CONSTRUCTION & MANAGEMENT OF SMALL GASWORKS

BY

NORTON H. HUMPHRYS,

Assoc.M.Inst.C.E., F.C.S.

WITH A SECTION ON

ACTUAL COSTS AND CAPACITY OF RECENTLY ERECTED WORKS

By J. H. BREARLEY.

E. A. Allant

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LONDON

JOHN ALLAN & CO.

8, BOUVERIE STREET, E.C.

1911.

PREFACE.

THE following pages are dedicated to my friends who come under the description of small gasworks managers as therein defined. They do not represent any attempt to add to the number of instruction books already available for the guidance of students or beginners. The object in view is to supply interesting matter for those actually in practice, who have not only had some training, but also more or less practical experience. The manager of a small gasworks frequently finds that he is one by himself. Even in this country there are out-of-the-way places where, for all practical purposes, one is as isolated as if he were out in the colonies, and men in such a position are usually found to be keenly interested in questions relating to the progress and advancement of the industry, and glad of an opportunity of discussing matters such as those to which attention is directed. They not only follow up modern advancements, but are quick to apply such as are suited to their limited circumstances; and it would be easy to name small gasworks that are in no way behind larger ones, so far as careful and intelligent management is concerned. Having these points in mind, I venture to hope that the following pages will receive a kindly and not hypercritical reception, as an endeavour to interest and assist the small gas manager.

I would also express appreciation of the valuable information given by Mr. J. H. Brearley, in the section on

"The Actual Costs and Capacity of Recently Erected Gas-works," which forms an excellent supplement. And thanks are due to Mr. J. W. Frost, accountant to the Salisbury Gas Company, for assistance in connection with Chapter XIV., and in the preparation of the forms and tables.

N. H. HUMPHRYS.

Salisbury, July 1911.

CONTENTS.

CHAPTER VIII.

CHAPTER IX.

CHAPTER X.

CHAPTER XI.

CHAPTER XII.

CHAPTER XIII.

CHAPTER XIV.

THE CONSTRUCTION AND MANAGEMENT OF SMALL GASWORKS.

CHAPTER I.

INTRODUCTORY.

The expression a "small" gasworks is one of degree. Those interested in concerns of the first magnitude, such as are to be found in London and our principal provincial towns, might look upon a 50,000,000 or 100,000,000 cubic feet works as "small," while others, whose experience has been confined to villages and small towns, would consider works of such magnitude to be decidedly large. But the expression, as understood in the profession, is a qualifying adjective applied to those undertakings whose operations are not sufficient in extent to warrant the employment of a whole time resident manager. With an output of 10,000,000 cubic feet or so per annum, there is usually sufficient work to warrant the employment of a qualified man who combines the offices of manager, secretary, clerk and collector, and generally takes entire charge of the daily operations, under the control of a board of directors, who meet once a month. And with modern requirements in view, the magnitude at which the introduction of an individual of this class can be reasonably considered is decidedly reduced, as he has the

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additional departments of slot meter work and maintenance of incandescent burners to take in hand. But in works appreciably below this limit, the practical part falls to the lot of a man who also acts as head stoker and yardman, whilst the bookkeeping and collecting are undertaken by a local solicitor or public accountant, or by some tradesman, as a spare time occupation. The so-called working "manager" is really more of a works foreman, being in no sense the manager of the company's affairs, but simply of the gasworks. It is in this sense that the word "small" is used in the title, and it is to undertakings running on such lines that the following remarks are addressed.

The number of these "small" works is larger than would at first sight be supposed. According to THE GAS WORLD Directory for 1910, there are some 450 undertakings in the United Kingdom making 5,000,000 cubic feet per annum, or less. And while a great amount of matter bearing on the construction and management of gasworks issues from the Press in the course of a twelvemonth, a very small proportion indeed is addressed to the special requirements of this class. The phenomenally large works, so large that not more than a very small percentage of readers are likely to have similar experience in practice, gets more than a fair share of attention, while the small one suffers as a consequence.

My first experience of a small gasworks dates back more than forty years, but I can well remember the feelings of self-satisfaction with which I received instructions to proceed to a certain works and attend to matters that would occupy two or three days. The railway journey, and the first night in an hotel, both carry considerable importance to a lad fresh from school. And since that time, in one way and another, the small gasworks has always been present with me, and I have been more or less responsible for the control of its affairs. In response to an invitation to set out my views and experiences, I propose to fully discuss the subject, but would like it to be understood that expressions of opinion are not advanced in a dogmatic sense, or as being the last word. For I am well aware that other engineers can point to as good, or to better, results secured by other methods than those which I shall describe.

The great advance in education, in technical and in business methods, that is such a remarkable feature of the period above mentioned, has not left the circumstances of the small gasworks untouched. It has considerably altered the complexion of affairs, and that in more than one direction. Some of these changes are an advantage, others the contrary; but, on the whole, the position has improved. Most of the recent advances in the construction of gas lighting burners, gas cookers, gas fires, and technical appliances, are applicable to the smallest districts, just as generator furnaces, dry-face purifier lids, and other novelties that might be mentioned, are applicable to the smallest sizes of generating or purifying apparatus. But, incidentally, it may be said that the more refined apparatus requires a corresponding order of intelligence on the part of the man in charge. The whole business of construction and management has advanced to a higher plane. I am led to make this remark by the frequency of complaints that modern apparatus has not yielded anything like the expected improvement in results. It is a common mistake to imagine that if enterprise is exercised by a liberal expenditure on the best obtainable apparatus, the rest will take care of itself. For very often the technical education of a working manager is of a narrow and very rule-of-thumb character, not extending beyond the practical details of working one particular kind of coal in one particular set of apparatus. I have known men, thoroughly competent and reliable in a way, who had kept up a satisfactory supply to a small district for years, but who were completely flabbergasted by such a simple matter as changing the quality of coal supplied. Such men do not take readily to novelties, and are slow to learn, though usually sure. So care must be taken not to introduce improvements that are beyond the capacity of the man in charge, and to see that, even at a little extra expense, he is properly instructed as to the methods of working. Under certain circumstances, such as when a man is left largely to himself in an awkwardly accessible locality, it may be desirable to give preference to simplicity, and not to expect more than can be obtained by good work on the old-fashioned lines. A man accustomed to the usual methods of running a grate furnace, for example, might soon melt down the walls of a generator setting, if left to work it with no guidance other than his previous experience. In making these remarks, it is scarcely enough to add that the working manager is usually willing to learn. He is usually prepared to take an interest in the new process, when its object is clearly explained to him, and I have been surprised at the successful way in which some men have taken up and mastered the details of the new appliance.

In the earlier part of the period above mentioned the selling price of gas was 7s. or 8s. per thousand. There were no competitors beyond candles and colza oil. But the advent of cheap petroleum has made it impossible to do more than a limited class of business at that price, and unless it is possible to sell at not more than 5s. the output will be small. In fact, it may be said that petroleum is the worst competitor that the small gas company has ever experienced. For a time its effect was very decided, until the situation was improved by the introduction of the Welsbach burner. There are many small undertakings charging 6s. or so, but their sales are under 2,000,000 cubic feet per annum. If they had any prospect of reducing the price, the sales would probably increase, as cookers or gas fires do not find much acceptance with a price greatly exceeding 4s. per thousand cubic feet. In accordance with the prevailing commercial spirit, which may be defined as "Get business; honestly if you can, but get business!" concerns selling at 5s. or more will do well to consider the desirability of offering substantial rebates on day consumption.

There is the more reason for entertaining this consideration in the case of a very small concern doing less than 2,000,000 cubic feet per annum, because even a substantial loading on each thousand cubic feet will scarcely represent a profit worth having. One shilling per thousand cubic feet amounts to only £100, and this is as much as can be expected under modern conditions of working. But it is quite possible that the sales could be increased to 3,000,000, or even 4,000,000, without much addition to the working expenses beyond the cost of coal. Under such circumstances a substantial rebate may be offered as a means of obtaining business that cannot otherwise be secured, and such a step would be as much in the interest of the users as of the sellers, as being likely to facilitate progress in the direction of an all round reduction in price. No one is anxious to offer a rebate if business can be had at the full price, or to let appliances on hire if they can be sold outright at 25 per cent. profit. But the general experience is that little cooking or heating business can be obtained on a price of 5s. or more, in the absence of a special rebate, and of a plan for hiring out appliances. There is not much ready money in the village or small town, and anything in the way of a large first outlay is an objection. The general success of the slot meter has shown that there are a large number willing to use gas, provided they can get it free of initial outlay. And this point should receive special consideration in districts where the consumption, having regard to the habits of the population, is low.

