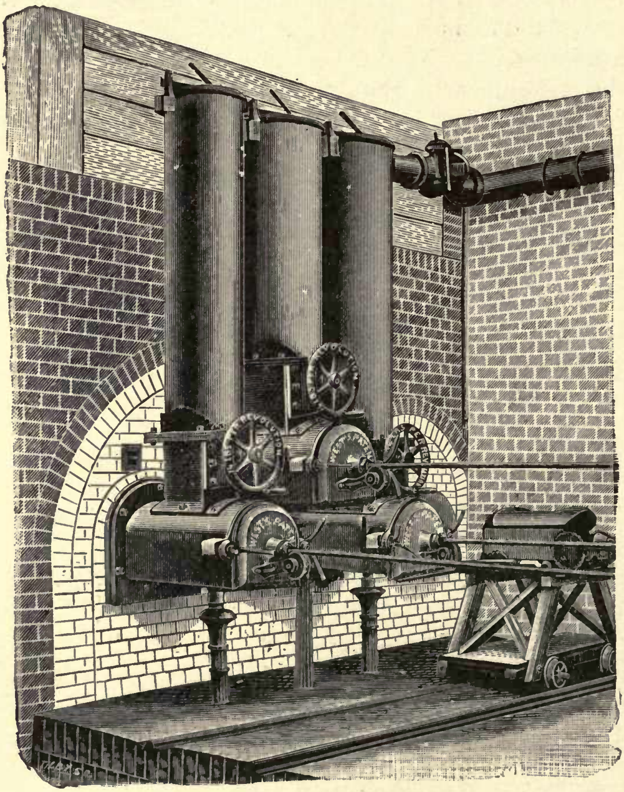


FIG. 18.—WEST'S ORIGINAL MACHINE—1873

Of the original experimenters in this direction, the name of Mr. John

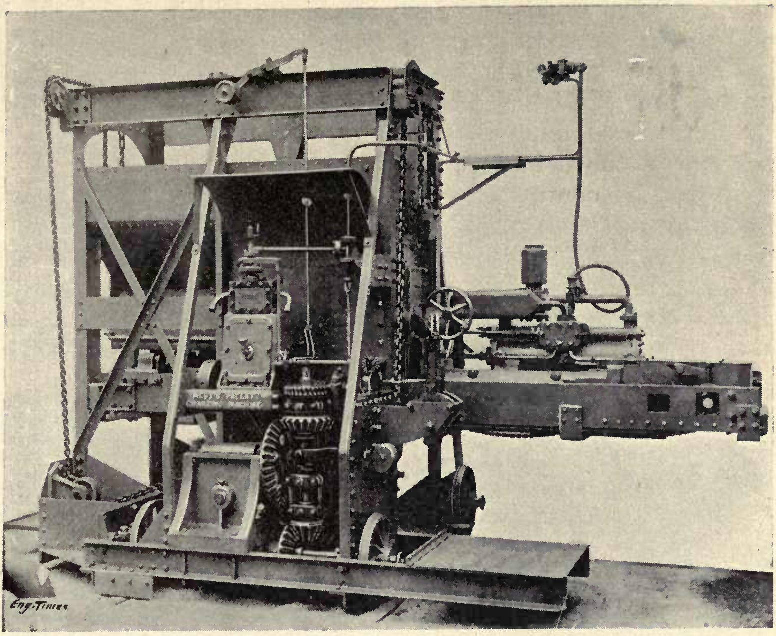


FIG. 19.—WEST S COMPRESSED AIR CHARGING MACHINE—1900

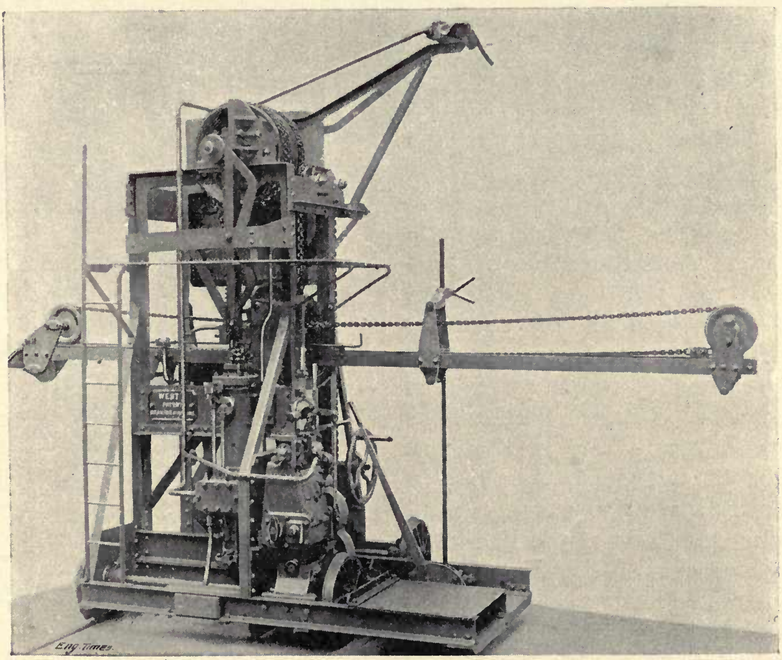


FIG. 20.—WEST'S COMPRESSED AIR DRAWING MACHINE.

West, M.Inst.C.E., stands out as the most prominent and most successful. It was in 1873, when manager of the Maidstone Gasworks, he introduced and patented the arrangement shown in Fig. 18, which may well be contrasted with his latest pattern of compressed air charging machine (Fig. 19), made by West's Gas Improvement Co., Limited, of Manchester. In the earliest arrangement, each retort had its own machine, the rod for working which was passed through a stuffing box in the retort lid. Each mouthpiece also had a cylindrical coal hopper, fed from above, which supplied the machine. A plate on the front of the charger, which ran on wheels, served to push the coke out of a sloping mouthpiece at the opposite end of the retort, the machine being, therefore, a combined charging and drawing one. The next step was the introduction of a travelling trolley, in front of the retort bench, which carried a coal hopper and the charging apparatus. Accessory machinery was also found imperative for successful working, and Mr. West introduced, for the first time, coal breaking, elevating and conveying machinery to work in conjunction with the stoking apparatus. It was not long before the natural development of applying some motive power to this manual machine presented itself. Alterations were made, certain mechanisms were added, and the whole was generally strengthened, so that, in the year 1881, we find a compressed air machine working at the Rochdale Road Gasworks of the Manchester Corporation.

Other means of stoking that were also in use about this time were Ross's steam drawing and charging machines, which had been brought

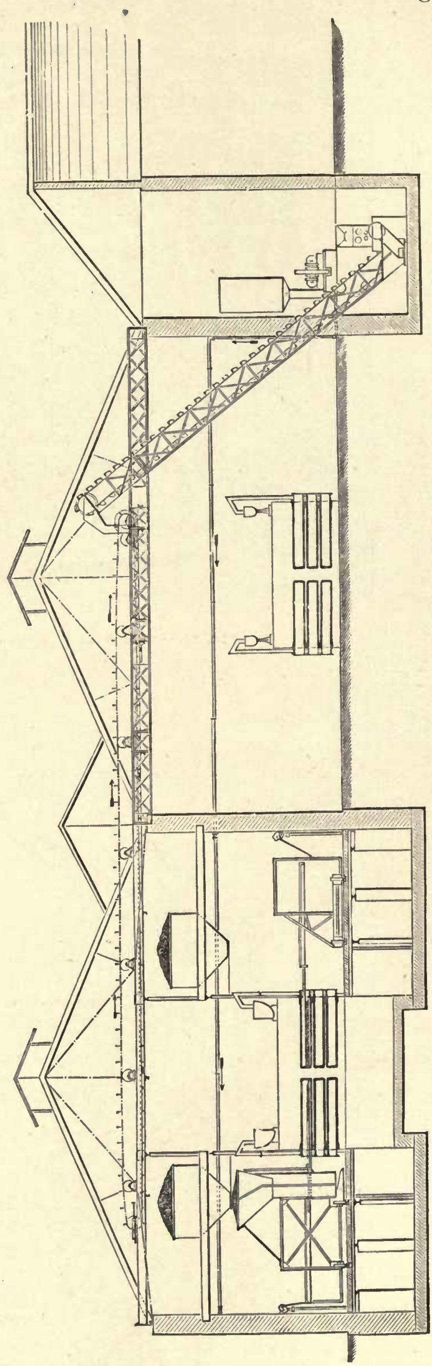


FIG. 21.—OUTLINE OF A GENERAL ARRANGEMENT OF STOKING MACHINERY.

out in America, and which were adopted at the Windsor Street

Gasworks, Birmingham, and the Nine Elms Works, London, in 1883, and the hydraulic machines of Mr. William Foulis, M.Inst.C.E., which, in 1884, were working at Manchester alongside of Mr. West's compressed air machines. Ross's steam machines, formerly made by Messrs. Tangyes, Limited, were self-contained, each machine carrying its own boiler. The writer believes that the drawing machine is still to be seen at work in Birmingham, but the weight of the machines and the skilled attendance the boilers required militated against them, and they are now no longer made. Mr. West has also introduced rope-driven machines, which were adopted at Blackburn in 1889, and have been put up in London, Sheffield, and elsewhere. The hydraulic machines have been very much improved by the combined abilities of Sir William Arrol and Mr. Foulis, and it would seem as if the two systems of compressed air and hydraulic power had each proved its claim to existence and permanence. Believing, however, as the writer does, in the advantages of generating both gas and electricity side by side in the same works, he sees no reason why an electrically driven machine should not be feasible for the charging and drawing of gas retorts. It would certainly have the merit of speed, cleanliness, adaptability, and would receive its current from the generating station with the minimum loss in power, trouble and inconvenience. It may here be remarked that British makers hold a monopoly in stoking machinery for gasworks, as the writer is unaware of any successful machine being made on the Continent or elsewhere abroad. It only needs a little more enterprise on the

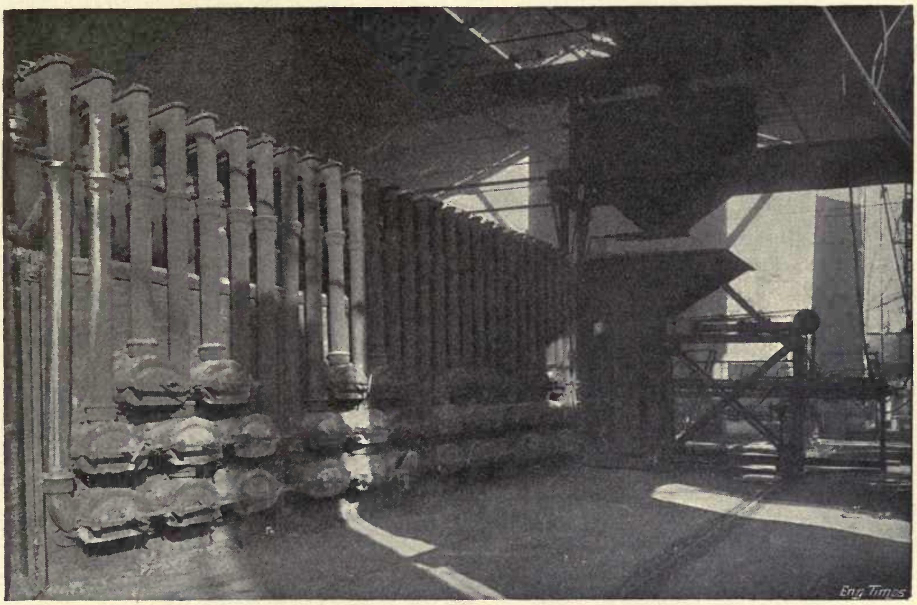


FIG. 22.—VIEW OF COAL CONVEYOR AND STORAGE TANK.

part of our makers to increase their output in this direction.

It will be easily understood from the exacting and almost continuous work of charging and drawing retorts that it is of the utmost importance that any machine entrusted with this work should be of the simplest, strongest, and most enduring kind, so that risks of breakdown may be all but eliminated. Its pieces should be easily renewable, its bearing surfaces wide and well protected, and its working parts covered in from the dust and dirt of the retort house. It will have to travel up and down the retort bench from one retort to another, it must have a vertical movement for the different tiers of retorts, and it must place the coal in the retorts in suitable quantities, and in uniform layers. Such are the requirements, and they are admirably fulfilled by West's compressed air charging machine, shown in Fig. 19, already referred to. The first movement is obtained by placing rails in front of the retort bench, on which the four wheels of the charging machine run, actuated by a motor and gearing in the ordinary way. Both the coal hopper and the charger itself are supported by strong double chains, and are able to be lifted or lowered the requisite height for the different tiers of retorts by worm wheels in forged steel. The charger itself is fastened on a hanging frame, and consists of a scoop and carriage, with mechanical arrangements for placing the coal in the retort, and for returning the charger to its mormal position. To charge a retort the scoop has to enter it twice: on its first journey it charges half the retort by turning over to the right, and on its second, the remaining half by turning to the left. The scoop never touches the retort, being suspended on its carriage, and by this means the wear and tear of the retort is saved. There are four levers conveniently placed near the operator, who stands on a platform; one, fitted with a clutch for throwing into action either the travelling or hoisting gears, but so arranged that these two movements cannot be in work simultaneously; another for actuating these two gears; a third for sending the loaded charger into the retort, all the subsequent movements being automatic, except that of overturning the scoop, which is controlled by the fourth lever.

The drawing machine on the same system is shown in Fig. 20. Its actions are naturally fewer and simpler than those of the charging machine, as apart from its movement on the horizontal and vertical lines, the rake rod has but the straight in-and-out action for withdrawing the coke. The drawing machine has, however, to stand far more severe shocks and usage than the charging, owing to the varying characteristics of the residual coke of the more or less burnt-off charges of coal, and from the rake bar becoming hot from the heat to which it is exposed. The travelling is worked by a compressed air motor, while the lifting of the frame and its rake bar is done by hand. The cast steel rake head on entering the retort is raised by a hand lever above the coke, and afterwards lowered into it for drawing it out. A vertical air cylinder, with controlling cylinders fixed to the main frame of the machine, actuates the driving of the rake rod, the varying strokes of which are under control. Water from a spray pipe plays on to the rake head to cool it, the water being supplied from a tank on the machine. It will be seen from the illustrations that these machines are very complete and ingenious mechanical contrivances. They are by no means so complicated as one would think at first sight, and the management of them may be learnt in a very short time by any man of average intelligence. The speed at which they work is considerable, and in ordinary circumstances they can draw and charge 80 retorts per hour, putting into each retort mouthpiece from $3\frac{1}{2}$ to 4 cwt. of coal. The air required for working the machines is compressed in two stages by the cylinders of an air compressor placed in a separate building, after which it is carried to cylindrical storage receivers, and thence by iron pipes to drums in the retort house, which carry the flexible hose attached to each machine. The most suitable pressure, found by experience, is the comparatively low one of 60 lb. to the square inch.

The general arrangement of the several parts of a stoking machine installation varies, of course, with the different circumstances and positions of buildings and plant in each case. Fig. 21 gives an outline of a general arrangement, as suggested by the writer, and as actually carried out. An elevated railway siding runs contiguous to a coal store in which a coal breaker is fixed for reducing lumps to a suitable and equal size. The coal is then elevated by buckets, as is shown, which throw it on to a trough conveyor, the plates of which push it across one retort house to another, where there is a 10-ton hopper or tank fixed on each side of the retort bench, to which stoking machines have been applied. At the bottom of each hopper is a door, through which the coal falls as required into the tank on the charging machine. A photograph showing the end of the coal conveyor, which fills the fixed hopper, and the charging machine standing underneath, ready to receive its supply, is given in Fig. 22.

The view given in Fig. 23 shows the arrangement at the largest gasworks in the world—that is, the Beckton Works of the Gas Light and Coke Company. It will be seen that coal stores run along the length of the retort house, from which elevators feed large storage tanks, standing above the retort stack. From these tanks the coal falls through shoots into the hoppers on the machines. At the Rotherhithe Works of the South Metropolitian Gas Company the machine carries with it its own elevator, the buckets of which are filled from the coal store at hand, and empty themselves direct into the hopper on the machine. Another arrangement was put up at the Wapping Works of the Commercial Gas Company, London. The elevator of the Rotherhithe plant is here replaced by a crane and grab. This is lowered into the coal stored in the adjacent bunkers, and supplies the machine as required. In this case the larger pieces are broken by hand through a grid, for this purpose, which covers the machine hopper. The machines in these instances are those of Mr. Foulis, made by Sir William Arrol & Co., Limited, and are worked by hydraulic power at a pressure of 400 lb. per square inch. Such machines were shown at work to the Chinese Ambassador when visiting Glasgow on a recent industrial tour. He was much impressed by them, and is said to have exclaimed, with admiration, "Here machinery is man's slave!"