The quantity sold per head of the population in the district supplied will, of course, be affected by local circumstances and habits, or by the presence, or otherwise, of factories or other special users. Taking an average non-manufacturing residential or agricultural district, it should be possible to sell 2,000 to 3,000 cubic feet per head per annum, by the adoption of a sound enterprising policy on the lines above indicated.

The incandescent gas burner and the automatic light controller are important factors in the management of small works. The low consumption of the former will be sure to command a certain amount of lighting business at any price. And the lighting and extinguishing of the few and widely-spaced public lamps is always a troublesome and expensive matter, taking a man away from the works at a most inconvenient time. The automatic controller is an established fact, and can be set to any desired schedule of hours of lighting. And for small districts the independent clockwork arrangement is more suitable than the pressure actuated machine.

The inhabitants of a small non-manufactory town do not, as a rule, go in for the late hours and hot suppers that are largely concerned in keeping up the average slot meter consumption per consumer in more important districts. There are many places where the average consumption may safely be left to take care of itself, but in some small towns considerable care must be exercised to avoid being overloaded with unprofitable consumers, persons whose average consumption is too small to afford a reasonable return on the special outlay for service, meter, cooker and fittings. When it is known that the company are prepared to put in fittings, free of first cost, there is usually no lack of applicants, who will come forward and see that they get the full quantity of apparatus provided, whether they require to use it all or not. With a high initial price, a 10d. or 1s. loading on the slot department, such as is quite practicable in larger districts, may raise the price to a figure that will stint consumption. Often a loading of 6d. is as much as can be wisely put on. An average consumption of at least 10,000 cubic feet per annum per meter is necessary, under such circumstances, to ensure a remunerative return, and this is not likely to be secured without the aid of the gas cooker. This point may be met by a clause in the agreement to the effect that the consumer will use not less than 9d. worth of gas per week, or, in default, will pay a quarterly rental for the meter and fittings. There should also be a rebate allowed on all gas used in excess of the remunerative quantity. These two regulations have the desired effect of increasing the consumption per consumer. In order to make sure of exceeding the 9d. per week, and thus avoid the charge for rent, the consumer will run into 1s. and upwards, and in order to make sure of the rebate, he will appreciably exceed the limit.

This point requires special attention in the case of the small district, because it is less able to provide for excrescences in the form of idle capital, or unremunerative outlay, than one having a larger rent roll. The agreed outlay per consumer is a fixed and certain quantity, perhaps £4, perhaps £5. The capital must be provided just the same, whether the consumer uses 100 cubic feet or 20,000 cubic feet per annum. If the average consumption does not exceed 6,000 or 8,000 cubic feet (I know places where this has actually been experienced), the result is that the slot department is a loss, and a drag on the general business, instead of being an assistance and a source of profit. There should be no difficulty, according to the nature of the district, in devising a mutually satisfactory scheme that would protect the gas company without carrrying the appearance of offensive high-handedness to the customer.

I think the most important improvement as regards the fortunes of the small works is the introduction of steel tube, which affects the position in two ways. By its means the distribution of gas to a distance of ten or twenty mile can be conducted on a paying basis. If there is a fairly large town within the limits of that distance, it may be possible to deliver gas into the works holder at a lower cost than it can be made on the spot. In the small works, the cost into the holder may be 2s. 6d. to 3s. per thousand cubic feet, but at a 100,000,000 to 200,000,000 works it will be quite 1s. less. There is a good margin to pay for the cost of delivery, and it may be more advantageous to buy gas in bulk than to make it on the spot, and to shut down the whole of the plant except the gasholders. Or if there is no large town within hailing distance, the question of a *district* company rather than a single village one is worthy of consideration. Instead of a supply for one small township, a suitable district, ten miles square or so, may be marked out, perhaps including one or more small gasworks that can be secured by amalgamation. The manufacturing, purifying and storage can be conducted, not necessarily at the centre of the district, but at the most convenient locality for cheap delivery of coal, such as in the vicinity of a line of railway. The comparatively small quantity of coal required cannot in any case be secured on terms equal to those for an order for 10,000 tons, and at the best the coal bill is a serious item. But in districts situated five or more miles from the nearest canal or railway depôt the cartage may increase the cost 25 or even 50 per cent., with most unfortunate results, as regards business. The price must necessarily be so high as to limit the consumption, as it does not do to follow the policy of the Irishman, who sold at a loss under the impression that it was the quantity that paid. Under such circumstances it is interesting to compare the cost of conveying 2,000,000 cubic feet of gas per annum, with a maximum of 500 cubic feet per hour, with the cost of carrying sufficient coal to make that quantity of gas a similar distance.

CHAPTER II.

THE LEGAL POSITION OF THE SMALL GAS COMPANY.

In common with all other traders, the small gas company gets the ordinary protection afforded by the general law, but as far as special legislation is concerned, the position is anything but satisfactory. It is practically outlawed in respect to this, unless legal protection is indirectly paid for by means of the fees and expenses necessary to secure a Provisional Order, which is the cheapest way of obtaining that very indefinite advantage known as parliamentry protection, or as a monopoly, but forms a very serious tax upon the resources of a small concern. We sometimes boast that in England there is not one law for the rich and another for the poor. However that may be in a general sense, it cannot be denied that there is one law for the gas company that can afford to pay for it and another for the one that cannot. So far as the small company is concerned, the advantage conferred by a Provisional Order at the present time (whatever it may have been when the arrangement was inaugurated) is of such a doubtful character that the position should be fully considered before loading the capital with legal expenses, especially if opposition is to be expected. When such expenses amount to only a trifling percentage as compared with the paid up capital, the matter is not of so much consequence, but when they amount to 10 per cent. or so, they constitute a heavy permanent debt that may be a very serious hindrance to the business of the concern.

The main feature of the privileges afforded by a Provisional Order is the exclusive right to supply in a certain district, in return for certain limitations as to selling price, quality and percentage of dividend. The exclusive right to supply is only of value when the district is so promising that, in the absence of such regulations, a second lot of investors would be attracted to it, and competition in gas supply would take place. There are many small concerns throughout the country that are not in possession of statutory powers, yet it is exceptional to hear of a second company being started; for the simple reason that the condition just mentioned does not apply. The first company barely gets a living profit, and under such circumstances a second is not likely to start, and the exclusive right is simply a fence built round a void space. The maximum price is usually well outside the limits at which business can be done, and any attempt to exceed it would mean ruination. And there is no sense in limiting the profits to 10 per cent., when they cannot by any reasonable possibility be expected to exceed 5 or 6.

It is true that the non-statutory gas company is dependent for its existence on the suffrage of the local authority, who can forbid the laying of main pipes in the public roads, and that the Provisional Order grants the necessary powers, subject to certain restrictions. But if the company is, unfortunately, on bad terms with the local authority, Parliament is of very little use. In any case, the company is dependent upon the good will of the public, whether as individuals or collectively. It cannot force any person or any authority to buy even a thousand cubic feet of gas. So the Provisional Order must not be regarded as a tower of defence against hostility. Disputes between small gas companies and local authorities are rare; but this is rather to be accounted for by the fact that the two bodies are to some extent synonymous, than by the non-existence of exciting causes. In urban districts, there is not a superfluity of suitable candidates for public positions, and it not unfrequently happens that the chairman of the gas company is also chairman of the parish council or urban district council, and that some of the members of the one are directors of the other. The small company is not altogether looked upon as a profitable investment, but is promoted, from a sense of public spirit, to provide the advantages incidental to a gas supply. Difficulties are more apt to arise when the ownership of the gasworks is of an absentee landlord character, as may be the case if the property gets on to the market, and is purchased by parties at a distance. Assuming that a Provisional Order is secured, the clauses usually embodied in it, referring to the right to lay mains, are so strangely worded and badly expressed that they are of very little use in the face of a hostile authority.