An outline sketch of the more usual type of hydraulic charging machine is shown in Fig. 24, and on comparing this with the photograph given in Fig. 25, a good general idea can be obtained of the machine and its working. The coal passes from the tank on the machine through a revolving drum C, in front of a pusher plate and rod A. There is a hanging beam, which is lifted or lowered to the desired height by the moving of a lever, which brings into play the cylinder D. A connecting slide or drawbridge is pushed into the retort to be charged, when on lifting the lever B, a hydraulic ram fixed on the hanging beam comes into play, and pushes the coal resting at A to the farthest end of the retort. On lowering the lever B, a second hydraulic

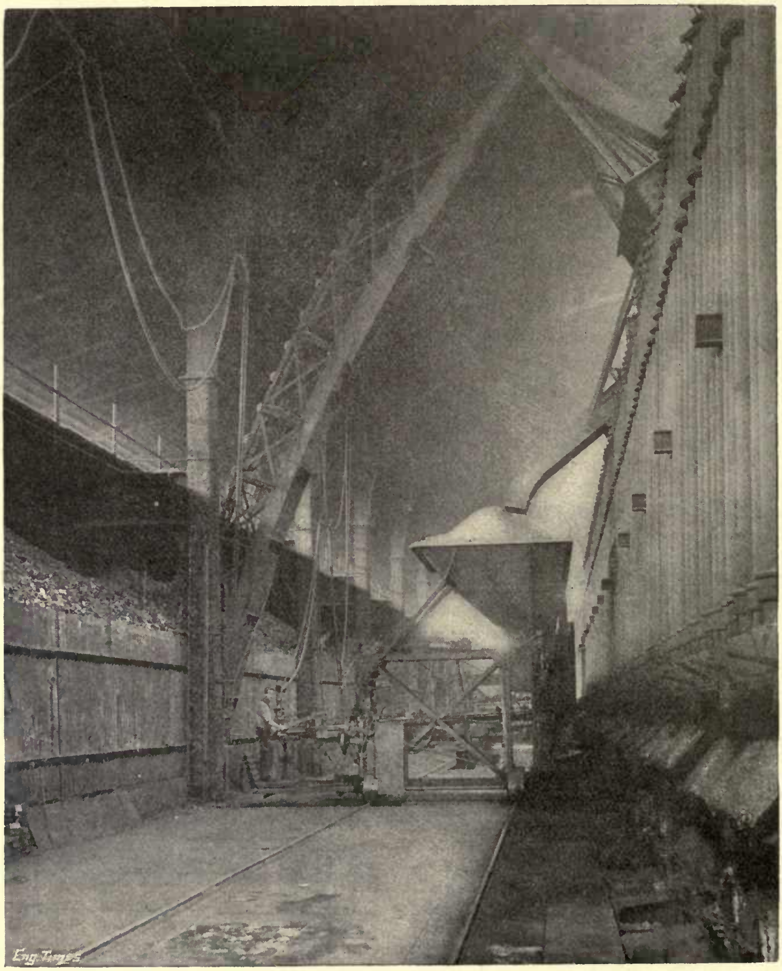


FIG. 23.—ARROL-FOULIS STOKING MACHINERY AT BECKTON GASWORKS.

ram actuates the return stroke. This operation is repeated, five, six, or seven times, as desired, for the complete charging of a retort 10 ft. long, with its $3\frac{1}{2}$ cwt. of coal, or thereabouts. On every return stroke, the valve of the coal drum C is automatically opened, thereby revolving the drum, and allowing the regulated quantity of coal to drop from the hopper for the ensuing stroke. A clever mechanism, consisting of two hydraulic rams with racks working against a spur wheel, which in turn is geared with pawls on to other wheels, gives the travelling movement to the machine. The exhaust water is conveyed by an outlet pipe to a trough F, running the length of the retort house wall, from which it is conveyed back to the original supply tank, feeding the hydraulic pumping engines.

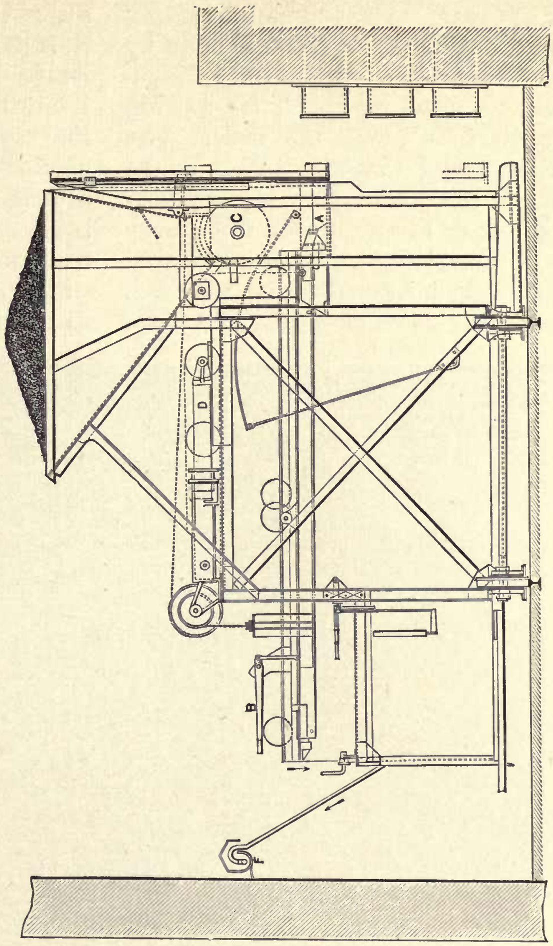
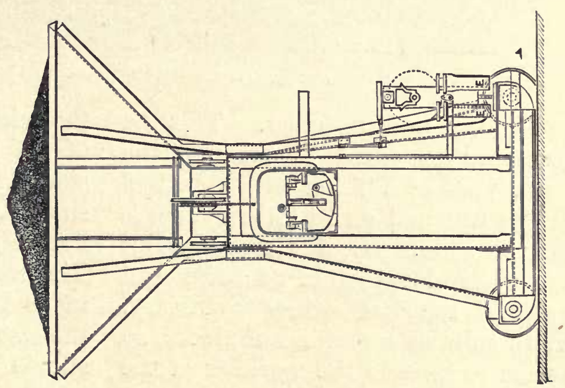


FIG. 24.—OUTLINE OF ARROL-FOULIS HYDRAULIC CHARGING MACHINE.

The hydraulic drawing machine, shown in Figs. 26 and 27, is built on similar lines as the charging machine. There is again a hanging beam carrying the rake rod with its cast steel head K, and two hydraulic rams H, set in operation by the lever I. By raising or lowering this lever, the operator controls the movements of the rake rod, which is kept cool by a water spray from the cylinder L, which receives part of the exhaust water, the remainder returning to the trough by an outlet pipe, as



for the charging machine. The lifting and lowering of the beam is done by the cylinder J, while G is the arrangement, worked by hand, for moving the machine along the rails. The writer found that the action of the slide of the rake rod on the supporting joist of I section soon wore away its bottom flanges. This meant that the whole joist had to be renewed, thus causing loss of time in removing, re-riveting and re-fixing. This he proposed to avoid by forming the main joist of a T bar with two steel angles fastened on to form a course for the slide. By this arrangement the angle pieces could be easily and quickly replaced when necessary. With suitable retort mouthpieces, so as not to impede the working of the machines and with facilities for getting the coke away rapidly, 60 retorts can be drawn and charged by one set of these machines in 60 minutes, though the time taken varies according to circumstances.

The best arrangement of retorts for the economical working of stoking machinery is that which has three retorts in each arch on the same horizontal line. The retorts should be "through and through," that is, without ends or middle dividing walls, so that no space is lost in allowing the rake rod head to get at the back of the burnt-off charge. The most suitable cross section of retort is the ⌂ shape, with a flat or curved bottom, 22 in. wide and 16 in. deep. The retort mouthpieces should be made a little bigger, if anything, than the size of the retorts, and their lids should all be made to shut in the same direction as that in which the machines travel when at work. Generally speaking, the saving by

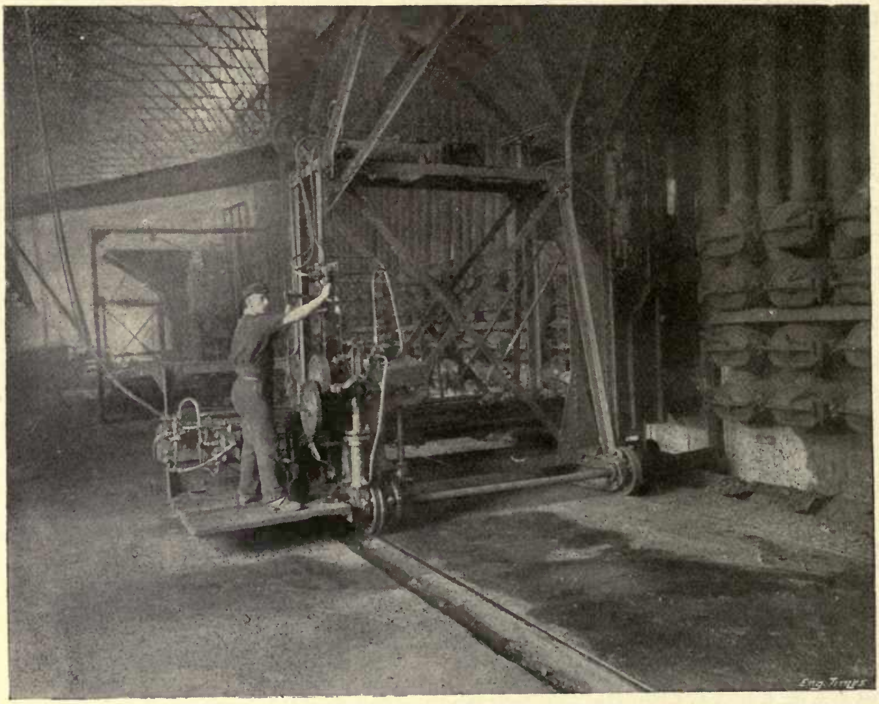


FIG. 25.—ARROL-FOULIS HYDRAULIC CHARGING MACHINE.

the introduction of stoking machinery in the number of men employed in the retort house may be taken at 50 per cent., while the cost per ton of coal carbonised, under favourable circumstances, is about 1*s*. The wear and tear of the machines varies considerably in different cases—from less than ½*d*. to more than 2*d*. per ton of coal. All of these figures, it will be noted, are rather less favourable than those already given in the preceding chapter on inclined retorts. It should also be remembered that, for the most satisfactory and beneficial working of stoking machinery, and for a sufficient return on the capital invested, the gasworks must be sufficiently large to give them, or a complete section of them, their full amount of work during the least busy season of the year. There are very few works sufficiently large to keep all the machines remuneratively employed throughout the whole year, while for the host of small works they are of course altogether out of the question.

It is for these small works that West's manual charging and drawing machines are suitable. From what has already been said, and from Fig. 28, the method of working will be readily followed. These machines are not intended to reduce the labour of stoking to the fullest extent, as is done by the power machinery, but they certainly lessen the labour and reduce the severity of the stoker's work. As will be seen, the charging machine carries its own supply of coal. The charger itself runs on three wheels, and has two semicircular scoops, which a long rod pushes into the retort. The scoops are arranged to charge each retort in two halves, first the farther, and then the nearer, and are overturned one to the right and the other to the left. The drawing machine is of very

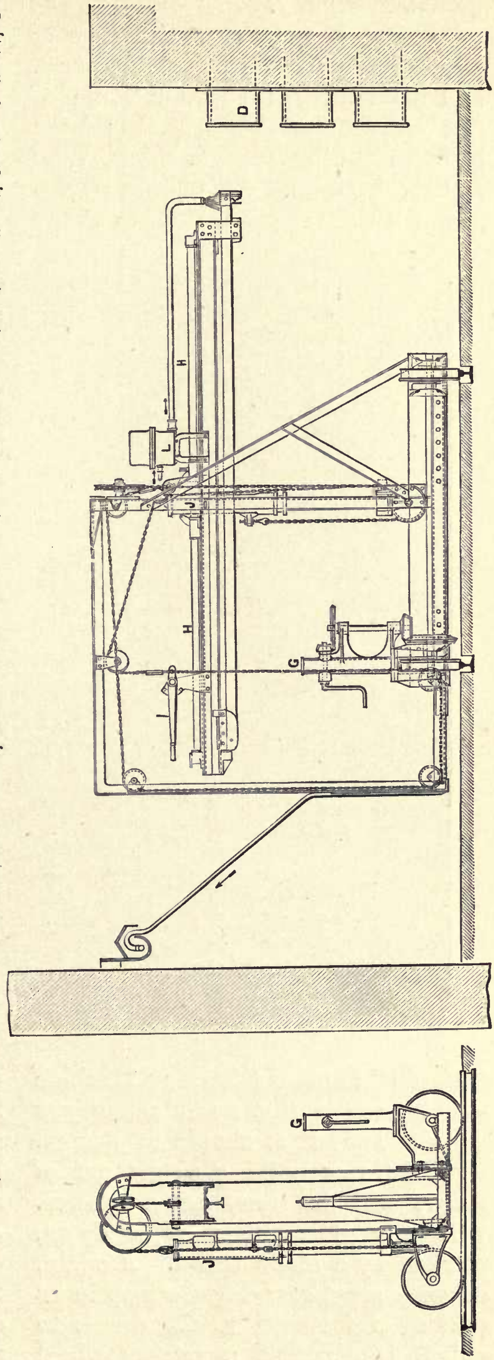


FIG. 26.—OUTLINE OF ARROL-FOULIS HYDRAULIC DRAWING MACHINE.

simple construction. It permits of the use of a heavier rake rod than the stoker would otherwise be able to handle, besides reducing the effort he has to expend.

In the last two or three years another machine, worked by hand, and eminently suitable for some of the very smallest works, has been brought out by Messrs. Biggs, Wall & Co., London. An unique photograph of this machine—known as the "Rapid" Manual Charging Machine—is shown in Fig. 29 as actually at work. That it is simple in design, with little or nothing to get out of order, will be seen at a glance. Primarily it consists of a drum, worked by a chain wheel. A chain, or wire rope, carrying a scoop in its cradle, is fastened to the drum, to which is attached a ratchet wheel and pawl arrangement for holding the charged scoop at the height required. The lifting gear has a short cross travel, which gives sufficient impetus for driving the scoop into the retort, while the whole is supported by and runs on longitudinal rails of 5 or 6 ft. gauge. By alterations in the diameter of the chain wheel the speed and power of the machine can be modified as desired. The initial cost of such a handy apparatus as this is very low, and consequently it has been, and is being, largely adopted at works both at home and abroad. By it the work of three men with scoop charging can be done by two, and it also has the advantage of doing the work quicker, and thereby increasing the make of gas, and reducing its cost. Messrs. Biggs, Wall & Co. are now

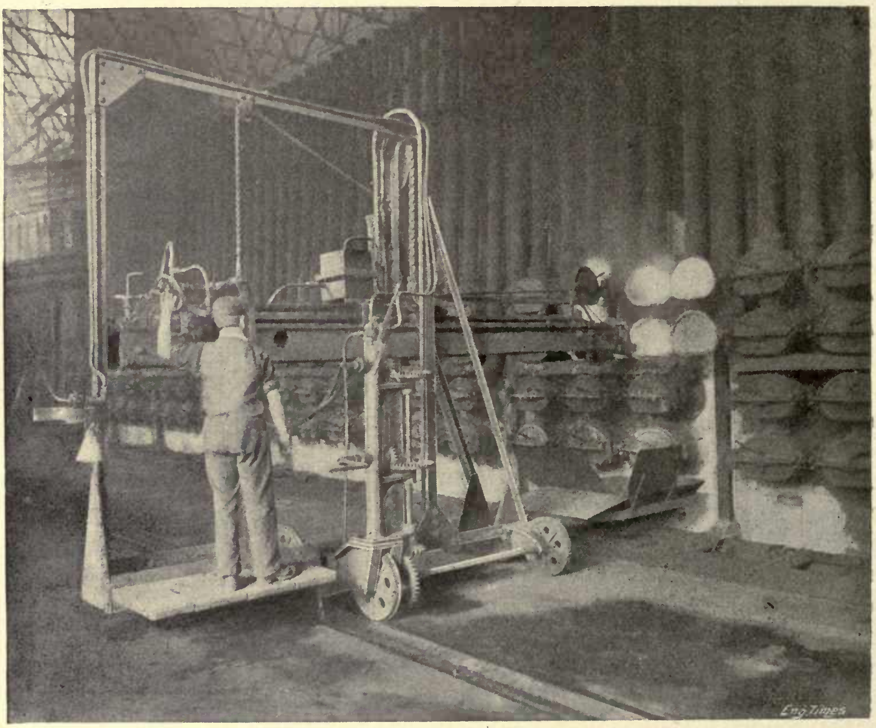


FIG. 27.—ARROL-FOULIS HYDRAULIC DRAWING MACHINE.