Referring to sections 6–12 of the Gasworks Clauses Act, 1847, it will be seen that sections 6–8 are clear enough, but that any advantage given by them is greatly discounted by section 9, which stipulates that no street shall be broken up except under the superintendence of the persons having the control thereof, or of their officer, and "according to such plan as shall be approved by such persons or their officer." Under this clause, the authority can practically force any terms they think fit, in the form of conditions, without which the consent or approval will not be granted. It is not clear whether the word "plan" is used in the sense of a general scheme, or of a drawing to scale. The latter construction has been maintained to be correct, in the face of the obvious absurdity. It is not practicable to strictly set out a scheme for a line of main, to be rigidly followed, without a preliminary examination of the soil that would involve opening up the trench to the full depth required. Because it is the invariable experience that unexpected obstacles are encountered, such as a drain or pipe that has been omitted or wrongly located on existing records, or unexpected variations in the nature of the soil, that have the effect of considerably modifying the original scheme. If a scale drawing is to be furnished beforehand, and to be rigidly adhered to, at the best a very unnecessary expense is incurred, and it may amount to a case of being called upon to make bricks without straw. The adjustment of the matter must depend upon mutual good sense and reasonableness.

The conditions as to replacement practically leave the company entirely at the mercy of the road surveyor. The word "reinstate," used in the Act, means that the road is to be left as good, not better, than before; but the temptation to utilize the occasion for securing a permanent betterment is too strong to be resisted. A country road, as a rule, is not kept in such good order, or so frequently metalled, as one in a town. If the traffic is small, it is probably repaired, at very long intervals, by means of a scanty dressing of inferior local stone, and the crust is so thin that it affords little or no protection to the newly-made trench. The surveyor may order a liberal dressing of the best granite, and lay it at the expense of the gas company. In one case, the surveyor insisted that all spoil not put back into the trench should consist of the top only, and he claimed and took away the spoil, thus securing a good supply of metal for use in other places. The trench, of course, suffered in consequence, and, in effect, the gas company had to re-metal it from end to end, at its own expense. The county suryeyor is sometimes inclined to be a small autocrat in his way, and to look upon anyone who disturbs the crusts of the roads as a sort of trespasser or interfering busybody, rather than as engaged in supplying an important public service, and is apt to treat him accordingly. Sometimes he rules that the company should pay 1s., or some other fixed sum, per yard of trench, to cover reinstatement, and I have known many cases where the surveyor's bill exceeded the cost of excavation.

I do not claim that the gas company should overlook the importance of reinstating the surface in its original condition, or in these days of bicycles and motor cars, of avoiding "camel humps" or loose stones. The latter are a particular source of danger. But in its own interest it is not likely to be so foolish as to neglect this point, because if any accident happens, the local authority does not accept the responsibility. The claim for damages is certain to come on the gas company, if the slightest excuse exists for it. It is a great hardship if the gas company is indirectly made to pay for the use of the roads, by having to effect a substantial improvement on the previous condition, or to make up a first-class road in places where a very indifferent one was previously tolerated.

If the surveyor is opposed to the gas company, on personal or other grounds, he can put it to great inconvenience and ruinous expense. The unsatisfactory nature of these sections of the Act is illustrated by the amount of litigation to which they have given rise, and by the vague and contradictory constructions that have been put upon them by various authorities. Law is altogether too expensive a luxury for the small company, as the expenses of a contested case may absorb the whole of the year's profits. There should be a cheap and easy way of settling any dispute that may arise, by an appeal to the Board of Trade, or other independent authority, and the company should be relieved from the cost of such portions of the replacement as can be proved to be permanent improvements.

The objections advanced in respect to sections 6–12 also apply to those governing public and private consumption, which are, in many respects, absurd. In all cases where a fixed and definite obligation is laid on one of the parties concerned, there should, in common fairness, be an equally fixed and definite duty on the other. In this respect, the law is one-sided. While it puts specific obligations on the gas company, there are no corresponding ones on the public authority or the private consumer. Section 11 of the Gasworks Clauses Act empowers any occupier within 25 yards of the company's main to demand a supply of gas, and states that the company is to provide a service pipe up to 30 feet in length at its own expense. This means an immediate outlay, and a standing responsibility in the matter of wear and tear. All the consumer is required to do is to guarantee to use a minimum, represented by 20 per cent. on the cost of the service, for at least two years. The 30 feet of service can be provided at a cost of about £1, which means that the company can only demand a guarantee to the extent of 4s. per annum. A user of such an absurdly small amount is not worth having at any price. He does not pay even an aliquot share of the establishment expenses. If the company is entitled to any guarantee at all, it should be sufficient to give a fair and reasonable return on the outlay, after paying all other expenses. Or there might be a minimum charge of, say, 15s. per annum, irrespective of consumption. The time limit might also be deleted, because the company will stand quite as much in need of a paying business in twenty years' time as now. As it is, if the consumer chooses to drop the consumption to a mere trifle, at the expiration of the prescribed or agreed time, there is no remedy. There should be power not only to stop supplies to the unprofitable customer, but to recover the cost of the service pipe.

A great deal has been made, in Acts of Parliament and elsewhere, of the power of the company to cut off the supply in the event of default as to payment. It is difficult to see where there is any special privilege in this matter, as it is open to any private trader to refuse to supply a customer whose credit is not sound. The threat to discontinue, as a means of bringing pressure to bear on the customer, is now of no value. At the time when no other equally convenient agent was available, it was certainly a power in the land. But if carried into effect it now causes little or no inconvenience. Some excuse may formerly have existed for hampering gas with conditions as to supply, price and quality; but such are absolutely unfair, when there is a free market, in all these respects, for competing agents.

The sections relating to public lighting are all drawn in favour of the local authority, at the expense of the company, and, like those just mentioned, are so indefinitely and ambiguously worded as to admit of more than one construction. When a gas company applies for parliamentary powers, the local authority usually takes the opportunity to get some special concession, in addition to the already onerous provisions of the model Acts, such as a stipulation that the price charged for the public lights should not exceed the lowest charge to any other consumer, or that all the roads in the district must be furnished, if desired, with lamps at a distance not exceeding 80 yards apart. The sections in the 1847 Act are to a large extent permissive, and not obligatory, but in the 1871 Act the word "may" gives place to "shall." Section 24 states that the undertakers "shall" supply gas to any public lamp within 50 yards of any of the company's mains, in such quantity as may be required. While the 1847 Act makes it clear that lamps, burners and pipes should be provided by the local authority, the 1871 Act is far from definite on that point, and it is very generally held that the obligation to supply as above instanced includes the laying of the service pipe. Many companies, at any rate, have thought that the better course was to accept the obligation of supplying the service pipe.

As in the case of the private consumer, there are fixed and definite obligations on the part of the gas company, but no corresponding obligations on the other side. The authority are simply to be supplied with as much (or as little) gas "as they may require." In this respect, the law presses more hardly on the small company, because it is based on the conditions that obtain in towns and populous places, and not on those usual in a village or small town. In a town of 20,000 or more inhabitants, the suppliers are fairly secure in respect to a consumption per lamp covering 3,700 or 3,800 hours per annum. But in small districts there is considerable parsimony. Small and widely spaced lights are considered equal to the requirements, and a very short time schedule, say from dusk to 10 p.m. or 11 p.m., for a period of six to nine months in the year. It is one thing to lay a pipe for a large burner that will be in use 3,800 hours in the year, and another to incur a similar expenditure to supply a small burner that will not be used for half that time. The very meagre proportions of the lighting bill do not leave any margin for service pipe, or other incidental expenditure, and every service pipe, apart from the first cost, carries a fixed charge per annum for maintenance and an aliquot contribution to the item of unaccounted-for gas, and these charges are fixed and constant, irrespective of consumption. The presumption is that wherever a lamp is required, there will also be private business, and that only in exceptional cases will the full length of 50 yards of service be called for. Even in large towns, the long service is more frequent than would at first sight be supposed, and in smaller places it becomes an important proportion of the whole. Under the most favourable conditions, the public lighting does not add much to the profits, and in small districts it is usually attended with a loss. And this loss does not fall so much on the shareholders as on the consumers. The 4 or 5 per cent. dividend would be paid in any case, and any loss from public lighting or otherwise would take the form of a tax on the price of gas. It cannot be too clearly pointed out to public authorities, and all interested parties, that any losses or extra expenses must eventually be met by the consumers, and perhaps stand as a permanent tax on the selling price.