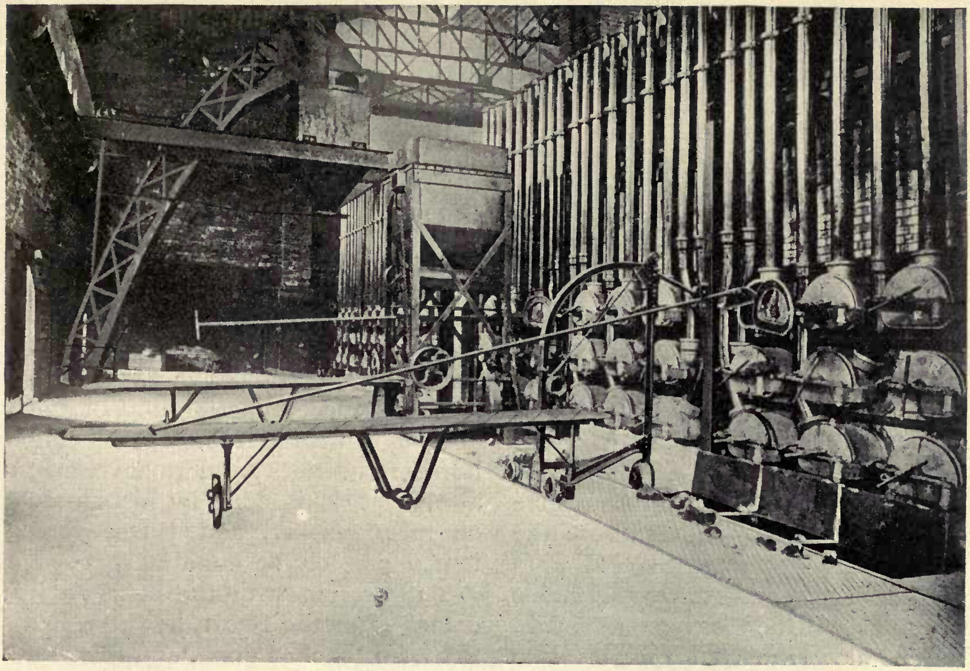
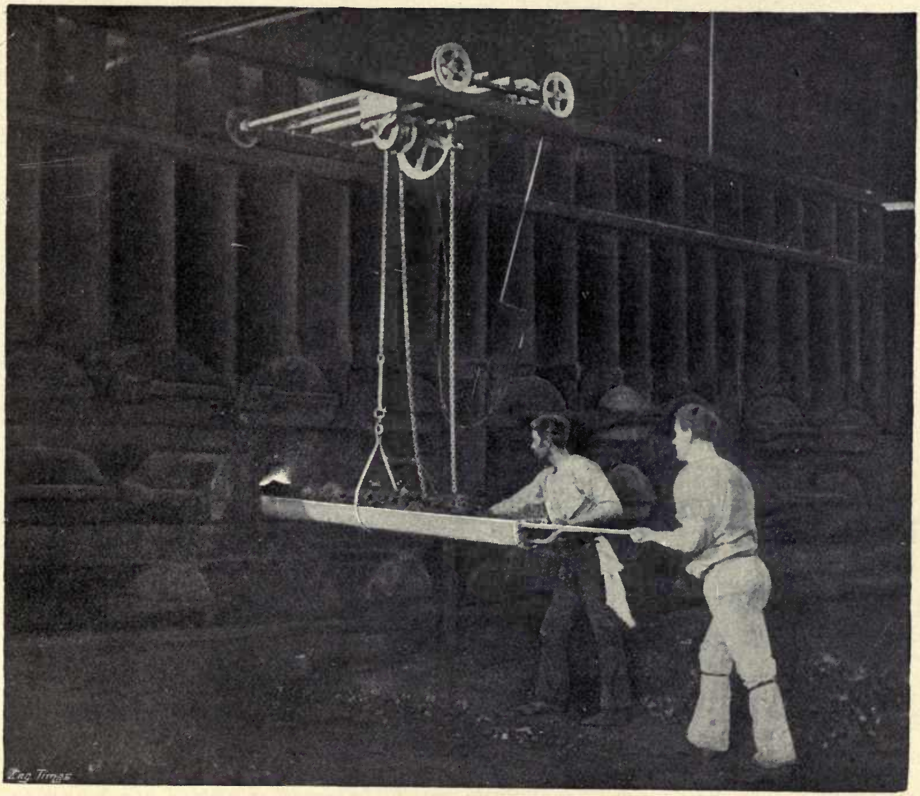


FIG. 28.—WEST'S MANUAL CHARGING AND DRAWING MACHINES.

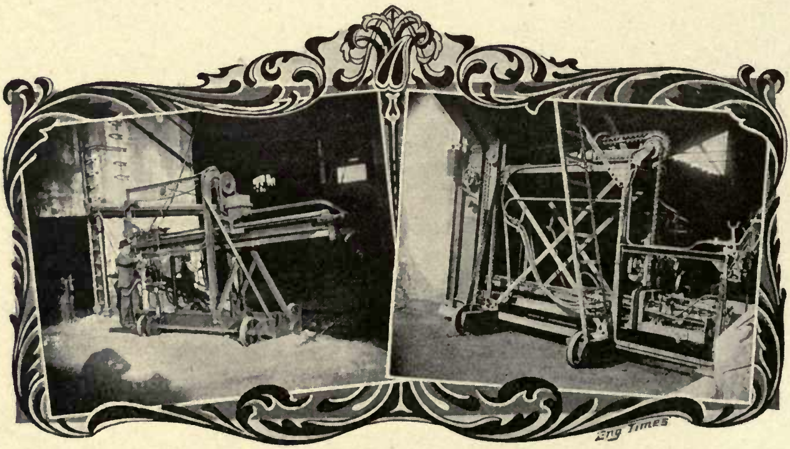


contemplating the application of steam or some other power to this manual machine, which will, no doubt, extend its usefulness among other than the smallest works, and increase still more the economy made by it.

Another arrangement applicable to the charging of retorts in small works has recently been brought out by M. Rouget, of Paris. The inventor's idea is to utilise the return course of an endless chain conveyor, and to combine in the same apparatus the means of supplying coal to the retorts and of taking the hot coke away from them. This is done by feeding the upper or return course of the conveyor, running above the retort mouthpieces, with coal from an elevator, and having suitable openings in the conveying trough, which allow the coal to pass into a shoot or funnel, of the requisite capacity for the amount of coal required for the retort. A supported scoop receives the coal from this funnel, and thus charges the retort in the usual way. The lower course of the conveyor runs in a trough full of water beneath the retort mouthpieces, and receives the drawn out coke, quenches it, and carries it out from the retort house.

We have reviewed, then, various types of machines driven by compressed air, by hydraulic power, and by hand, for the performing of the arduous work of charging and drawing horizontal retorts; and we have seen, also, that it is done by machinery cheaper, quicker, and better than it can possibly be done by man.

The dealing with the coke as it comes from the retort, however, has not been touched upon, and this will form the subject of the next chapter.



CHAPTER IV.

COKE PLANT.

AFTER the charge of coal in the retort has been exposed for a sufficient length of time to the heat of the furnace, it becomes, as it is termed, "carbonised," and only a layer of coke is left as a residual. This coke forms by weight about 70 or 75 per cent. of the original charge of coal, and it will easily be understood that the problem of effectively and economically dealing with this quantity is one of great importance to the gas engineer. In the old days, and even to a large extent at present, the stoker drew the coke out from the retort with his rake, and dropped it into a barrow placed underneath the mouthpiece, while his companion would quench it with water from a hose or bucket. It would then be wheeled away to the coke yard, where it might receive a second quenching, so as to prevent any possibility of its taking fire when heaped up on the coke stack. This sometimes happens, and it is a very serious, as well as difficult and arduous task to extinguish a fire that

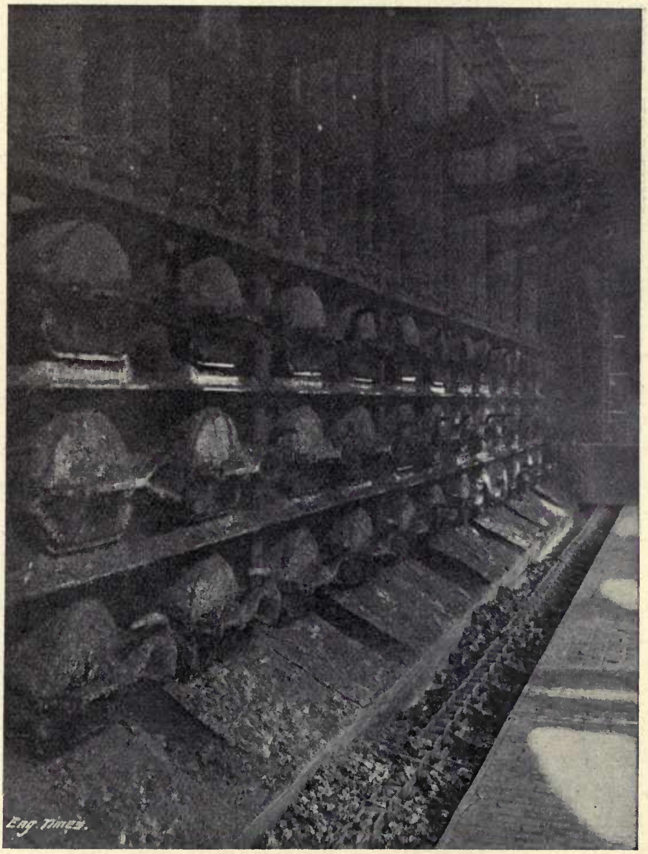


FIG. 30.—HOT COKE CONVEYOR, MADE BY WEST'S GAS IMPROVEMENT COMPANY.

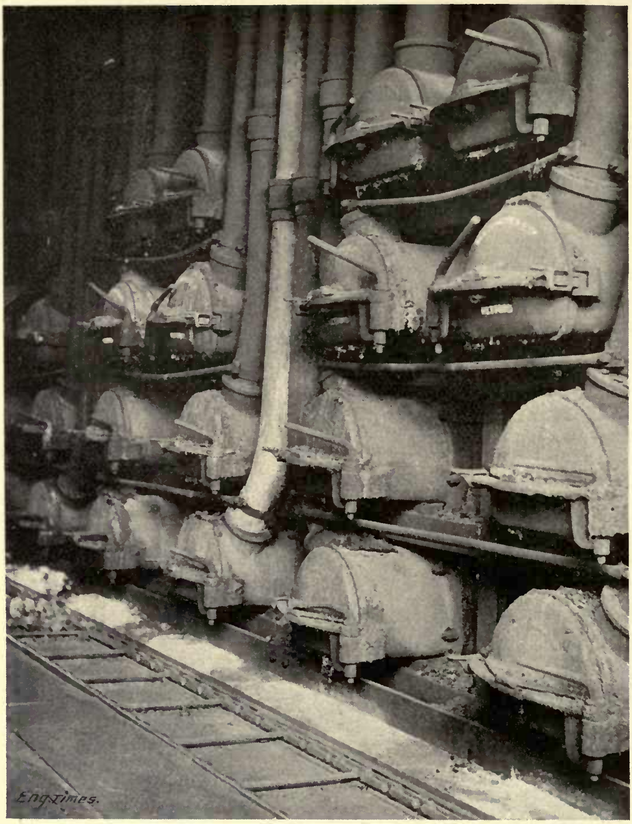


FIG. 31.—THE "DE BROUWER" COKE CONVEYOR, MADE BY MESSRS. W. J. JENKINS AND COMPANY.

has broken out—perhaps in the middle of some hundreds of tons of coke. Special barrows have, of course, been designed and made to facilitate as much as possible their easy filling and emptying, but the labour involved in carrying, quenching, stacking, and loading coke is sometimes as costly as one shilling per ton, and, therefore, every available means should be sought for reducing such an expensive item. There are still many works of importance that have adopted machinery in some form or other for charging and drawing gas retorts, but which still hesitate about the further expenditure required to make their retort houses as automatic and as economically worked as possible. Gas engineers in this respect might well take a leaf out of the book of their electrical brethren, who never hesitate to introduce machinery for conveying their raw material, provided they can see their way to the saving of even a small fraction of a penny. Of course, one reason why the adoption of mechanical arrangements for dealing with coke has been retarded somewhat is no doubt the fact that it is a very nasty, gritty and brittle material to manipulate compared with coal. The former has a grinding and emery-like action on all that it comes in contact with, while the latter to some extent acts as a lubricant itself. Then again, and in consequence, there was the usual outcry of "wear and tear." It was supposed that that would prove an

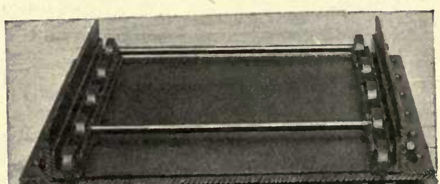


FIG. 32.—VIEW OF THE "DE BROUWER" CHAIN AND TROUGH.

insuperable difficulty to the general adoption of machinery for handling coke. But to-dav there are unmistakable signs that coke conveyors for carrying off from the retort house the principal residual product of gas-works are decidedly becoming fashionable. The experience that has been purchased by the few—amongst whom are Mr. Charles Hunt, of Birmingham, and Mr. John West, of Manchester—is now at the disposal and for the profit of all.

Fig. 30 shows the combined conveyor of these two gentlemen, made by West's Gas Improvement Co., Limited, as applied to a bench of inclined retorts. The conveyor trough is fitted into the drawing stage, while the return chain of the conveyor is seen passing along overhead. The construction of the conveyor will easily be followed from the photograph given. A roller chain runs along a central path, and scraper plates, suitably shaped to the form of the trough, gently carry forward the coke as it falls from the retorts. This conveyor contains the requirements that should be found in all arrangements for a similar purpose; the parts should not be affected by heat; they should be able to be easily examined and renewed; and the conveyor should not turn the pieces of coke over each other, but should cause as little "breeze" or coke dust as possible.

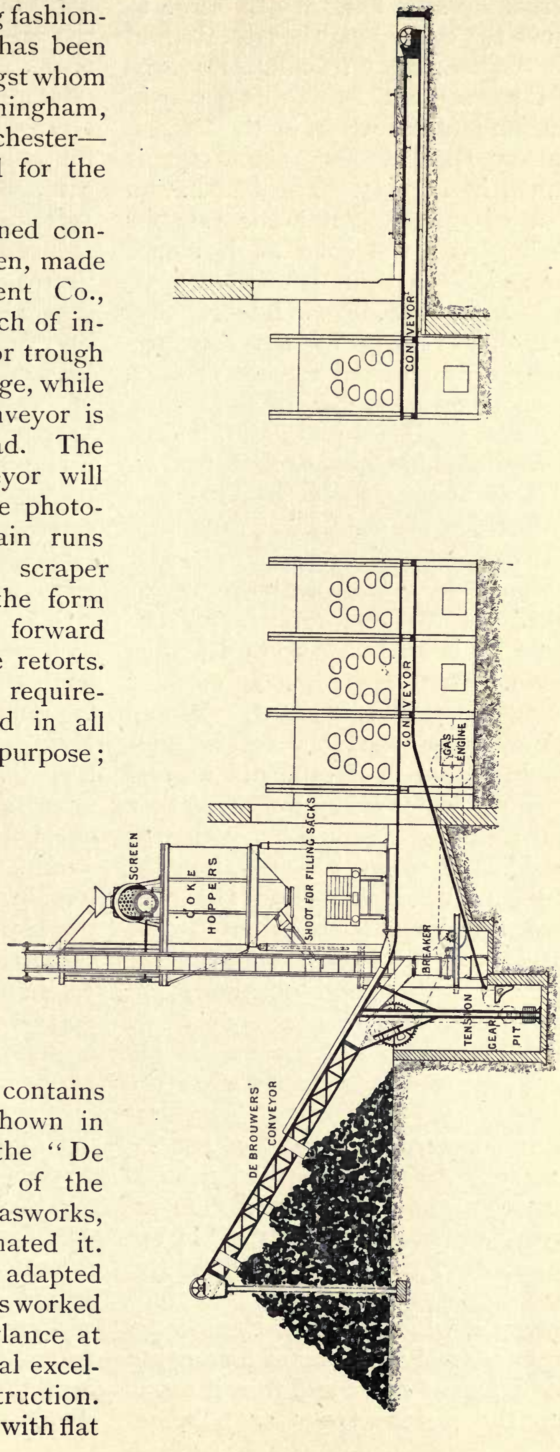


FIG. 33.—OUTLINE OF COKE PLANT AT THE CRYSTAL PALACE DISTRICT COMPANY'S WORKS.