The gas testing clauses are now an absurdity in any case, seeing that flat-flame burners are practically out of use, and that the suppliers may safely be trusted not to follow such a suicidal policy as the supply of an article deficient in illuminating power or impure. If they did so, many customers would simply cease to use it. But to call upon a small concern to fit up a photometer and photometer room, at an expense of £80 to £100, when the apparatus will not be used and is not required, is simply making an unnecessary charge on the consumers. It is only in large and important districts that an official examiner can by any possibility be considered necessary. In small districts the whole thing is a farce. The borough surveyor or some other official who knows nothing about it is appointed examiner. One gentleman holding such an appointment told me that the salary was nil, and that the service rendered was equivalent to the salary. In another instance, after being furnished with monthly returns from the examiner, all carried out to two places of decimals, a question was raised respecting the apparatus. On inspection, it was found to be covered with rust, the cord on the governor broken, taps set hard from corrosion, and evidently undisturbed and unused for months, not to say years. Further inquiry elicited the fact that the "official tests" were taken with a cheap pocket quantity indicator, which, with a fine show of getting a fair average result, was applied, without notice, to any public lamp in the district. By this means, the examiner got fair samples of the bulk, which he considered could not be depended upon at the photometer room. If the testing apparatus is required at all, a simple appliance, such as an approved variety of the jet photometer, would answer every purpose in a country town.

The Alkali, etc., Act, which, unlike the Acts already referred to, applies to all alike, whether statutory or non-statutory, involves an unjustly heavy tax on a small maker. Before one can make sulphate of ammonia there is a tax of £3, os 5d. per annum to be paid. The nominal amount is £3, but it must be transmitted to London by money order, cash or cheques not being accepted. There is no reason why it should not be payable to the local tax collector, like other taxes; but by means of this ingenious little shuffle the Government secure £3, os. 5d. for a tax of £3. The tax is all very well for companies making a profit of some hundreds a year on the sale of sulphate, but a little company, making, perhaps, 4 tons of salt a year, can barely earn a fair profit on the cost of the plant. Companies making less than 5 tons a year might well be exempted; and the tax should be graduated according to the quantity made.

In referring to the Alkali Act, one would like to acknowledge the extremely courteous and pleasant way in which its regulations are carried out. The inspectors are always willing to give advice when required, and the information so obtained is reliable and useful. Their periodical visits are a source both of pleasure and profit.

Taken as a whole, the provisions of the Gasworks Clauses Acts are of very little value to the small company, and it is more important to get a good representation of local influence on the board of directors than to secure a Provisional Order.

CHAPTER III.

ON RAISING AND LAYING OUT CAPITAL.

ALLUSION has already been made to the necessity for avoiding unnecessary legal expenses, and the same caution should be extended to every branch of capital expenditure. Capital once sunk cannot be recovered, except by sacrifice of profits, and, therefore, the time to exercise care and judgment is before the money is spent. For various reasons, the expert care and skill that is applied to larger concerns is not available, and, therefore, it is more usual for a 5,000,000 cubic feet works to be overloaded with capital responsibilities than a 50,000,000 works. And, unfortunately, the smaller works has not, as a rule, the opportunity for wiping out errors in this respect, by extension of business, that obtains in the larger. I know several small companies with a capital equivalent to £1,200 to £1,500 per million cubic feet of gas sold per annum. Taking the higher limit, it is evident that a charge of 1s. 6d. must be made on each thousand cubic feet of gas sold before a modest 5 per cent. dividend can be paid to the shareholders.

A great desideratum, when the company is formed, is the services of a gas engineer who combines with the necessary expert knowledge for preparing a design on the most efficient and economical lines, a sufficiently intimate knowledge of the district, the habits of the population, etc., to be able to form a reasonably accurate forecast of the quantity of gas required, for the first few years at any rate. Some experience in districts of similar size and character is a substantial help, but each district has its special peculiarities, and even places apparently as much alike as two peas will show a considerable difference as regards quantity of gas used per head per annum. The information obtained by canvassing is of a very uncertain character, and in some parts of the country there is considerable reluctance to promise support, and especially to sign any paper. My experience of canvassing is usually that the unexpected happens. Persons who were looked upon as pillars of support, for one reason or another prove to be broken reeds, and others who stoutly opposed the formation of the company, because they desired the district to keep up its distinctly rural character, are among the best customers. In one case, a gentleman never passed the mainlayers at work, laying the gas supply into a village, without expressing strong disapprobation, and when the parish council put up twenty public lamps, he objected that one might as well live in London. But within two years his house was lighted throughout, his food was cooked by means of gas, and a geyser and two or three gas fires, etc., were also in use. Some of the old-fashioned folk have considerable nervousness, but familiarity breeds a different feeling, and gas is now so familiar to all that it is no longer regarded as an untried novelty. One or two persons of established position in the district, who are believers in the advantages of gas, and will use it in their own houses, besides recommending it to their friends, will secure more business than a regular canvasser.

It may happen that none of the directors have any expert knowledge, and that they place themselves entirely in the hands of a firm of construction engineers, who undertake the whole outfit from the retorts to the burners, at an agreed price. There are firms who lay themselves out for this class of work, and, in fact, make a speciality of it, and if a well-known, reliable firm is employed, the result will probably be satisfactory. But it is only human nature to think of self first and of the shareholders second. There are opportunities of working off second-hand plant, more from a desire to find a home for it than from a conviction that it is just the thing that the company requires. There have been so many improvements in every department that second-hand apparatus, particularly if over twenty or twenty-five years old, should be looked upon with some suspicion. I have known some few instances where the company has not been fortunate in the selection of its contractor, and as a consequence is saddled with an expensive lot of unsuitable or antiquated second-hand plant, that is troublesome and costly in working. Some of it has been rejected from other works on account of particular defects, and any saving in first cost is swallowed up by lower working results. But these are the exceptions rather than the rule, and if a reliable firm has been engaged, and not been cramped by niggardly, bucolic bargain-driving, consisting of a senseless beating down of price, which is considered sound business in some country districts, a good dividend-earning plant is put down. But the constructing firm, especially if they come from a distance, cannot be expected to make a very accurate forecast as to probable consumption per annum, or per day.

In some rapidly increasing districts, it is a wise policy to put down a plant of ample size, with a margin for future increase. But what is the use of a 5,000,000 cubic feet plant, and the prospects of combining a fair dividend on the outlay with a moderate and reasonable price for gas, in a district that is never likely, by any reasonable possibility, to take more than 2,000,000? It does not follow, as a safe rule, that there will invariably be an increase; and at any rate the future may be left to take care of itself. Things, if they move at all, move slowly and deliberately, and there is no fear of being caught napping by such a sudden increase in demand as to overtax the resources. While exercising care in regard to expenditure, there are one or two directions in which it is well to be liberal. Land is fairly cheap in rural districts, so it is as well to secure sufficient at the start, to last, so far as one knows, for all time. Landowners, as a rule, take up the position that the gasworks is an undesirable neighbour, likely to depreciate the value of surrounding property. But if a gas company, having a site of half an acre, finds that additional land is required for extension, and offers to relieve the adjacent owner of a part of this depreciation by taking over another half acre at the original price, it is not an uncommon thing to find that the land has improved in value, perhaps to the extent of 100 per cent., by its being in the vicinity of the gasworks. So a wise plan is to make sure of no trouble as to additional land, for the next generation. An excess of land can be turned to account as garden ground or otherwise. With this exception there is no part of the plant that need be expensively in excess of present requirements. An advantage of plenty of land is that the buildings and plant can be so disposed as to admit of enlargement at any time, with a minimum of taking down and alteration. Taking down existing plant, or moving it to a fresh site, is a dead expense. It is a good plan to so arrange the principal buildings that one wall is on and forms part of the boundary line. The expense of a fence or party wall is saved, and the maximum yard space secured. The principal buildings may be so grouped as to utilize as far as possible both sides of each wall, having due regard to considerations of safety. The tar and liquor well and the purifiers must be well away from the furnaces. The retort house should have gables parallel with the settings, as the former can be lengthened indefinitely without more taking down than the removal of one end wall. The condenser tubes should be of comparatively large size, and with that proviso any of the usual forms of condenser can be enlarged by simple addition. More columns may be annexed, or the existing ones lengthened. Provision for telescoping and thus doubling the capacity of a gasholder at a future time is not a costly addition. While the works are in process of construction there is some saving in first cost by arranging an excess capacity throughout of about 50 per cent., as compared with the cost of enlargement to a similar extent by a subsequent operation, and circumstances may exist to fairly warrant such a proceeding. But in the average country district habits of life are primitive, and likely to remain so. The introduction of gas will not affect them. The shops will continue to close at 7 p.m., as before, and lights will be out at 10, as a general rule.

Another cause of excessive capital is simple incompetence. If a skilled firm is engaged to carry out the whole scheme, not only will the works be well designed, but competent working instructions will be given as to operation and management. But sometimes a local resident, having no training or previous experience in the profession, will undertake to manage and engineer the company, and in this connection it is a too frequent practice to make an unfair use of the drawing office staff of the constructing engineer, by getting the firm to provide unsigned designs, which are put before the board as the work of their officer. He may be an ironmonger, a blacksmith, a coal dealer, or an agricultural implement agent, but he acquires his experience in the management of gasworks at the expense of the concern—and the bill is usually heavy. If he undertakes to put up the gasworks himself, with the aid of such bargains in the way of second-hand apparatus as he can pick up by answering advertisements, matters are made worse. In any case, his deficiencies are not only apparent in the capital, but also in the revenue. His expenditure as regards first outlay is not only extravagant but the working results will not be of the best. There is no concern so small that it cannot afford to pay for sound professional advice, and in some respects more skill is required to run a 2,000,000 cubic feet works on lines that are likely to be satisfactory to all concerned than a 20,000,000 works. In addition to consultation at the start, the expert gas engineer may with advantage be asked to spend a day once a year in looking into the working results, as it is probable that the suggestions made in his report will repay his fee several times over.

So far, we have considered the case of a company starting *de novo*; but it may happen that the object is to acquire a going concern. It is no uncommon thing for a small gas undertaking to get into the market. Very frequently, such is started by one person, and several reasons may arise to lead to its sale or disposal. In such case, an artificial value may be put upon it—that is, a capital value in excess of actual structural cost or expenditure—the margin being considered to represent "goodwill," or a trading profit to the vendor. The small undertaking, however, cannot afford to incur substantial intangible liabilities in the form of what is popularly known as "watered" capital. An artificially inflated capital must mean, at least, one of two things—a high selling price, or a low rate of profit; and probably an undesirable combination of both. There is enough to do to earn a fair dividend on the bare structural expenditure, especially during the first year or two, while the business is in process of development, and very little margin for profit on added capital. I never heard of a small company that could run a loaded capital on lines that were equally satisfactory to the shareholders and consumers. In taking over a going concern, an accurately drawn statement of accounts, showing all the details of the outlay on capital, and the annual income and expenditure, authenticated by an experienced accountant, should be obtained. And if more than one undertaking is to be included, a similar course should be taken with regard to each one, and each one should stand on its own bottom. If the circumstances warrant an important addition for profit or goodwill, or as a consideration for interest on unproductive outlay during the development of the business, it will be well to consider the advisability of liquidating this by an annual charge on the profits, rather than to allow it to stand as a permanent capital liability.

The above remarks apply especially to prospectuses addressed to ladies only. A wife is a convenience in many ways, and one of them is that if she happens to appear on a list of shareholders in her own name, she will be the recipient of circulars that are not also sent to her lord and master. Such, at least, is my personal experience. I have in this way obtained a perusal of some of this class of literature that otherwise would have been inaccessible. There is usually some sort of a special inducement, such as a "guaranteed" 6 per cent. dividend for a limited time, or a prospect of the property obtaining a position and value similar to that of neighbouring large concerns. Comparisons with other undertakings in the locality are absolutely useless as a means of indicating the value of one particular undertaking. The practice of sending to a special class of investors, also, is not to be regarded as a recommendation.

That somewhat indefinite value represented by the term "goodwill" is not a large one in undertakings of this class, and the difference between actual cost and a fair selling price is in no case more than a moderate percentage on the former. There is, therefore, very little margin for the operation known as promotion, which means that third parties manage to pocket a substantial profit on the transaction. The effect of such operations on the permanent business will be evident from the preceding remarks.

But for one works or company about to start, there are a dozen already existing, and some labouring under one or more of the disadvantages above indicated. And while one is expected to indicate the pitfalls that may be avoided by those who as yet are not committed and have a free hand, it is also necessary to indicate the lines to be followed by those who, possibly through the errors of their forefathers rather than their own, are in a bad way. Things move slowly in the small district, and the course of retrenchment may be tedious. Under such circumstances, one must be satisfied to be slow and sure. By persistently following a judicious course for perhaps twenty-five years, it is possible to bring an apparently hopelessly encumbered position into one of soundness and security.

It is desirable that all the parties concerned in the affairs of the company, whether paid employees or customers, should have a financial interest in the undertaking. Out of two managers that in other respects were equally suitable

I would give preference to one who would stake his little capital in the concern. A good representation of the consumers on the board of directors will also greatly facilitate smooth working

CHAPTER IV.

LAYING OUT THE DESIGN OF WORKS.

THE chief thing to be borne in mind in connection with the laying out of a design for a small works is that the working and everyday conditions are peculiar to that class, and altogether different from those at a works sufficient in size to have a competent foreman always looking round, a complete set of workshops on the premises, and a dozen or more hands at call, in case of emergency. Under such circumstances, a fracture, a stoppage, or other difficulty, can be energetically attacked, and repairs quickly effected. I have seen designs drawn up by qualified engineers that are beyond criticism if they could be worked on the lines of large works, but possess glaring defects when considered from the present point of view. The small works is left for hours at a time in the charge of one of that class of men known as intelligent labourers, who has had no extended experience or training at a gasworks, and perhaps was never inside more than one in his life. He has acquired, in a rule-of-thumb way, a knowledge of his duties and of the use of simple tools, and can caulk a joint, fix a clip on a cracked pipe, take down an ascension pipe, or carry out such like simple operations. But even if qualified to avail himself of it, he has not an equipped workshop or a full kit of tools at hand, and the works may be in an out-of-the-way locality, some distance from the nearest engineering works. His time is occupied at frequent intervals by matters of daily routine. Simplicity, and facility for examination, cleaning and repair, with the least possible interference with everyday operations, should be a leading consideration.

Regard should also be had to the capabilities of the man in charge. There is a common impression that by exercising liberality in the purchase of the best, which probably means the most expensive, appliances, the workman has less to do, and his responsibilities are reduced. But while the actual mechanical labour may be less, the same cannot be said as regards care, intelligence, judgment and skill. A regenerator type of furnace will not take care of itself, nor can a man whose experience has been confined to grate furnaces be expected to master all its details without proper instruction. The improved results that are and can be secured from the latest types of apparatus require a greater degree of skill, and not less.

In some of the early treatises on the construction of gas-works, a great deal of attention is given to the selection of a site. Any remarks on this subject are largely discounted by the fact that the engineer rarely has a free hand in the matter. In country districts, and especially where no factories exist, there is much opposition from landowners (or, as it frequently happens, the landowner), who do not want certain lines of landscape to be interfered with. In one instance, an endeavour was made to conceal the gas-works inside a high castellated wall. There is no accounting for the taste that prefers an unnatural and artificial imitation fortress, in a locality where there is nothing to defend, to a plain wall or block fence. And there is no necessity for adding to the expenses by superfluous structures of this sort, because the desired result can be accomplished, by a few trees judiciously placed, in a much less prominent and more natural manner. Trees are never an eyesore, and they do not attract attention and set people wondering what there is behind them.