Another admirable hot coke conveyor, which also contains these essential features, is shown in Fig. 31. It is known as the "De Brouwer," from the name of the manager of the Bruges Gasworks, who some years ago originated it. In the case illustrated, it is adapted to a bench of horizontal retorts worked by stoking machinery. A glance at Fig. 32 will show the practical excellence and simplicity of its construction. It is made up of link chains with flat wearing surfaces, and fastened together by stay bars, which serve to move the coke along the false bottom plate of the shallow trough. An outline of the first plant of this kind put up in England at the works of the Crystal Palace District Gas Company, is shown in Fig. 33. The installation is a completely automatic one for dealing with the coke as it comes from eighteen beds of eight retorts, each 20 ft. long, or one hundred and forty-four retorts in all. As the coke is drawn from the retorts by a machine on each side of the bench, it strikes against a plate on the front of the machine, and is thus thrown on to the conveyor. The trough is laid perfectly level, and water is run into it at suitable points so as to keep it cool, and to quench in part the hot coke. As the conveyor leaves the house it is inclined upwards, thus serving, when desired, as an elevator for filling the coke yard. Where the conveyor begins to rise, its sides are increased in depth, and a good stream of water is run into it, so that the coke is thoroughly quenched outside the retort house without in any way inconveniencing the men from the large quantity of steam given off. By these means a great difficulty with some other conveyors has been effectively overcome, as where hot coke is quenched inside the house itself, the clouds of steam produced are a source of considerable nuisance and delay to the workers. As the quenched coke is carried up the rising part of the conveyor, it naturally drains itself of the water, and, if not required for the yard, falls down a shoot upon another conveyor, which elevates it, passes it through revolving screens for sorting into different sizes, and thus it drops into the storage tanks or hoppers. From these, railway wagons, carts, and sacks are automatically filled by the mere pulling of a lever which opens the doors of the hoppers. A photograph of this very successful arrangement is given in Fig. 34. By the courtesy of the engineer of the company, Mr. S. Y. Shoubridge, the writer can testify, from personal observation, to the extreme ease and neatness with which this admirably designed and arranged plant fulfils its important and useful work. Messrs. W. J. Jenkins & Co., Limited, of Retford, who hold the sole right to make the "De Brouwer" conveyor in this country, are to be congratulated on the great success which has attended their first erection of this particular plant. It is reported that the saving by its adoption in the instance described will amount to 5*d.* per ton of coal carbonised, after allowing for full charges for depreciation, wear and tear, etc. Even were the resultant economy less than the figure quoted, the security of the work being properly done, the less amount of supervision required, the reduction of men, the immunity from strikes and other troubles, would all tend to secure an extensive adoption of the system. Learning by experience, it is quite possible, not to say probable, that any future installation on similar lines would be even an improvement on the first. It might be questioned, for instance, whether revolving screens for sorting the coke into the three classes of large, small and dust, are unavoidable, and whether the same degree of success could not be obtained by fixed screens, placed at an angle, thereby allowing gravity to do the work that is now done by gearing. Again, the storage hoppers should be of the most ample size, say,

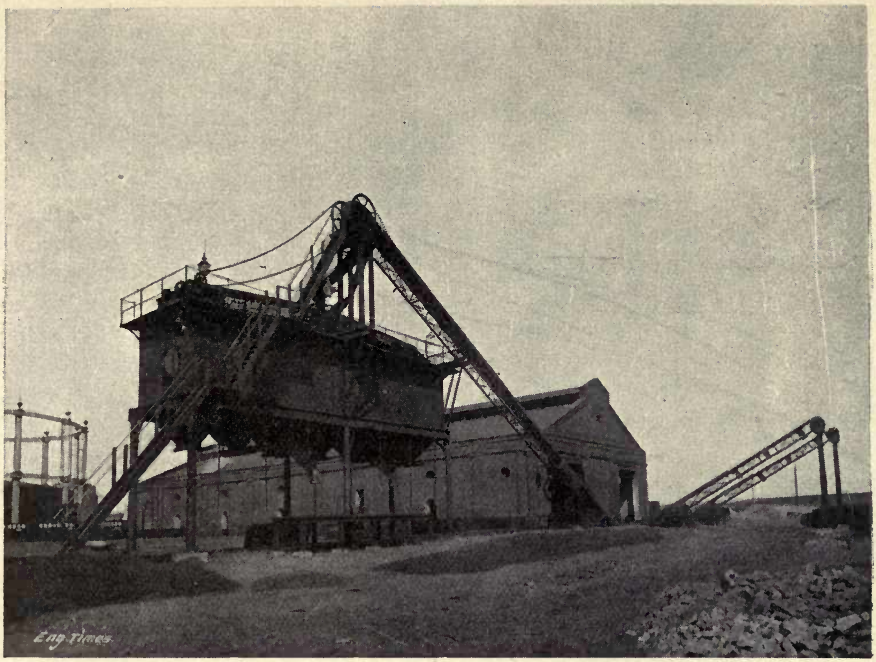


FIG 34.—VIEW OF COKE CONVEYORS, SORTING SCREENS, AND STORAGE TANKS, MADE BY MESSRS. W. J. JENKINS AND COMPANY.

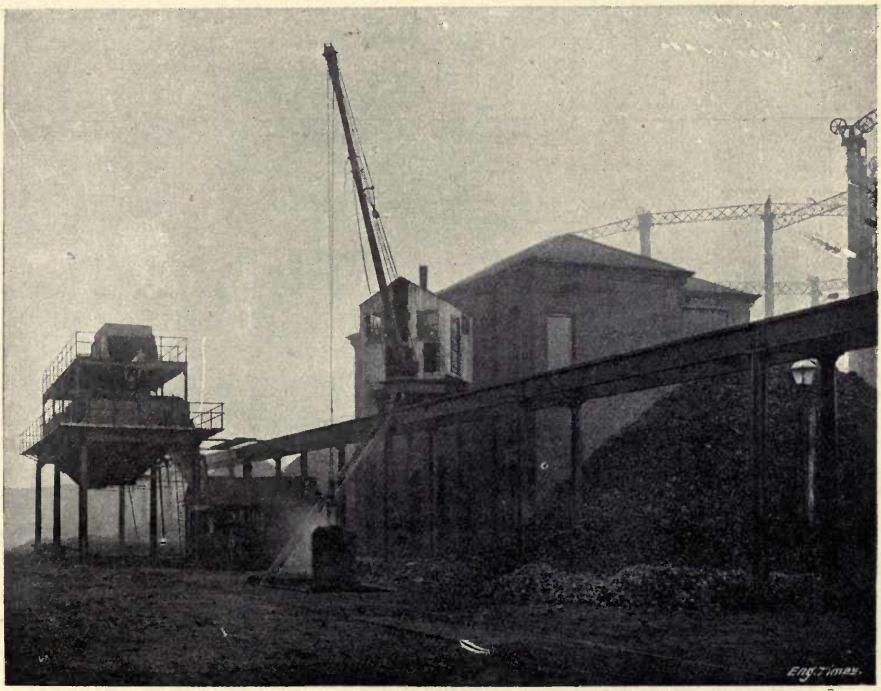


FIG. 35.—VIEW SHOWING TRAVELLING CRANE LIFTING LOADED BUCKET FROM COKE PIT.

to hold forty-eight hours' supply, and perhaps some arrangement of draining the coke dust, which naturally holds most of the water from quenching, might be devised. Coke breakers, too, might be considered superfluous, or simpler means of breaking adopted, if found to be required. When, however, one remembers the army of labourers, with their sacks or their baskets loaded with coke, for the filling of wagons or carts, that one was accustomed to see formerly, it is surely a satisfactory advance to be able to fill a railway wagon in a few minutes by one man only.

As we saw in the case of coal, that it is one problem to handle it economically and mechanically for its direct consumption, and quite another to deal with it equally successfully in the coal stores, so it is with coke. What is the best means of stacking several thousands of tons of coke in the yard? As for coal, so for coke, an elevated railway has been adopted in some works. At Glasgow, for instance, under the engineership of Mr. Foulis, where the drawing stage of the retort house is above the ground level, the coke drawn from the retorts is dropped through suitable openings in the floor into small tip-wagons, running on a 2 ft. gauge railway below. Special, small, but powerful locomotives, attended by boys, pull the trainloads of coke up elevated tipping banks, where it is thrown out and quenched. Parallel to the tipping banks, and about 15 ft. above the ground, runs, on an 8 ft. gauge railway, a steam crane with dredger bucket, lifting each time about half a ton. From this crane, either rotary sorting screens or railway wagons are supplied. Instead of locomotives, tip-wagons fastened to an endless rope are sometimes used, and other varieties and combinations of tip-wagons, with fixed or movable cranes, aerial ways, and travelling conveyors are also in some cases employed. Fig. 35 shows a travelling overhead crane, taking a loaded bucket from the coke pit to place it either in the coke hopper, preparatory to screening, or to deposit it on the stack in yard. This work was also carried out by Messrs. W. J. Jenkins & Co.

American engineers have for a long time been using all kinds of elevating and conveying appliances to a far greater extent than has been done in England, and the study of their methods and practice in saving labour in the transport of materials proves both interesting and beneficial. A photograph of an American belt conveyor, as made by the Robins Conveying Belt Company, of New York, is given in Fig. 36. It shows a conveyor that was put up for the New England Gas and Coke Company at Everett for taking coke from wagons to storage hoppers, and which raises it to a height of 60 ft. This form of combined elevating and conveying belt offers many advantages. The belt itself has an india-rubber covering, thicker in the centre than at its edges, which increases its toughness, elasticity, and durability, the last item varying from four to six years. The conveyor is carried on guide and idler pulleys in the usual way, and needs but little power, attention, or framing.

Apart from the storage of coke in the open yard (for covered stores are not the general practice in England), it is sufficient for a works to have adequate means of speedily supplying its customers' carts, railway wagons, or canal barges. The accompanying illustrations show

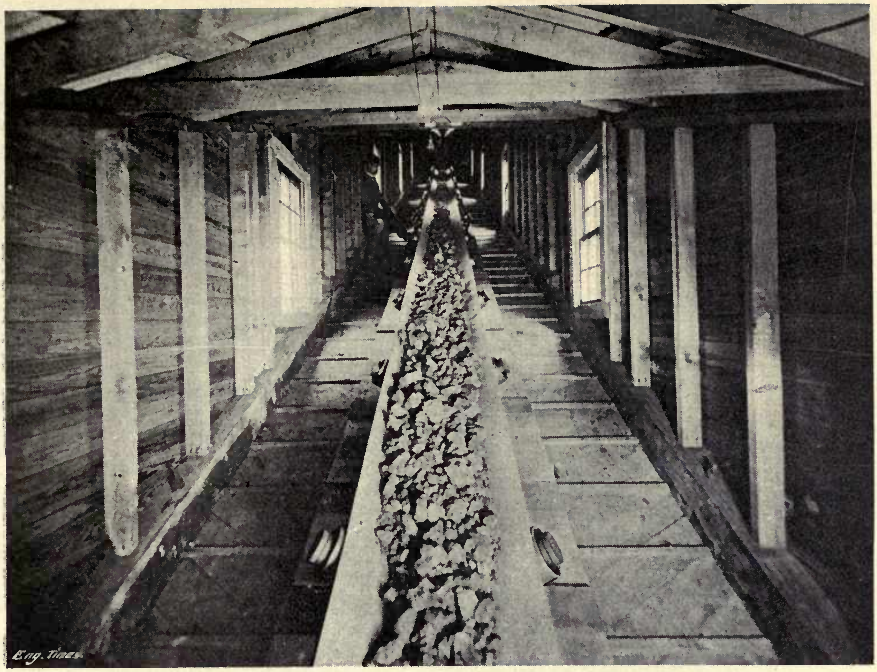


FIG. 36.—THE "ROBINS" BELT CONVEYOR ELEVATING COKE TO A HEIGHT OF 60 FT.

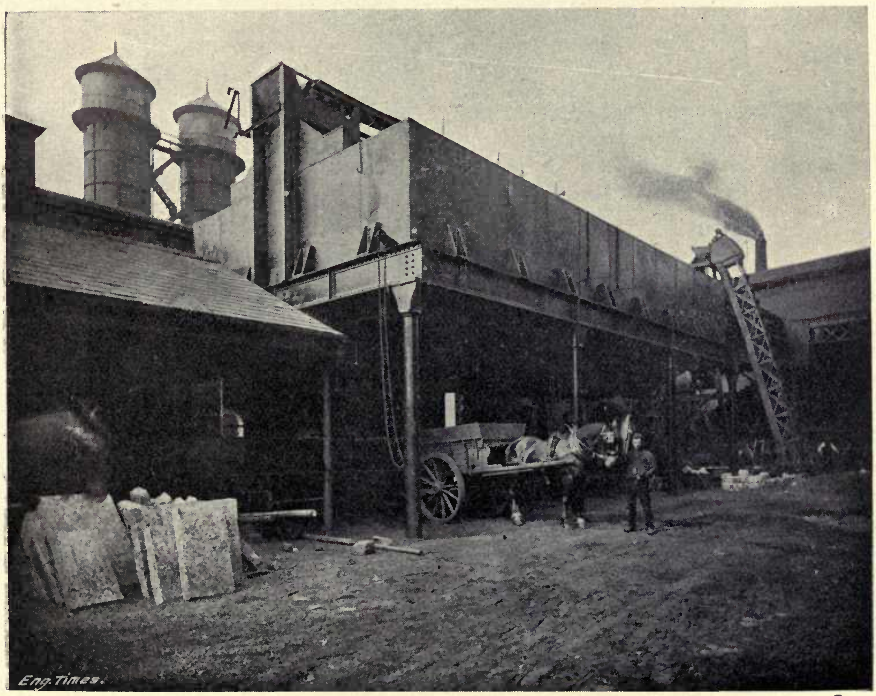


FIG. 37.—COKE ELEVATOR AND STORAGE TANKS FOR FILLING CARTS.

instances of these. In Fig. 37 an ordinary bucket elevator, made by West's Gas Improvement Company, lifts the coke on to a conveyor from which the large storage tanks are filled. The customers' carts, on arriving underneath the hopper containing the required quality, quickly receive their supply, and were weighbridges placed below, the exact weight of coke could be given without the slightest trouble or loss of time. For small works, with the railway siding raised above the general ground level, as is often the case, the simple arrangement illustrated by Fig. 38 for filling wagons with coke may advantageously be adopted. It would be easy to provide for the elevator to be driven from the same engine, which might also drive a coal-breaker and elevator for the service of the retort house. The arrangement in the view was carried out by Messrs. Stott & Co. The next illustration (Fig. 39) is from work erected by Messrs. Graham, Morton & Co., Limited, of Leeds, and clearly shows a push-plate conveyor for filling four coke storage tanks on the side of a canal. It will be noticed that each hopper has a movable shoot, worked by balance weights and chains, and also a door, operated by an attendant from the platform above by means

FIG. 38.—COKE ELEVATOR FILLING RAILWAY WAGGONS.

of rack and pinion gearing. The bottoms of the tanks are so made that, on the doors being opened, the whole of their contents will at once be discharged into the barge. The same firm also makes a conveyor for carrying hot coke from the retort house, which offers some distinctive features. It is of the scraper pattern, and is formed of roller chains, covered

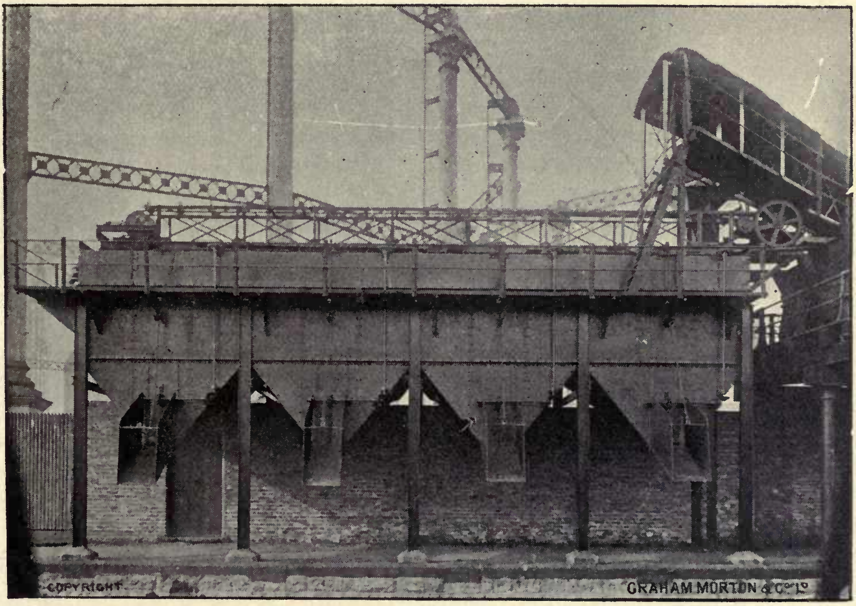


FIG. 39.—COKE STORAGE TANKS FOR FILLING CANAL BARGES.

by deflecting plates, and joined by cast-steel bars of T section, the whole being under water. Other parts are in cast-iron, as being the most suitable material to resist the heat of the coke, and all are very easily renewable.

In this and the preceding chapters on the subject, we have briefly reviewed the most important labour-saving appliances found in gas-works, chiefly in and around the retort house, where, it is commonly said, profits are made or lost. We have seen that, by the adoption of the best means, the whole of the operations included between the arriving in the works of the raw material, coal, to the stacking of its principal residual product, coke, may be performed by machinery, without once requiring to be touched by hand. An altogether different method of producing illuminating gas from that already described, and by which the labour saved is considerable, will be dealt with in the next chapter under the title of "Carburetted Water Gas."

CHAPTER V.

CARBURETTED WATER GAS.

WHAT is carburetted water gas? This question may perhaps be best answered by consideration, in the first instance, of the plant used in its manufacture, and of the process usually followed. We may take as a typical example the arrangement of apparatus introduced into this country, and brought to a great state of perfection, by the acknowledged leaders of such work, Messrs. Humphreys and Glasgow. Reference to Fig. 40 will help to make clear its principal features. It will be seen that there are five main vessels, three of which are concerned with the actual production of the gas, while the other two deal with its partial purification. The former, known as the generator, carburetter, and superheater respectively, are formed of a steel shell, inside of which is a layer of non-conducting material and lining of special fireclay blocks. It will be noticed that the first vessel, or generator, is built in cupola fashion, and has a top door, through which it may be conveniently filled with coke from suitable trolleys, such as the one shown. The generator is supported from the ground floor on columns, which allow of easy access to the bottom door, for the purpose of removing clinker and ashes. Attention to the grate, placed above the ash-pit, is easily given by the side doors, which are clearly shown in the view. Both above and below the fuel bed in the generator are pipes connecting to the second vessel, called the carburetter. Both this vessel and its companion, the superheater, are filled with chequer-work in firebricks of about 2-in. spaces, and by means of which an enormous heating surface is obtained. An oil spray is introduced at the top of the carburetter, and centrifugally distributed, by which the gas from the generator becomes carburetted or enriched. The gas passes from the carburetter to the superheater by a connection at the bottom, and goes up through the latter vessel, at the top of which it is taken off by a pipe, which conveys it to the small tank known as the washer or seal. Inside this pipe, at the level of the stage flooring, is fixed an oil-heater, a simple arrangement of profiting by the temperature of the passing gases to warm the oil, preparatory to going to the distributer in the carburetting vessel. From the washer the gas goes to the scrubber, shown outside the building, and then to the condenser, where its temperature is gradually reduced. Thence, by its own pressure, the gas forces its way into a small or "relief" gasholder, from which it is pumped by an exhauster, passed through purifier boxes to take out its remaining impurities, and thus to the meter to be measured, and to the final gasholder to be stored until required. Underneath the coke stores is seen the boiler for supplying steam to the generator and engines, which drive blowers or fans.

When gas is to be made, a fire is lit on the grate of the generator, which is then filled up with coke. The blowers are afterwards started, raising the fuel to a high state of incandescence, while the gases from it, carbon monoxide and nitrogen, pass through the carburetter and superheater, through the open valve on the top of the latter, and thus away by the stack above. On the chequer-work becoming sufficiently heated, a secondary supply of air is led from the blowers by the underground pipe shown in the view, to the top of the carburetter and the bottom of the superheater. By the regulation of this secondary air supply, the temperature in the two vessels may be controlled as desired. The required heat, or about 1,700° F., having been obtained, the blowing operations, or, briefly, the "blow," as it is termed, must be stopped, and the stack valve on the top of the superheater closed. Steam at 100 lb. pressure is then admitted beneath the incandescent coke in the generator. The result of this is that the oxygen in the steam combines with the carbon of the coke, forming carbon monoxide, and this, with the released hydrogen from the steam and with traces of other gases, makes up what is known as "water gas." This water gas, which has no illuminating power, passes along, as already seen, to the carburetter, where it becomes impregnated with the gasified vapours from the oil spray, thereby giving it the illuminating or enriching power required. The function of the superheater, and in part also of the carburetter, is to render the oil impregnation of a more perfect and permanent character, and for this reason these vessels are known as "fixing" chambers. It will be easily understood that, as a result of these operations, the temperature of the generator fuel, as well as of the chequer-work in the subsequent apparatus, will have fallen considerably. When, therefore, a certain drop has taken place, the actual gas-making, or "run," as it is technically termed, must be brought to an end. First the oil is shut off, and then the steam, which allows the remnant water gas to take up any oil vapours that may have been left behind. Thus we have seen made, first, the "blow," or preparatory air-blasting, followed by the "run," or time of gas-making. These two processes follow each other in regular sequence, so that the actual period of gas manufacture is intermittent. Let us once again commence the "blow," so as to recoup the lost heat. The stack valve must be opened as before until the required temperature has been regained. This being done, the original process is repeated. There is this exception, however, that instead of the steam being admitted below the fuel bed as before, it is introduced above it, so that the work of breaking up the steam into its constituents may be equalised throughout the mass of fuel, the lower part doing no more than the upper. We have found, then, that carburetted water gas is the name given to the gaseous product obtained by the passing of steam through incandescent carbon, and saturated afterwards with gasified oil.

Though it is practically only within the last decade that carburetted water gas has become commercially successful and general in this country, its main principles have a good deal of history behind them. It was Felice Fontana, an Italian, who proposed about the year 1780 to produce a combustible gas from water by passing it over iron and carbon. Subsequent experiments, dating from the first quarter of the present century, with which the names of Vere, Crane, and Ibbetson are connected, were all of them processes for passing water or steam into closed retorts containing coal, tar, resin, or different oils, in course of distillation by heat. Michael Donovan, however,

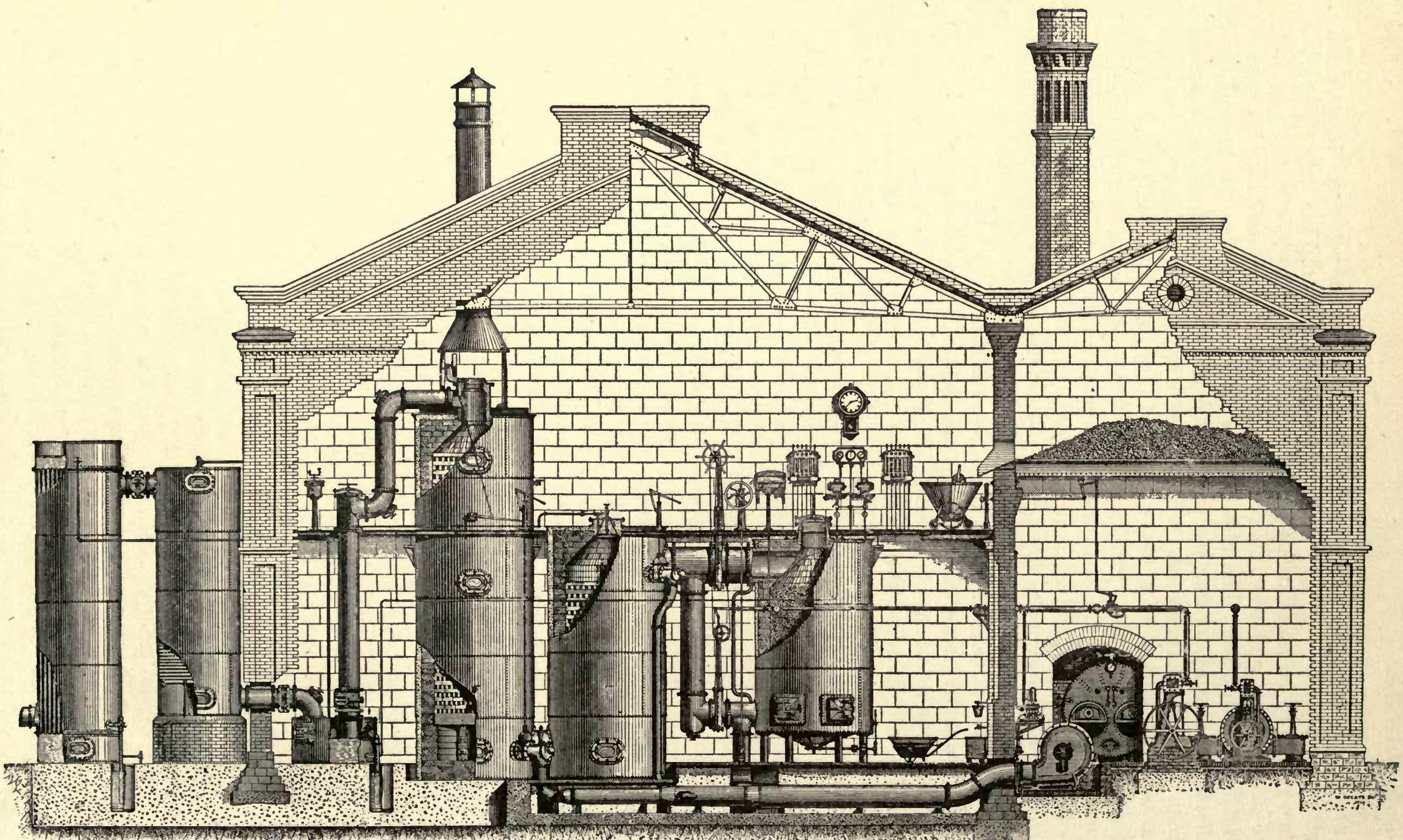


FIG. 40.—MESSRS. HUMPHREYS AND GLASGOW'S CARBURETTED WATER GAS PLANT.

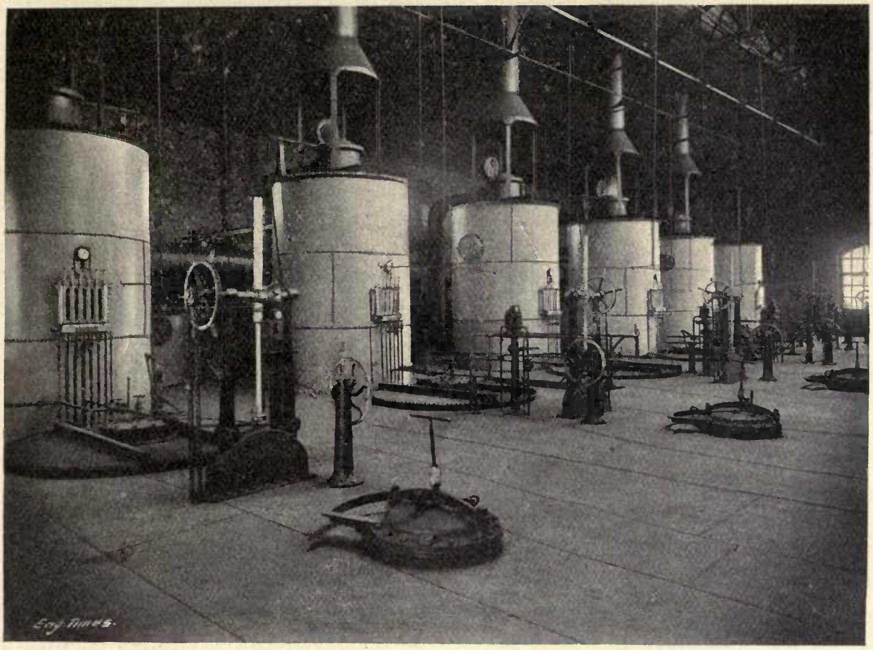


FIG. 41.—WORKING STAGE OF MESSRS. HUMPHREYS AND GLASGOW'S INSTALLATION AT LIVERPOOL.

in 1830 made a step in advance by bringing gas made from the action of steam on incandescent coke into contact with tar oils. This, it will be remarked, shows the germ of the modern idea. Later, in 1845, William Pollard combined the blowing of steam in conjunction with air. Four years afterwards, in the year 1849, was introduced for the first time the important feature of blowing up coke in a cupola to an intense state of incandescence by an air blast, and the subsequent admission of steam. This was done by J. P. Gillard at Narbonne, France. Following in his footsteps comes a crowd of imitators, with modifications in details, until we reach the first apparatus of Professor Lowe, erected at Phœnixville, Pennsylvania, in 1873, which is the basis from which later plants have developed. Carburetted water gas is therefore an offspring of international parentage, Italian, French, American and English.

The present and ever increasing extent of its manufacture is little short of astounding. Particularly in the United States and Canada has its adoption been most extensive, almost to the exclusion of coal gas, for in the former country nearly three quarters of the total gas production is carburetted water gas. It says much for it, that in such a cultured and "solid" city as Boston, not a cubic foot of coal gas is made, the whole of the city's gas manufacture being on the system under review. The possession in North America of large petroleum oil fields, as well as anthracite coal, the coke of which is eminently suitable for water gas purposes, naturally conduced to the preference for this particular gas. Its introduction, however, into England in the eighties was somewhat unfortunate, and it has largely been by the enterprise and experience of Messrs. Humphreys and Glasgow, and their judicious alterations in the plant to meet European requirements, that the initial drawbacks have been so successfully overcome. It does not seem natural to expect, however, that England, with its prodigality of coal, will ever take up the manufacture of carburetted water gas as fully as might otherwise be the case. Of course one of the deciding considerations in the manufacture of carburetted water gas is the supply and price of the oil to be used. As is well known, the two great sources of petroleum are found in North America and Southern Russia, though a third district, and one with future possibilities, is just being opened up in Borneo. It might be thought that the English oil market would benefit from these competitive sources of supply, and, no doubt, to some extent that is the case. But recently, with the price of oil at 5*d*. per gallon, compared with 2½*d*., as it was only two years or so ago, there has not, naturally enough, been a sufficient inducement for gas engineers to extend their plant in this direction. Notwithstanding this, however, as already stated, the progress made in the introduction and extension of carburetted water gas in English gasworks has been enormous, and whereas ten years ago not a single plant was at work, to-day we find scores, capable of producing more than 125 million cubic feet daily. The oil supply for its manufacture has risen from nothing to about 200,000 tons per annum. Carburetted water gas has even had conferred upon it the dignity of a Parliamentary inquiry, brought about in 1898 by a faddist opposition of meddlesome medical men, on the plea of its containing an excessive and dangerous proportion of carbon monoxide. The committee recommended certain limitations to its supply, but hitherto no legislation has been made concerning it, and it may safely be said that, on the score of danger, it would be as reasonable to interfere with the sale of razors as with the supply of carburetted water gas.

Fig. 41, which shows a large installa-

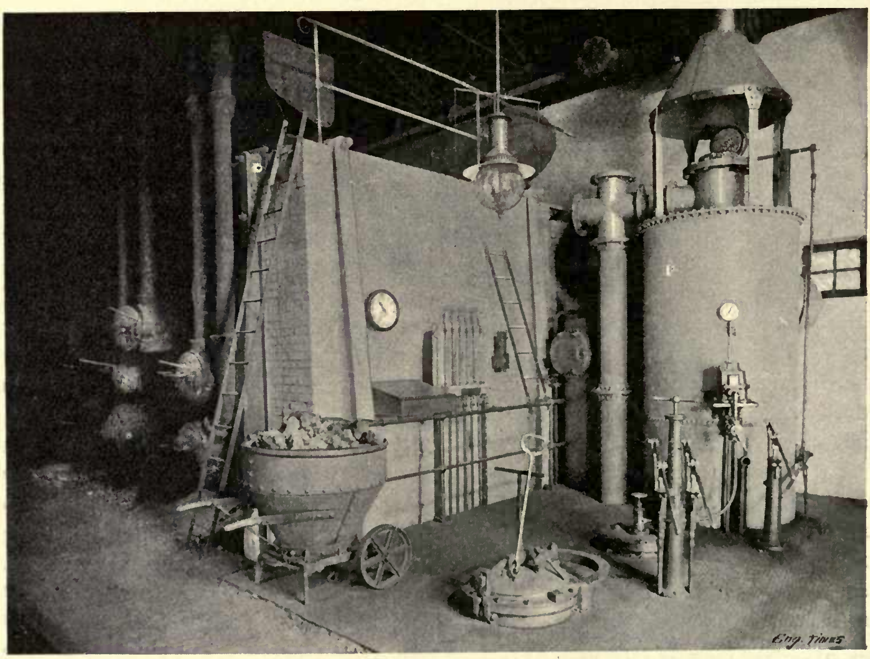


FIG. 42.—"THE OLD AND THE NEW."

tion of carburetted water gas plant, put up by Messrs. Humphreys and Glasgow at the Linacre Gasworks, Liverpool, will give the reader some idea of the working stage. He will, no doubt, be at once struck by its neat and compact appearance, and we may now consider some of the system's advantages, and what are its claims to be considered as a "modern method of saving labour." When it is said that, speaking generally, five men with carburetted water gas apparatus can make the same quantity of gas in the same time as fifty stokers working coal gas plant, nothing more need be added. And then, think of the difference in the labour! The grime and dirt and dust and filth and sweat and force that are the unavoidable accompaniments of coal-gas manufacture, compared with the cleanliness, neatness, and ease of manipulating the "blow" and "run" of carburetted water gas. The juxtaposition of the two systems shown in Fig. 42 may here be noticed. It illustrates, also, another important advantage possessed by water gas apparatus, and that is the smallness of space taken up by it. This may be roughly considered as being one-fifth of the ground space required by coal-gas plant for an equal production of gas. In the illustration given—at Falmouth—the congested state of the works only allowed room for the water gas vessels to be put on the site intended for two arches of retorts, and yet, even here, there is room for duplicating the original installation. The saving in space by the apparatus itself, however, is not so great or so important as that made by the accessory economy of area in the storing of material. Oil may be kept in one-fifteenth of the space required by coal for the production of the same amount of gas. It should also be remembered that the consumption of the gasworks' coke in the water gas generator affords some means of controlling the market, and, at the same time, offers some relief from the large quantities of surplus coke often left over from one season to another.