A special feature with the old school was that the gasworks should be situated in the lowest part of the district. This certainly has the advantage of rendering it practicable to work with a lighter holder pressure; which was a more important consideration in the days of the flat-flame burner than it is at present. Seeing that ordinary coal gas in mains takes up an additional inch of pressure for a rise of 100 feet in respect to altitude, and loses to a corresponding extent for a fall to the same extent, it follows that the pressure in parts of the district 100 feet above the level of the works may be, but not necessarily so, during the times of heaviest consumption, actually higher than that at the inlet of the governor. I know a district three miles from the works, and over 100 feet higher above datum line, and the gain of pressure due to the rise is greater than the loss represented by the pressure required to carry or drive the gas, with the result that the pressure at the far end is higher than at home. The converse, of course, applies. If a part of the district is lower than the works, extra pressure must be applied to force the gas down the hill. The rule, of course, like all others, must be applied with judgment. It does not pay to keep the whole of the district under an excess of pressure in order to ensure that half a dozen customers living in a valley should get enough. The low parts of the district are apt to be boggy and subject to flood, which means extra expense for foundations and a risk of operations being stopped and the property seriously damaged, by sudden flooding of the furnace ash-pits, the store wells and connections, and the gasholders. Anyone who has had the job of starting operations again, after the works have been flooded to a depth of 3 feet or so above the yard level, will agree that a very heavy price has to be paid for any advantages incidental to a low level, and that the lowest level is not necessarily the best site.

The most important considerations are direct connection with rail or canal and a central position as regards the district to be supplied. When the works are a hundred miles or more from the colliery, the cost of conveyance may actually be greater than the original cost of the coal. There are several works in the South of England where the railway company get a larger proportion out of the cost of coal on the works than the colliery proprietor. The cost of conveyance constitutes a heavy and a permanent tax on the working expenses, apart from any charges for cartage. And to the cost of cartage may be added quite 5 per cent. on the cost of the coal to represent losses due to dust, breakage, exposure to weather, etc. So it is a great advantage if a site can be obtained on the boundary of a railway goods yard, or the bank of a canal, and that the coal shed should be so located that trucks or barges can be brought alongside, and the contents transferred by one throw with a shovel. The most favourable conditions are when the railway is at an elevation of 10 feet or more above the working floor, so that the trucks can be unloaded by gravitation, and little or no trimming is required. Sometimes a short special siding can be arranged. The saving of cartage applies not only to coal, but also to retorts and fire-brick, purifying material, pipes, etc., and to coke, breeze, tar or liquor that are to be sent away from the works. It is the usual experience that the railway company expect to share to some extent in the advantages of direct communication, by means of special charges for siding rent, or a charge for laying down the special siding that is three or four times that of the actual structural cost. So it is advisable, before concluding the purchase of a site that offers the advantage of direct communication, to ascertain the terms of the railway company, and to arrange the heads of a provisional agreement. I have known cases where the special charges quite covered the advantages of direct connection, and the cost of unloading to the gas company was as much as if the stuff had to be carted a quarter of a mile.

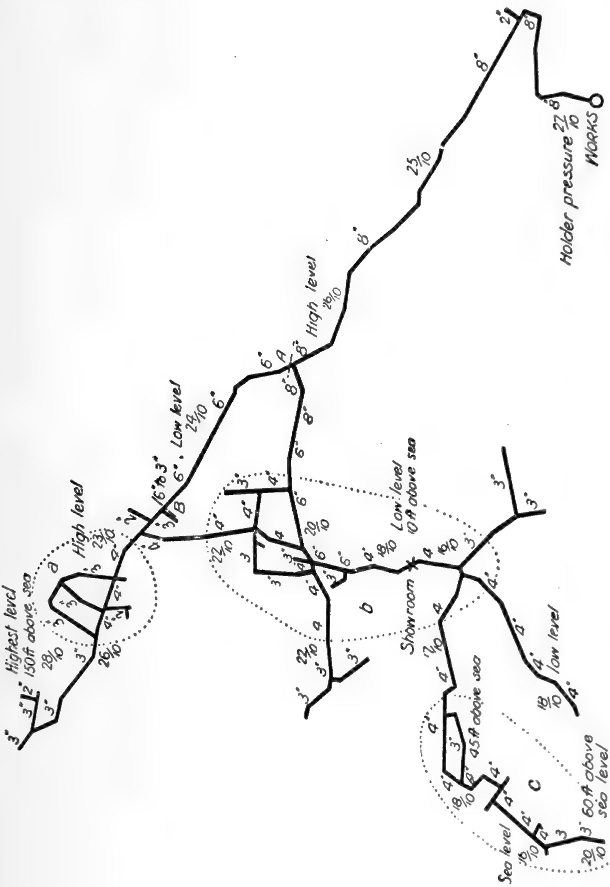
The advantage may also be neutralized, to a large extent, by unsuitable designing of the works. Many years ago I visited a works and observed the railway trucks close on the boundary of the property, and congratulated the manager on his advantage as compared with another works where everything had to be hauled half a mile. He was somewhat dubious on the point, and explained that the retort house and coal store had, for some reason, been built on the opposite side of the yard, with the result that every ton of coal had to be barrowed a considerable distance, and the cost of clearing and trimming, for a truck actually on the premises, averaged out about 7d. per ton. In the case of water carriage, it may also happen that the quay or wharfage dues practically neutralize any saving due to the direct connection.

If carting of coal or other material cannot be avoided, a difference of 200 yards or so as regards distance does not greatly affect the cost. That is to say, if one site is 500 yards distant and another 300, no very great degree of favour need be extended to the latter on that account. The labour of loading and, perhaps, unloading, amounts to a considerable part of the total. At one works, where the distance to be traversed by the carts is a quarter of a mile, the contract price of hauling coal is 6d. per ton. At another, where the distance is nearly a mile, the corresponding figure is 9d.

There are several reasons why the works should be well in the centre of the district. The distribution question is paramount, as if the works are at one end of a long straggling district, or on one side of a fairly square and compact one, it follows, as a matter of course, that to ensure sufficient pressure at the far end or the far side, there must be an excess over at least half the area supplied. That is supposing that there is only one main leading off from the works, which is the usual thing in a small district. On this point, there will presently be more to say. The lamplighter usually commences and finishes his round at the gasworks, and the working manager also attends to consumers' complaints, and is continually going backward and forward in all parts of the district. If the works are some way out from the centre, both lighter and manager lose a lot of time in back journeying, or covering the same ground twice. Under such circumstances it is worth while to consider the question of town stores for consumers' materials, such as meters, cookers, service pipe, etc. If the stores are at the works and a consumer at the far end requires his meter or stove changed, there is the out journey with the new article, and the home journey to return the old one. A suitable building for use as a workshop and store, in the middle of the district, can usually be secured at a small rent. And in the case of the larger class of works, doing 6,000,000 cubic feet a year or so, and where fitting and maintenance are also undertaken, the town store may well include an office and showroom, and be used as a centre for all outside business. Sometimes it can be located on the premises of a tradesman, who is prepared to give attention at all times in business hours, in the way of booking orders or complaints, receiving accounts, etc. Of course, it is preferable, for many reasons, that the whole of the business should be concentrated on the works.

The illustration given on next page, which appeared in "The Gas World," illustrates the difficulties incidental to location of the works at one extreme of the district, and with a low level at the other. The gasworks are at one corner of the district, one to two miles distant from the principal centres of consumption, and the bulk of the gas has a longer distance to travel than would be the case if the works were situated in or close to the centre of the district.