Another striking quality of the apparatus under our consideration is its immediate and ever ready value in an emergency. To heat up a regenerative setting of coal gas retorts, preparatory to gas making, necessitates considerable care and time—generally, one may say, three days. Water gas plant, on the other hand, may safely be brought into action in three hours. What relief this means, perhaps is only known to those gas engineers and managers who have been in need of and profited by it. But in addition to being a stand-by for any sudden call for increased supply, it is equally of emergency value as regards the quality of the gas made. In case of mishaps, which happen sometimes in the best regulated gasworks, a turn ot the oil-regulating cock above the carburetter will instantly produce the desired effect. In old days, the ordinary coal-gas was enriched, or increased to the required illuminating power, by means of carbonising a certain quantity of rich cannel or boghead coal. Now, however, the same result is obtained by the far handier and more economical process of carburetted water gas, by which the coal-gas may be increased in illuminating power at will, and in an instant. There are yet other advantages accruing from the manufacture of carburetted water gas, but enough has been said to show how beneficial its employment may be, not only to the engineer, but also to the gas worker and gas consumer alike.

As though not to let American engineers have undisputed sway in the arrangement of water gas apparatus, the well-known gas engineering firm of Messrs. Samuel Cutler and Sons, of Millwall, has devised a similar plant to that already described, but into which they have introduced some modifications and improvements. That their apparatus has been adopted and duplicated at such works as those at Plymouth and Southall speaks for its character and workmanship. An illustration of the ground floor of the Southall installation is given in Fig. 43, which shows clearly the generator, carburetter, and superheater vessels, while at the back is seen the washer or seal. In connection with the last mentioned, Messrs. Cutler and Sons have introduced a rotary scavenger, which prevents to some extent the formation of hard matter from the waste products of manufacture, and reduces the so frequent necessity of periodical cleaning. Another important feature in Messrs. Cutlers' plant is their interlocking gear, by means of which it is impossible to have open at the same time both the air and steam valves. Were this not so, the operator, from carelessness or ignorance, might forget to shut all the air valves before turning on the steam, and so an explosive mixture would be formed in the air mains, with possibly disastrous consequences. This interlocking gear successfully and automatically prevents such an occurrence. Other details are a special form of oil sprayer, and gearing for the purpose of reversing the up or down working in the generator, which has already been referred to. As likely to prove of some interest, a photograph of the excellent arrangement of pressure gauges for the Plymouth installation is given in Fig. 44. There are two oil meters, which record the exact quantity of oil used in the carburetter, and gauges showing the pressure of the oil from pumps and in heater, the steam pressure in generator, and, in short, the pressures

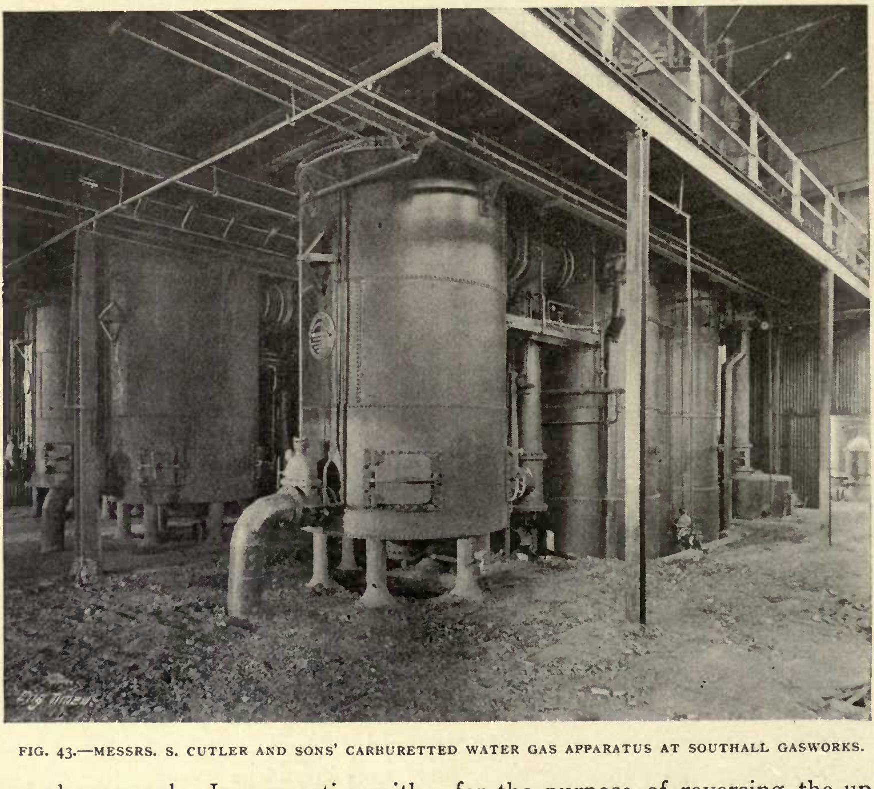


FIG. 43.—MESSRS. S. CUTLER AND SONS' CARBURETTED WATER GAS APPARATUS AT SOUTHALL GASWORKS.

in every division of the plant are plainly indicated under the eyes of the operator, who may be guided accordingly.

Fig. 45 affords a view of the machinery room of a carburetted water gas plant, the one illustrated being from the work of Messrs. Humphreys and Glasgow at Manchester. At the left are the pumps, at the end, the rotary exhausters for drawing the gas from the "relief" holder, and forcing it through the subsequent purifier boxes, and on the right are placed the horizontal steam engines for driving the blowers for the air-blast. In many cases, the fans are belt-driven from high-speed vertical engines, though they may also be driven direct. An illustration is given in Fig. 46 of an engine and Roots' blower, combined on one bed plate, as made by the famous firm of Thwaites Bros., Limited, of Bradford. A vertical tandem compound steam engine drives the blower direct by means of two connecting rods from a single cross-head. To enable the machine to be run for long periods, great attention has been paid to lubrication, which is effected by a central oil reservoir, thereby allowing all parts to be oiled while the engine is in motion. As break-downs in water gas plant must be carefully guarded against, it is needless to say that all machinery is in duplicate.

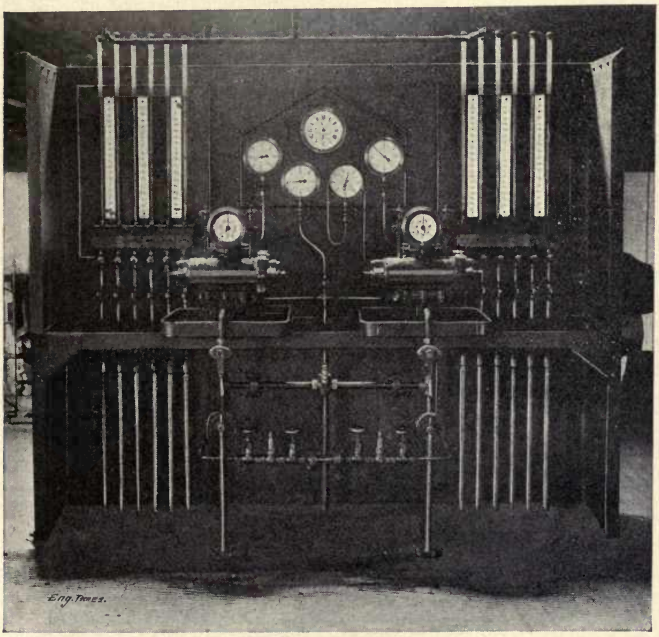


FIG. 44.—ARRANGEMENT OF PRESSURE GAUGES FOR MESSRS. S. CUTLER AND SONS' PLANT AT PLYMOUTH.

We now come to the latest development in carburetted water gas manufacture. This is due to Mr. Carl Dellwik, who in 1896 proposed certain modifications which may have, and indeed one may say are having, far-reaching results. His apparatus consists simply of a generator, built in the usual way, with an internal chamber of loose firebricks for the purpose of storing up heat. It will be remembered that, in the process already described, the gases formed by the air-blast through the deep bed of fuel were carbon monoxide and the liberated nitrogen. Carl Dellwik found, however, that by proportioning the coke bed to the air-blast, reducing the former and increasing the latter, he was able by the excess of air to convert directly carbon monoxide into carbon dioxide. Instead, therefore, of developing only 2,400 heat units per pound of carbon, which is the number produced in forming carbon monoxide, he developed 8,080, or $3\frac{1}{3}$ times more heat units by his production of carbon dioxide. The result of this is that the time of the "blow" is shortened, and the duration of the "run" is lengthened. In the older processes, the air-blast continues for about ten minutes, while the gas-making period, or steaming, lasts just about half that time; in the Dellwik system, the "blow" is over in two minutes, while the "run," or water gas generation, continues for eight minutes or more. As a consequence of all this, the Dellwik generator will produce double the quantity of water gas than was formerly possible, with the same amount of fuel and labour expended. And what about its enrichment? This is done quite separately, by adding to the water gas benzol vapour.

The corporation gasworks of the Prussian town of Königsberg, a town of 165,000 inhabitants, and celebrated as the birth and burial place of Kant, were the first in which this new system was adopted. A photograph of the two Dellwik-Fleischer generators, erected at these works in 1898, is given in Fig. 47. The coal gasworks had in every particular reached their utmost limit of production, and the gasholder storage was only 30 per cent. of the daily make of gas, so that, with an increasing consumption, the management were hard put to it to meet the winter's demands. The speedy installation of the Dellwik water gas plant, and its most successful results in actual working, saved the situation. At Königsberg, the water gas is benzolised after being taken from the relief holder, and then mixed with the coal gas before entering the main gasholders. In adopting the process at Erfurt, in Saxony, the water gas, in the proportion of about 25 per cent., was mixed with the coal gas in the hydraulic main above the retort benches. The mixture was carried

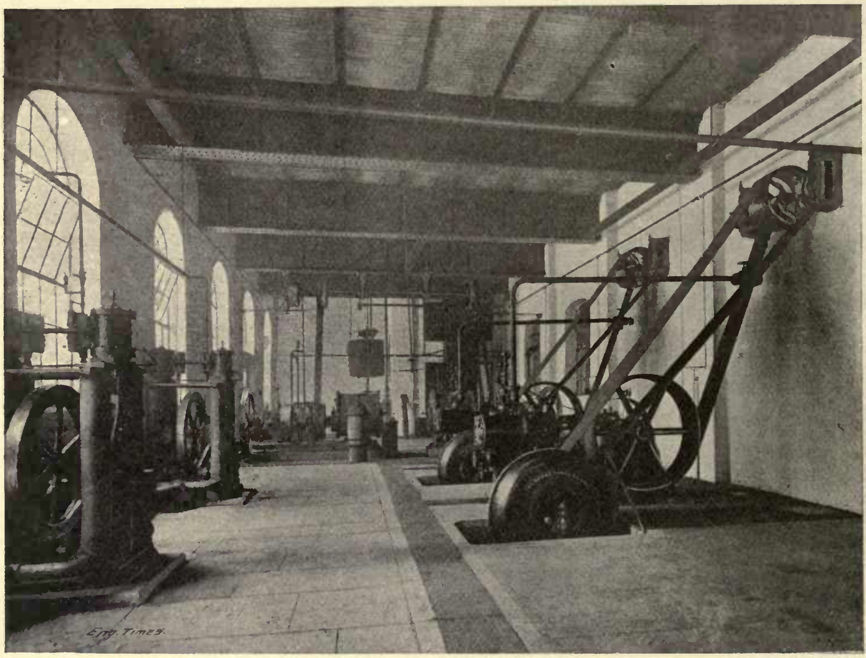


FIG. 45.—MACHINERY ROOM AT MANCHESTER IN CONNECTION WITH MESSRS. HUMPHREYS AND GLASGOW'S CARBURETTED WATER GAS PLANT.

along through the different coal gas plant in the ordinary way, and afterwards carburetted with benzol. It was found, however, that leading the water gas into the hydraulic main interfered to some extent with the normal working of the retorts, and, therefore, the original arrangement was modified by mixing the two gases in the foul main before the condensers. The early mixing of the water and coal gas has proved a source of considerable economy in the quantity of benzol used, no doubt owing to the former absorbing some benzol contained in the coal tar vapours. It may also be thought, as suggested by Prof. Lewes in a recent lecture, that the leading of raw water gas direct into the coal gas retorts might be productive of beneficial and economical results, owing to analogous reasons. The idea is that by hurrying the stream of coal gas out of the red-hot retort by means of the introduction of a flow of water gas, the breaking up of valuable hydrocarbons will be avoided, and their absorption by the water gas may be attained. Thus the make of gas per ton of coal would be increased, and also its illuminating power might be raised. In short, partial, if not complete carburetting of water gas might take place in the coal-gas retort itself. It is interesting to know that an experiment on such lines is being made at the works of the Crystal Palace District Gas Company, on six beds of eight retorts each, placed horizontally. The retorts are twenty feet long, through and through, with two hydraulic mains, one of which will be shut off. The water gas will be led to the bench by a six-inch pipe, provided with a regulating valve, and smaller take-off mains will carry the gas into one end of each retort. The resultant mixture will pass

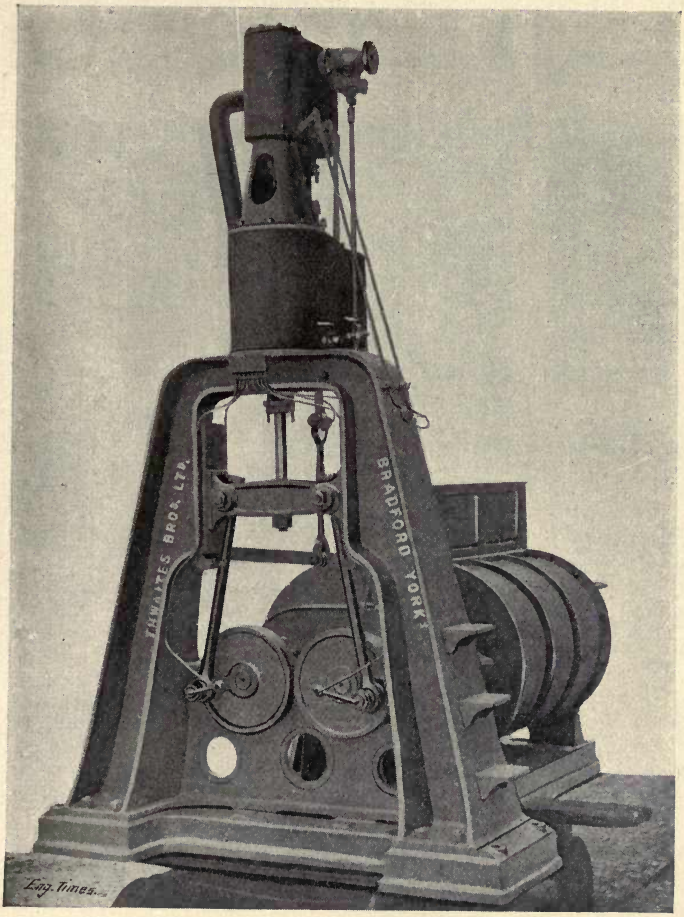


FIG. 46.—HIGH SPEED VERTICAL STEAM ENGINE AND ROOTS' BLOWER COMBINED ON ONE BED-PLATE, AS MAY BE USED FOR CARBURETTED WATER GAS INSTALLATIONS.