Over-elaboration in the furnace and retort settings should be avoided, not only because they are costly in the first place, and the small percentage in fuel or increase of yield, thereby secured is not sufficient to pay interest on the outlay, but also for the reason previously indicated. In some instances, the results of a drastic change have been for the worse, and the working not so good as with the old apparatus. A man who has been used to alter his dampers to the extent of 3 inches at a time finds it difficult to understand that ½ inch will make a difference on a generator furnace. A stage floor and full depth cellar is not only costly, but inconvenient in working by a gang of one; and if the furnace is melted down or injured by ignorant working, the expense of replacement is serious. There are excellent designs, that are both cheap and simple, on the market, and practically as good results can be obtained with the shallow type of regenerator and a cellar 3 feet or 4 feet deep, covered with movable iron plates. This statement, of course, does not apply to a large works, but to the conditions peculiar to



Broken lines show boundaries of areas of greatest consumption. The pressures marked are those given during the hours of greatest consumption. (The scale of the reproduction is, roughly, 2 inches=1 mile.)

small works. Whatever the form of furnace used, the working results cannot be expected to equal those that should be obtained when working continuously, week in and week out, under skilled supervision, and with such refinements as analyses of flue gases. In the large works, any one bed is lit up, and worked continuously until so far worn that shutting down for repairs is necessary. But in the small works there must be changes every few months, in the way of letting down or taking up, and, for some period of the year, banking up at night. The yield per ton must necessarily be somewhat less, and the fuel account be greater.

The special difficulty in small works is to prevent or minimize idle time on the retorts, because idle retorts under fire are white elephants, in more senses than one. Not only do they require more fuel, but they wear more rapidly, and are more liable to develop cracks and leaks under irregular work. And this leads up to the consideration of retort house units. By this expression I refer to the number of retorts in a bed, because half a bed cannot be under fire at one time. It must be the whole or none. And a retort cannot be worked with satisfactory results on less than a full charge. In large works, the retort unit may be as large as working arrangements will admit, and there is no need to limit the number of retorts in a setting. But in the small works it is possible to have both the retort and the furnace units too large or too small, having regard to the maximum and the minimum output, and to the variations in demand throughout the year. There is too much adherence to the 9-feet by 16-inch section retort, a very good size for a 30,000,000 cubic feet works, but not necessarily the best for a 3,000,000 works. In a works where the daily demand ranges from 5,000 to 15,000 cubic feet, not only may the number in the bed, but the size, be varied with advantage. The 9-feet by 16-inch retort is too big a unit, and some of the retorts, at any rate, may be smaller, say, 8 feet by 14 inches. The 14-inch retort is going out of fashion now, but some good work was done with it. A combination such as three beds of three in each cannot be worked to so good advantage as a set of two, three and four. It does not afford sufficient variation, and, therefore, involves a lot of idle time. The particular conditions of working should be considered as regards both the retort unit and the furnace unit.

It is very poor economy to cut down the number ot retorts to that represented by the bare maximum requirement. Not only is it wise to have at least one bed in excess of actual requirement, as a provision against emergencies, which are more apt to occur in the small than in the large works, but there is otherwise no margin for variation according to the demand, and the beds cannot be fully worked out. Often a bed that is good for three months' work is cut out and renewed because it is not safe to go through the winter.

Another reason why the retorts should be small is because the labour is inferior. The 6 foot 2 inch Irishman with the long reach goes off to the colliery or the ironworks district, and the available labour for the gasworks may be both weak and elderly. The charging will be done by hand (the charging machine is not yet an entire success with the gang of one), and, therefore, special care should be taken not to set the retorts too high. Given a 9-foot retort, having the bottom 5 feet 6 inches above the ground, and an elderly and none too robust stoker not exceeding 5 feet 3 inches in stature, the prospects are not in favour of that prompt and even laying in of the charge that is indispensable to a good working result. The arches may be both narrower and lower than is usual in works of average size, because too much space round the outside of the retorts means a waste of fuel. There should not be more than is necessary for the proper circulation of the furnace gases. The waste of heat by radiation, also, is in some proportion to the square feet of surface in the setting, and will not be so great with a small as with a larger setting. There is no economy in putting in larger arches than are, for the present, required, in view of some indefinite future requirements, such, for example, as an arch large enough for five retorts and setting only two in it. The economy in structural cost is more than offset by bad working results, and it is better to put down no more than is wanted for present requirements, and to replace when necessary.

Taking the designs all round, there is apt to be too much blind imitation of the practice at larger works. Two beds cannot be run as a fraction of twenty, as the circumstances are altogether different. If the working manager has previously held an appointment as engine house hand, or one of a retort house gang, he is apt to overlook this point. Six, five, or even four-hour charging may prove best when the retorts can be run continuously, but with a scale of operations too small to admit of this being done, there is room for considerable skill in deciding upon the best conditions as to hours of charging and weight per charge, that will minimize idle time and banking up. Another problem peculiar to the small works at certain seasons of the year is whether it pays to run a bed of four on three charges per twenty-four hours, and bank up at night, thus avoiding the necessity for a second "hand," or a bed of three on four charges per twenty-four hours, which cannot be managed with less than two men. It is a question of fuel and wear and tear against wages, and must be decided by local conditions.

A common defect in the small works is the provision of one chimney for the whole of the settings, and that too lofty, too large in section, and square inside. There may be good reason for carrying the products of combustion up to 50 or 60 feet above ground level when they proceed from twenty or more furnaces, and the surrounding district is fully populated. But for one to three beds, and with ploughed fields on three sides, this does not apply. For many years it was supposed that a long chimney gave a better draught, but it is now known that the "pull" of a chimney is more a matter of proper sectional shape and area, as compared with the work to be done, than of length. But a chimney is not made of elastic material, and if the section is right for July it is not large enough for December. If three furnaces are under weigh at Christmas, and only one at Midsummer, the chimney must be too large at one time or too small at another. Taking up or letting down one bed upsets the working of the others, and some waste of coal takes place until a satisfactory adjustment suited to the new conditions is arrived at. At the heaviest season of the year, just when the full working is needed, it is found that the pull is not equal on each bed, and the one farthest away, or otherwise least favourably situated, will not heat properly. A crack or accumulation of dust in the chimney upsets the whole of the settings, and cannot be repaired or cleared without interference with the daily routine.

Thirty feet or so in height, sufficient to clear the ridge of the retort house roof, and an area of 100 to 120 square inches for each bed in use, is quite sufficient. If soundly built, lined with fire-brick to the top, so as to keep in the heat, and round in section, such a chimney will give a pull of $\frac{4}{10}$ inch at the base. A larger chimney, say 2 feet square in section, will not give half that pull, because eddies take place in the corners, and check or interfere with the draught. These may be prevented by building in a round drain pipe or piece of broken retort at the base, and another at the top. One of the best chimneys I have met with was 35 feet high, and 18 inches square in section, and had the corners filled up for a space of about 3 feet high at the base, and an 18-inch drain pipe built in at the top.

Sometimes the fire-brick lining is continued only up to half the height, but this is a mistake, because fire-brick is a better non-conductor of heat than red brick. The unlined portion of the chimney is of very little value as a means of increasing the draught, because the products of combustion are cooled or reduced in temperature. A chimney of absolutely non-conducting material, that enables the products of combustion to maintain their temperature till they escape at the top, will give the best results. In one case, an unlined chimney cracked at the top, and 10 feet had to be taken off; and the shortened chimney actually gave a rather better pull.

It is an advantage to weather the top of the chimney, not to leave it flat or horizontal, say at an angle of 30° from the inside edge outwards. If the chimney is 18 inches square, an iron cap with a round hole 18 inches in diameter, and sloping downwards at 30° towards the outer edge, may be provided.

A separate and independent outlet to each setting is preferable, for several reasons, and the cost need not exceed that of a single chimney and main flue. Each setting can be worked independently and under unvariable conditions, and the chimney can be bodily taken down, if desired, without affecting or interfering with the other settings. A convenient arrangement when the flue outlet is on the top of the setting is to run up a dwarf chimney, 14 inches square inside, for a height of 4 or 5 feet. This should preferably be placed over the division wall, rather than immediately on the crown of the arch. On the top of the chimney is an iron base-plate, carrying a length of 12 or 15 feet of wrought-iron tube. Tubing of a suitable diameter is now made in the solid, and it need not be carried higher than sufficient to clear the ridge of the retort house roof. The damper can be controlled by a rod and lever on the front of the setting. This arrangement admits of covering and closing the top of the chimney, which is the only really effective way of checking excessive draught, either for banking up or for Sunday stoppage, and is useful as a protection from the weather when the bed is not in use. There is always a leakage of air when the bottom dampers are supposed to be closed, and the generator arch, or furnace arch, suffers as a consequence. A large waste of fuel and proportionate shortening of the life of the setting has been known to result from neglect in this respect, and the introduction of the top valve has proved a satisfaction and economy all round, reducing fuel consumption and labour and prolonging the life of the setting. The valve consists simply of a disc a little larger than the top of the chimney, carried on a vertical spindle attached to the side of the tube by guiding eyes at suitable intervals, and supported at the bottom by the iron base-plate. A lever handle is fixed to the lower part of the spindle, at right angles to the disc, and by giving it a half circle turn the disc can be placed square over the mouth of the chimney, or turned quite clear of it, as may be required.