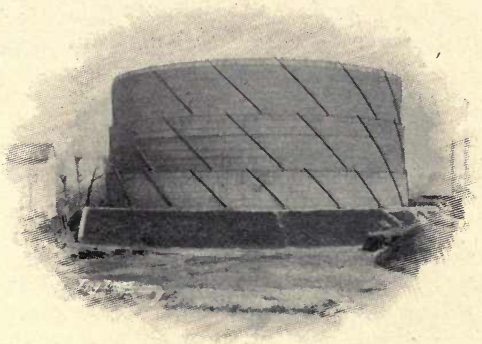
off at the other end, up into the single hydraulic main, and so away. The results of such an experiment will undoubtedly prove of great interest, and possible importance, to the gas industry generally. The writer thinks that a bench of inclined retorts would lend itself even more suitably to treatment in the way suggested. For it has already but one hydraulic main, and the coal-gas is taken off, for mechanical and other reasons, from the lower end, contrary to the natural flow of the gas, and therefore the introduction of a hurrying current of water gas would seem doubly suitable.

It may be asked why benzol is chosen for the enriching material. The answer is to be found in the present high prices of petroleum oil, as already noted, the existing low cost of benzol, owing to its increasingly large output from coke oven recovery plants, and lastly to its well-known high carburetting value. The prohibitive import duties of Continental countries on petroleum have hitherto successfully stifled any possibility of the erection there of any carburetted water gas plant, but it remains to be seen whether some countries, Germany at least, will not now be able to profit by benzolised water gas. It may here be mentioned that in this country, for some time past, we have had a very admirable, compact, and safe benzol carburetting apparatus, known under the name of the "Whessoe-Munich," and made by the gas and general engineering firm of the Whessoe Foundry Company, Limited, Darlington. Such a carburetter may be very advisedly and economically used in conjunction with Dellwik water gas.

FIG. 47.—THE GENERATORS OF THE DELLWIK-FLEISCHER WATER GAS PLANT, KÖNIGSBERG.

Thus far we have only referred to benzolised water gas as an auxiliary to coal-gas manufacture, serving to increase its illuminating power as required, and acting in precisely the same way as carburetted water gas plants hitherto. It must not be overlooked, however, that some small towns, Brummen, Osterfeld, Warstein, and Wiborg, are using the gas from Dellwik-Fleischer generators as water gas, pure and simple, without carburetting or enriching it in any way. This is, of course, quite possible and practical where all the burners are on the Welsbach incandescent system, and it has been remarked that such burners give an even more brilliant light, when using a mixture of coal and water gas, than with the former alone. With gas engines, also, the use of water gas is both economical and satisfactory, as engines may be had which need only thirty to thirty-five cubic feet per horse-power-hour, and the clean character of the gas reduces clogging up of the valves, and other working parts in contact with it. It is not surprising, therefore, to know that more than one large industrial concern has established a Dellwik water gas plant to serve all its requirements in the way of light, heat, and power.

The present tendency, both within and without the gas industry, is toward the reduction of the actual illuminating power of the gas supplied. This common-sense movement has also been confirmed by a Parliamentary committee approving, in May, 1900, of the South Metropolitan Gas Company's Bill for the reducing of their London gas from sixteen to fourteen candle-power. At last the fetich of sixteen, and higher, candle-power gas has been thrown down, and the reasonable and more economical course may be followed of supplying a lower quality gas, which, properly consumed in proper burners—not the barbaric "batswings" of a bygone day—will given even better illumination than formerly. May not still further progress in this direction be looked for? With coal at the present high price, and some clamouring for its export taxation, and others concerned for its ultimate exhaustion, with the North Londoner privileged to pay, at the end of this enlightened century, 3*s.* 5*d.* for every thousand cubic feet of gas he uses, with the competition of the undeniable advantages of the electric light, surely the gas industry generally will do well to examine carefully its condition, and make sure that nothing is left undone, internally or externally, for gas shareholder, gas worker, or gas consumer towards economy of manufacture and reduction of price. The plants described and the processes mentioned in this chapter all tend to that end.



CHAPTER VI.

PURIFYING PLANT.

WE now come to the last department of gasworks in which any great opportunity presents itself for large economy of labour. It is generally known under the name of "the purifiers." To understand properly what the functions of these vessels are, and what are the problems of labour-saving connected with them, it may be as well to glance for a moment at the impurities contained in coal-gas as it leaves the retorts. These are principally tar, ammonia, carbonic acid, sulphuretted hydrogen, and other sulphur compounds. The first two are completely eliminated by condensers and scrubbers of various forms, which do not come within the scope of the present subject. With the remainder the purifying plant, or the purifiers, are concerned. At the commencement of the history of gas lighting it was found that, to make the industry of practical use, the removal of these impurities was imperative, the most pernicious one being sulphuretted hydrogen. Thus at Coventry, in 1805, lime was mixed with the water in the gasholder tank, and stirred at intervals to prevent settling, the effect being that the gas, on passing through it, lost some of its impurities. This, traced back to the beginning, was the origin of the purifier box. Two years later, in the lighting of the Catholic college at Stonyhurst, Lancashire, Clegg adopted a separate vessel containing lime-water, for the purpose of purifying the gas. It was soon found, however, that, although entirely efficient, the resultant material, on being removed from the purifier box, was so obnoxious in character that other means had to be resorted to. Thus quick-lime was adopted, being first reduced in size, and then well watered. This proved successful in every way, taking from the gas both the carbonic acid and the sulphuretted hydrogen, and this means of purification still continues to be the most prevalent in England. It was not until some years afterwards that the valuable properties of oxide of iron for eliminating the sulphuretted hydrogen from coal-gas were discovered. This material, mixed with calcium chloride, was first brought into notice by Laming in 1849, but it was Hill who, later in the same year, proposed using oxide of iron without other chemical admixture, treating it merely with sawdust, to render the material permeable to the gas passing through it. A combination in separate purifying boxes of these two substances, lime and oxide of iron, forms to-day the means whereby illuminating gas is rendered free of impurities and domestically usable.

From the original Stonyhurst lime-water cast-iron box, but four feet square, we have to-day the lime and oxide purifiers measuring scores of feet each side, made up generally of plates bolted together, of the standard size of five feet, handed down to us from the earliest days of gas manufacture. Instead of boxes containing a few pounds of material, we now have vessels into which 100 tons and more are placed, and it is with the labour-saving problems connected with the handling of such large quantities that this chapter proposes to touch upon. It is not possible, however, to effect such economies with purifying material as can be done with coal and coke, for the latter are continually to be dealt with, while the former require only intermittent handling. There is also, approximately, but one-twentieth of the quantity of lime and oxide of iron used in a gasworks, as compared with the amount of coal and its residual. Notwithstanding this, however, the judicious arrangement and working of the purifier boxes, their economical and rapid filling and emptying, may exercise an appreciable effect upon the fortunes of a gas undertaking. Let us first see what the exact description of a purifier amounts to. It is a cast-iron vessel, made up of plates each about five feet square, set upon a firm foundation. The top part of the plates is of U section, into which water is placed for the purpose of sealing, or preventing the escape of the gas. The sides of a cover, made up of plates and stiffened with bars of different sections, stand in these water lutes, as they are termed, and the whole cover over the box may be lifted and removed at will. Inside the purifier box, and supported from its side plates, are sieves in wood, which carry the purifying material, be it lime or oxide of iron. The number of the tiers of sieves in each purifier varies according to the material used, and the depth of the box, though, as stated, it is generally five feet. With lime, there are often four layers, each about four inches deep; while with oxide of iron, two layers are usually employed, or sometimes only one, about three feet in depth. The gas, entering through the bottom of the box, passes through each layer of material, and then on through similar layers in other boxes, which generally number six in a set. It will be understood, then, that it is no light labour to place the sieves or grids, arrange carefully and properly the required bed of material in each layer, and, when the lime or oxide of iron has done its duty, and is sufficiently impregnated with the impurities of the gas, to take off the purifier cover and empty the foul material. At the present time, the most usual arrangement is to place the purifying boxes well in the ground, leaving the water lutes, or about two feet, standing above. The material used for purification is then brought alongside the boxes in wheel-barrows, or in narrow-gauge waggons, tipped into them, and spread by a man placed inside the vessel. In changing such a purifier, there is the labour of shovelling out the exhausted material, and the wheeling away of the barrows. On such a system as this there are three modifications which suggest themselves, and of which photographs are given in Figs. 48, 49, and 50. In the first, the purifiers are sunk in the ground as mentioned, but a floor is added above for the preparation of the material. In the second case the positions are reversed, the boxes being placed on the upper floor, while the ground floor is used for the material itself. This, it may be added, is the more general form adopted. The third shows a similar arrangement to that of Fig. 49, but with yet another floor above the purifying vessels. All the examples given were carried into execution by a firm of contractors justly celebrated for this class of work, Messrs. R. & J. Dempster, Limited, of Manchester. The designs and arrangements adopted also show that ingenuity and ability one would expect to find from the engineers concerned in each case respectively:—Mr. P. G. Winstanley, of Wolverhampton; Mr. H. Morley, M.Inst.C.E., of Cardiff; and Mr. Thomas Bower, Assoc.M.Inst.C.E.,

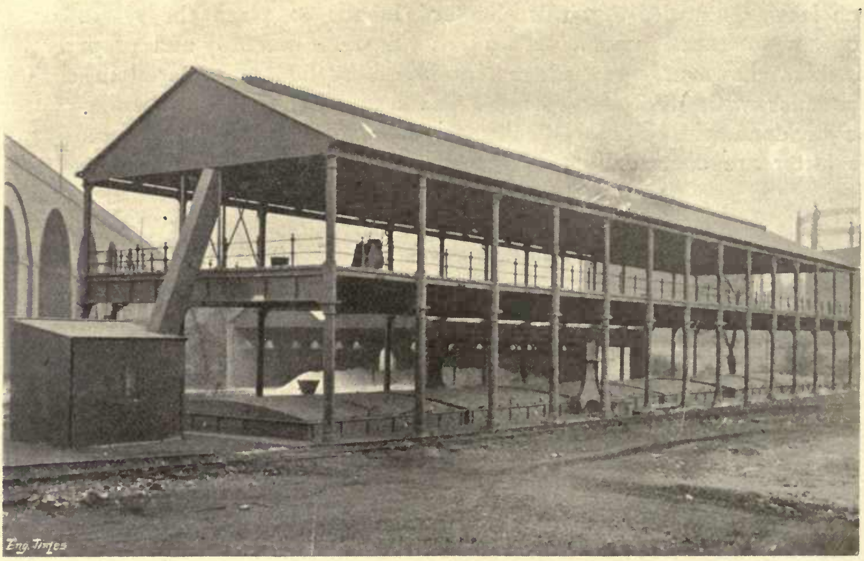


FIG. 48.—VIEW OF PURIFIERS IN GROUND AND FLOOR ABOVE.

of Hartlepool. The schemes of these engineers and managers of prominent gas undertakings are sufficiently important and interesting as to repay a little

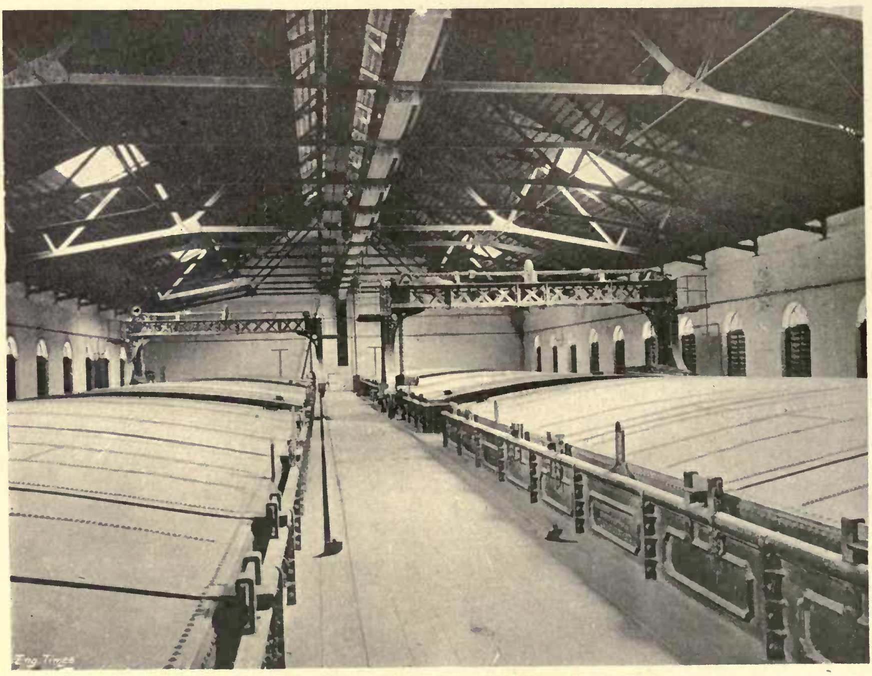


FIG. 49.—VIEW OF PURIFIERS ON UPPER FLOOR AND BELT CONVEYOR.

further description. The ground purifiers of Fig. 48 are emptied by means of buckets lowered into them from a travelling hoisting apparatus, which is placed above the upper floor. The material, oxide of iron, is spread over this for the purpose of revivifying it, and when it is again ready for use, it is dropped through circular openings, of which there are four to each box, direct into the purifiers below. Reference to Fig. 51, which shows the upper floor, the boxes. Attention may also be drawn to the neat apparatus for lifting the purifier covers, when the material in a box has to be changed. The belt conveyor is fed by an ordinary bucket elevator. The third view (Fig. 50), with its two storeys, has the advantage of a very complete railway system in connection with it. An overhead railway, for the coal service of the works, is on the level of the top floor, while a low-level railway for dealing with the

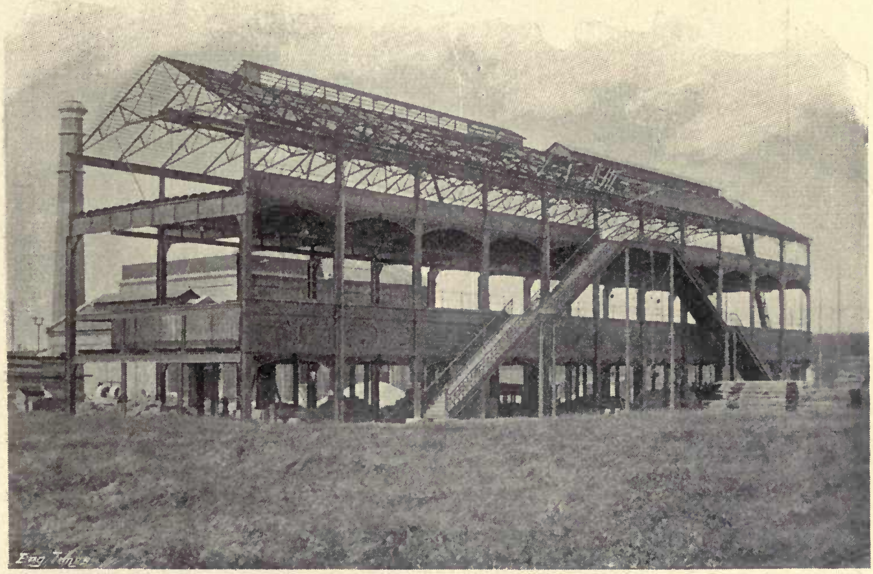


FIG. 50.—VIEW OF A DOUBLE-STAGE PURIFIER HOUSE.

hoisting apparatus, buckets and opening, will make this clearer. Reverting to the second illustration (Fig. 49) a good view is obtained of the admirable construction of the boxes and of the covers. The holding down catches of the latter will be noticed, which serve to keep the covers in position against the pressure of the gas which would naturally tend to lift them. The purifiers in this instance are filled by a canvas shoot, supplied from the central endless belt, shown in the roof, while they are emptied by gravity through suitable openings in the bottom of the coke runs on the ground. These two railways can therefore be easily utilized for the purifying material: the high level for bringing in the lime and oxide, and the low for taking away the spent matter. The boxes will be emptied, as in the previous instance, through openings in the bottom plates, and the oxide of iron to be revivified for further use will be taken in hand-trucks to an elevator to be lifted once again to the top floor. Opinions are divided as to the respective merits of the ground floor, single, and double stage arrangements of purifying plant. The probability is

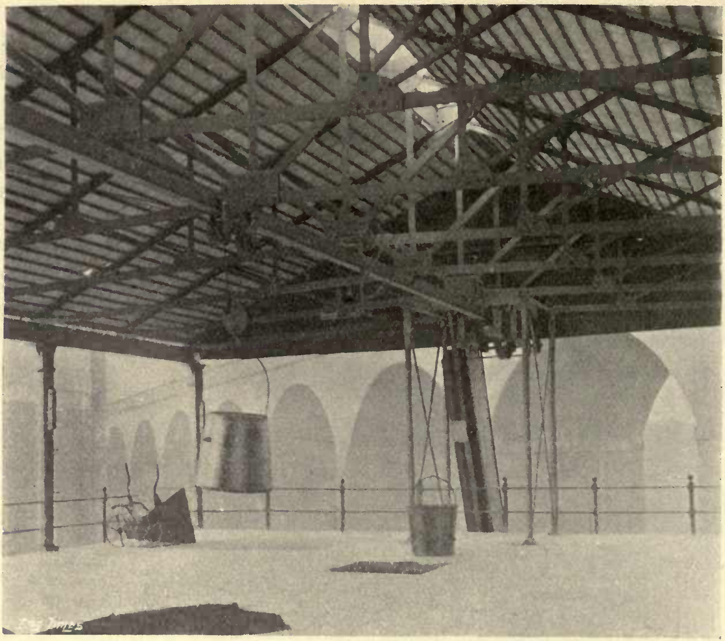


FIG. 51.—VIEW SHOWING REVIVIFICATION FLOOR ABOVE PURIFIERS, BUCKETS, AND HOISTING APPARATUS.

that each has its advantages over the others in certain conditions, and only local considerations and experience can decide as to the best course to be followed in each case. The writer's own experience, however, leads him, in a general way, to lean to the opinion that, for the most economical and efficient working, it is fully justifiable to incur the increased capital expenditure required by a two-floor house, and to raise the material by hoists, or by elevators in conjunction with band conveyors. The last are particularly suitable for such

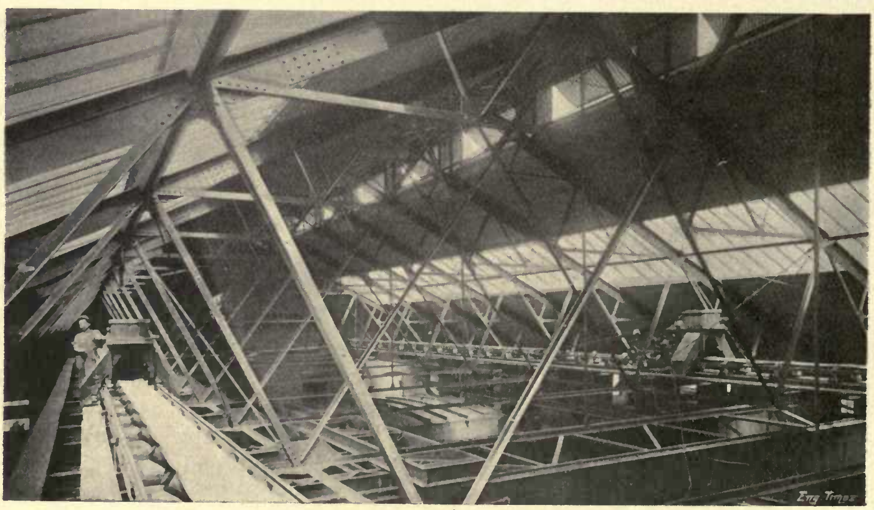


FIG. 52.—VIEW OF ROBINS' BELT CONVEYORS SUPPLYING THE PURIFIERS AT THE NEW AMSTERDAM GAS COMPANY'S WORKS, NEW YORK.

strong corroding substances as lime and oxide of iron, and there is evidence of their coming into more general use. Fig. 52 shows part of a system of such conveyors, as made by the well-known Robins Conveying Belt Company, of New York, and at work in the purifier house of the New Amsterdam Gas Company in that city. A conveyor takes the material from underneath the boxes to an elevator, which feeds a reversible belt, supplying in turn either of two conveyors, which distribute the material to the purifiers below. A new belt conveyor has also recently been brought out by Messrs. Graham, Morton & Co., Limited, in connection with which they have introduced patent self-oiling idlers made of cold drawn steel, which would seem to offer some advantages over those in cast-iron hitherto in use.

The tendency of late years, in common with other apparatus, has been towards the construction of ever larger and larger purifying plant. It had long been known that, for the complete saturating of lime or oxide of iron with the impurities of coal-gas, the element of time was of paramount importance, and thus small boxes through which the speed of the gas was necessarily rapid, were found inefficient. To get a lengthened period of contact between the impure gas and the purifying material, it was necessary to build boxes of very large area. The speed of the gas through purifiers for their greatest efficiency should not exceed sixty feet per hour. The building of the purifying vessels on the old lines, with their heavy plates, their water lutes, their ponderous covers of many tons, their powerful lifting apparatus, had therefore to be modified. It was left to Mr. Henry Green, the engineer and secretary of one of the oldest and best-conducted gas companies in the country, that of Preston, to show what ought to be done, and how to set about it. Figs. 53 and 54 will enable some idea of the character of Mr. Green's original proposals to be obtained. In place of separate vessels, the boxes were built together and divided off by internal partitions. Instead of large heavy covers sealed in water lutes, there were a number of light flat covers (Fig. 53), "dry-sealed," *i.e.*, kept gas-tight, by means of bolts and indiarubber strips. Where before was needed a heavy lifting crane, now the covers could be raised by an ordinary chain-block. Instead of the purifying material becoming exhausted and completely fouled, as it did in small boxes in a few days, in these 90 ft. by 35 ft. purifiers it lasted weeks and months. And so on the category of advantages might be named—economy in floor space, economy in weight, economy in erection, economy in cost, economy in purifying material, economy in labour, and increased economy all round. Needless to say, other gas engineers have lost no time during the past two or three years to pay the sincerest compliment to the engineer at Preston—that of imitation. Perfection, however, does not exist, and, naturally enough, other ideas have grown out of the original as regards details, and improvements have been sought. A photograph is given in Fig. 55 of the latest design of purifier on this "dry-sealed" principle. The boxes are shown as in course of erection at the maker's works, the Whessoe Foundry Company, Limited, of Darlington, a firm with a considerable reputation for excellence in the construction of gas plant. Among other points in the design of these boxes, with which the writer was connected, may be noted the swing-bolts for fastening the covers. Swing-bolts were also used for the Preston purifiers, but the pockets into which they fell back were found to become choked up, and their adoption was discouraged. By the arrangement under review, however, of separating the 35 ft. square boxes, and having the floor plates a foot or more below the cover-tops, the swing-bolts can fall back without any chance of impediment. These bolts, also, are provided with handle-bars, as shown, for facilitating the labour, and reducing the time taken in fastening and releasing the purifier covers. The indiarubber jointing, instead of attempting to make it adhere to the underside of covering, is let into a small groove cut on the top flange of the plates. The writer is of opinion that were a round section of rubber used, in place of

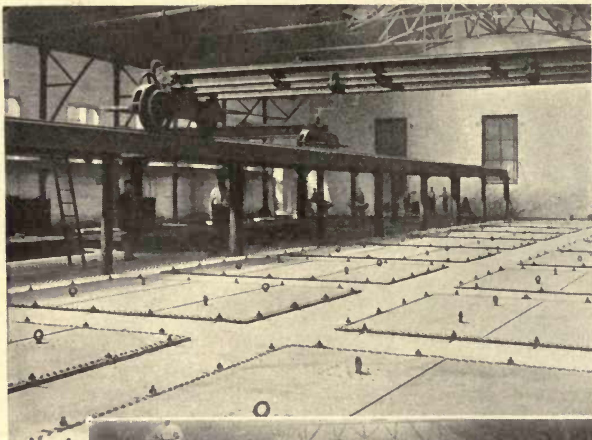


FIG. 53.—MR. HENRY GREEN'S SYSTEM OF "DRY SEALED" BOXES.—VIEW OF GANGWAY AND COVERS.

FIG. 54.—VIEW OF THE PRESTON PURIFIERS, WITH COVERS REMOVED FOR CHANGING MATERIAL.

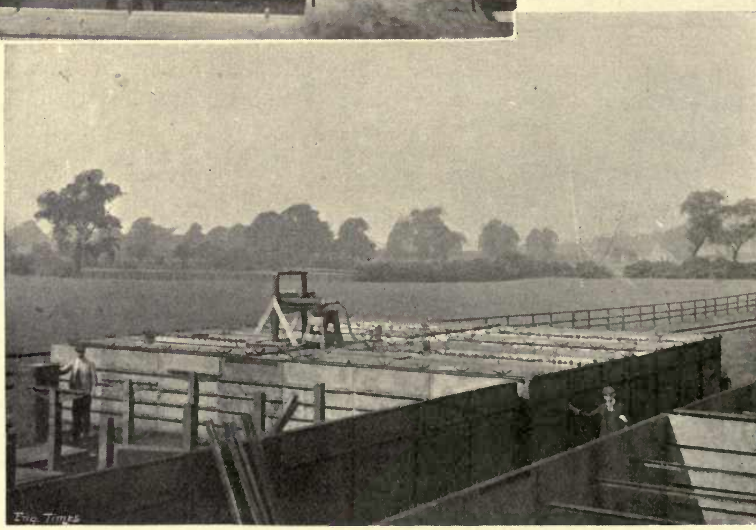


FIG. 55.—PHOTOGRAPH SHOWING "DRY SEALED" PURIFIER BOXES AS ERECTED IN THE YARD OF MESSRS. THE WHESSOE FOUNDRY CO., LIMITED.

the rectangular form hitherto adopted, and were it let into a slot shaped so as to grip it, a gas-tight joint would be made with less trouble than at present. The view underneath such boxes as those described is shown in Fig. 56, taken from recent work of a celebrated firm of founders at Keighley, Messrs. Clapham Brothers, Limited. The illustration shows the discharging doors, placed between the inlet and oulet gas pipes to the boxes, through which the purifying material is dropped on to the ground floor below. The inlet pipes, it will be noticed, are of U shape, and form water valves for shutting off the gas to the different purifier boxes. By admitting water into the semicircular bends, the gas is effectually sealed or shut off, while by opening the cock on the drain pipe underneath, the gas is again allowed to pass into the purifying vessels above. Though such water valves have the absolute security of tightness, it may be questioned whether the many reliable forms of dry centre valves—particularly that known as the "Weck"—do not offer a sufficient guarantee of efficiency, combined with other advantages.

The general Continental practice of purification is different from that at home. Here in England lime is the more usual material used, and oxide of iron the exception. Abroad the reverse is the case, and in Germany, the land of chemists, lime is practically unknown as a purifying material. There, carbonic acid (which is in reality not an impurity proper, but merely a diluent of coal-gas) is allowed to remain in the gas, the difference in the illuminating power being either ignored, or made up for in other ways by enriching processes. As shown in the preceding chapter, the modern tendency is toward lower grade and cheaper gas, and the writer thinks that following the Continental practice of abolishing the use of lime may further enforce progress in this direction. Lime after use in purifiers is practically a

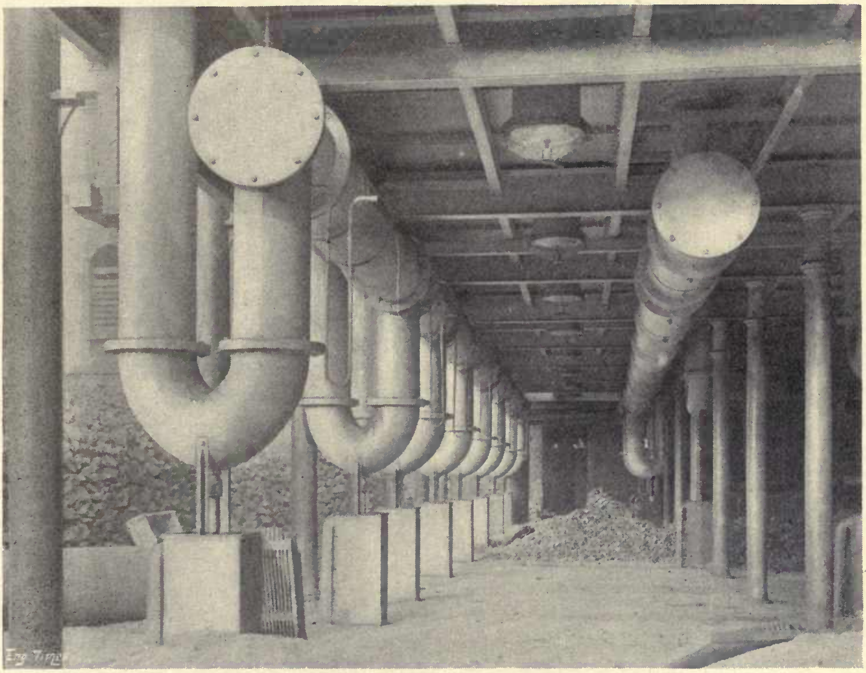


FIG. 56.—VIEW TAKEN UNDERNEATH PURIFIERS ON A STAGE FLOOR, SHOWING DISCHARGING DOORS AND INLET AND OUTLET GAS MAINS.

waste substance, but oxide of iron may be treated so as to be able to be used again and again, while valuable cyanides and sulphur may be recovered from it. As a labour-saving material it is also much to be preferred, for it possesses the property of being revivified on exposure to the air. This was indicated by Laming, who has already been referred to, but it remained for Mr. F. J. Evans, the engineer of the former Chartered Gas Company, of London, to introduce, as he did in 1849, the system of the revivification of oxide of iron *in situ*—*i.e.*, by forcing air through the material in the boxes without touching it in any way. Thus, instead of having the labour of emptying the purifiers, and revivifying the oxide by turning it over and over on the ground at short intervals, the material was made to continue in active service in the boxes for weeks and months. A further improvement has also been made, consisting in the introduction of air to the coal-gas before it reaches the purifiers, to the extent of 1 to 3 per cent., whereby continuous revivification of the oxide is carried on, in part, along with the fouling of the same. This, however, is found in actual practice to have its limitations; but from the point of view of saving labour the revivification of oxide of iron *in situ* should certainly find place. There are two important conditions required for the best revivification of oxide: first, a sufficiently high temperature to expel the water contained in the used material, and second, thoroughly dry air for its revivifying. It is difficult, as will be easily understood, to obtain these conditions to a satisfactory degree by merely spreading and turning over the oxide on the ground. Not only is a lot of floor space wanted, which is another reason for placing the purifiers on an upper stage, but the labour and time involved is very great, sometimes even a horse and plough being used. Mechanical means of revivifying have been introduced, but though these save 25 per cent. in ground space, and even more, and notwithstanding the better control they offer as regards the essential conditions of revivification, they are as yet unsuccessful, and it may be said that there is still need of an efficient revivifying oxide machine.

There are two other ideas that are ever present with gas engineers, and the practical solution of which is always being awaited: the continual carbonisation of coal, and the perpetual purification of its gas. It may be that we are nearer these two processes than before, and that we may see their eventual successful development. Or it may be that ere then another illuminant or further discoveries may be made, or, what is still more probable, that the character of the supply of coal-gas may have undergone radical change on some such lines as have been referred to in these chapters.

Our present and immediate purpose, however, has been to show how, and to what extent, manual labour has been, and should be, superseded in gasworks. We have seen the various developments made in the carrying, discharging, storing, and carbonising of coal. We have watched the travel of its residual coke from the retort house to the purchaser's carts and waggons. We have followed the manufacture of an auxiliary, carburetted water gas, and we have traced its possible future. Finally, we have shown the means adopted for purifying the gases, and the constructional and other improvements brought about in connection therewith. From a judicious selection and combination of the foregoing, economies may be made, gas may be cheapened, and, as a result, the general prosperity of the community will be increased through the adoption of modern methods of saving labour in Gasworks.

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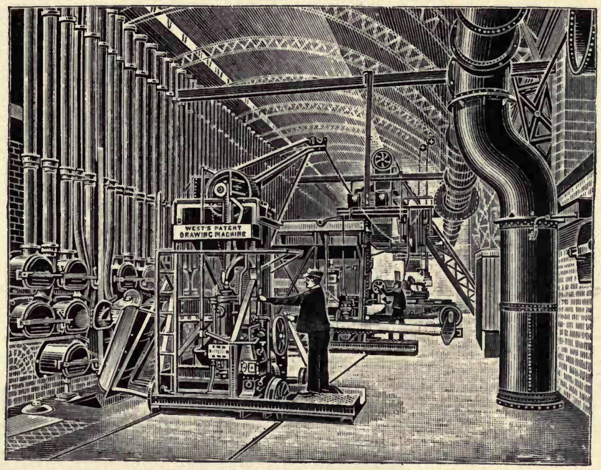

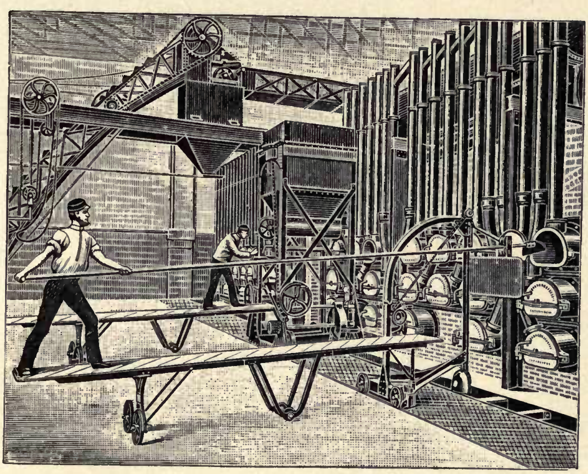

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