A common mistake in the small retort house is an excess of ventilation openings. Too much draught is as bad for the workmen as not enough, and will interfere with the economical and effective heating of the retorts, and means a considerable addition to the fuel bill in the course of a twelvemonth. In a house where the number of retorts open at one time does not exceed three, there is no reason for making provision to take away the products from twenty or thirty. A ridge ventilator extending from end to end, and a large aperture in each gable wall, may not be out of place in a house containing some hundreds of retorts, and with drawing or charging every hour, but where only one man works at a time, it is too much. The efficiency of the ventilation is not in proportion to the area of the apertures, and I have seen so-called ventilating arrangements that were more effective in beating the smoke about the ears of the workman than in removing it. A few short vertical shafts are more effective than louvres or other obstructed outlets, and they should be a narrow rectangle rather than square in section, so as to spread the smoke into a thin layer. There is a great difference in the appearance, as viewed from outside, of smoke issuing from an aperture 18 inches square, as compared with one 9 inches by 3 feet in horizontal section. The outlets for the smoke and hot air must be proportional to the inlets, but the latter part is apt to be entirely overlooked, and it seems to be supposed that the outlets are all that is required. The hot and foul air will not be drawn away unless there is a proper inlet for fresh air to take its place. A large extent of outlet area, with no inlet other than that incidentally afforded by the door, means an uncomfortable, draughty, and probably badly ventilated house. It is easy to see if a house clear freely; and if it does not, the condition can frequently be improved by very simple means.

Another common defect is inadequate and bad designing between the hydraulic main and the holder inlets, and the absence of a foul main. The result of this is trouble in the winter and in cold weather. The gas pipes may be taken direct into the open air by a short cut through the retort house wall, passed into a condenser, and thence to a small set of purifiers. Under such conditions we may confidently anticipate trouble from accumulations of pitchy matter, which clog the seal boxes, and bays back the condensed liquid, preventing it from getting away to the store well. A large quantity of tar and liquor goes forward into the purifier connections, necessitating stoppage for clearance at frequent intervals, and increasing the back pressure, while the purifying material, being called upon to complete the extraction of tar, in addition to discharging its own legitimate function of removing carbonic acid and sulphuretted hydrogen, becomes clogged and inactive long before it is properly saturated in a chemical sense. A chemical examination of the spent lime heap will show the presence of a very appreciable proportion of free or unused lime, or, if oxide is used, the oxide will be rejected as spent and inactive before it has accumulated a proper proportion of free sulphur. I have seen samples of so-called spent oxide that contained less than 40 per cent. of free sulphur, and were really inactive because they were clogged with tar. The extravagant consumption of material, increased working expenses and incidental loss will increase the manufacturing costs to an extent much larger than is required to pay the interest on the cost of a properly designed plant. If a lad of ten is dressed in his father's old clothing, shortened in the sleeves and legs, the result is not satisfactory, either from a utilitarian or aesthetic point of view. This fairly represents the position at some small works, where the apparatus between the hydraulic main and the gasholder is simply a miscellaneous collection of cast-off stuff from larger works, that is simply eating its head off, so far as satisfactory working results are concerned; and some of it was possibly rejected and disposed of as much because of its proved inefficiency as to make way for larger.

It is true that the tar and liquor may be valueless, but granting that such is the case, there is still a necessity that the tar should be all taken out before the gas reaches the dry purifiers, and that the ammonia should be extracted and its purifying capabilities fully utilized. It is cheaper to extract carbonic acid with ammonia than with lime. As a matter of fact, an ample-sized foul main, condenser and washer are as necessary in the small works as in the large, and are equally a good investment. The foul main may be carried round three sides of the retort house, and through the purifier house, or coal shed, if these are adjoining, before passing out to the condenser. And the fall should be towards, and not away from, the flow of gas. The late R. H. Patterson pointed out, many years ago, the advantages incidental to drawing off the condensed liquids at the hottest part. It is a known fact that lengthening an ascension pipe has been found a cure for obstinate choking. A foul main inclined towards the hydraulic, so that all the condensed liquid flows back against the current of gas, provides both advantages, and the practical result is improved illuminating power, and that the hydraulic main, seal trap, etc., are kept clear and free from pitch. I have known the addition of a foul main on this principle to improve the illuminating power to the extent of 2 candles, enabling a cheap local coal to be used without the aid of cannel or enriching material, and entirely obviating stoppages in the condenser or the clogging of the purifying material with tar. The thinner liquid thrown down towards the outlet end, flowing back to the hydraulic, serves to dilute the more viscid matters that are first deposited, and to carry them freely through to the store well.

There is usually a demand for fairly uniform candle-power. Weak pressures and small pipes in various parts of the district throw into prominence a comparatively slight variation in illuminating power. But cannel or high-class coal is sometimes used as much for thinning the tar in the hydraulic and condenser as for keeping up the illuminating power. I once met with a small works so deficient in this respect that only cannel coal could be used. When a good brand of bituminous coal was tried, as a matter of economy, and to prevent the smoke and soot due to excessively rich gas, the result was a complete breakdown.

In the large works there is no question as to the removal of the whole of the ammonia, because it is a source of profit. But when the works is so small that a sulphate plant is out of the running, and any small sum obtainable from a neighbouring gasworks for the liquor barely covers the cost of cartage and carriage, there is a disposition to regard ammonia simply from its capability or otherwise of adding to the profits, and to overlook the fact that it is also an objectionable impurity. It acts powerfully on copper and brass, and when any appreciable proportion is allowed to remain in the gas, the water in the gasholder tanks becomes charged to a sufficient extent to corrode the holder. There will also be frequent complaints of stiff taps and hinge joints from the consumers, and the meters will be affected. So, even if the liquor has to be given away, it is desirable to extract the ammonia from the gas, and, in so doing, to utilize its purifying capabilities, especially so as it means a reduction in the other impurities and in the cost of running the dry purifiers. With efficient washing, it is possible to dispense with the use of lime, if that material is costly or there is difficulty over the disposal of the spent, without, at the same time, having to use a regular proportion of cannel to keep up the illuminating power.

Crude ammoniacal liquor may be diluted with water till the strength is reduced to about 3 ozs., and applied direct as a liquid manure. This means adding 4 or 5 gallons of water to 1 of liquor. I have known it to be used in this way both for grass and for roots. Once a farmer was induced to try it on half a field, the other half being left untouched, and the half so treated gave a heavier and better crop than the other. The difference in texture and colour was quite noticeable. My attention was directed to this matter by a table quoted by Mr. Newbigging ("Gas Manager's Handbook"), giving the results from ten different kinds of manures, ammoniacal liquor amongst the number. The latter was used in the proportion of 100 gallons to 20 perches of land, and the result was an easy first, both as to quantity and quality of product.

Another reason why liquid purification is apt to be neglected in the small works is the special difficulties in connection with its application. The tower scrubber, which is a common feature in gasworks, large or small, cannot be worked to advantage if it is dependent upon hand pumping, which is admittedly erratic and unreliable. I have seen a hand pump in the retort house and a flushing cistern on the top of the scrubber, and the stoker was supposed to work the pump after every charge; but, amid other calls on his time, it is apt to be forgotten. If it is practicable to provide an overhead tank that will contain six or twelve hours' supply, this can be filled up once or twice a day, and something like regular action ensured. Unless this can be done, the tower scrubber is not worked to the full advantage. A non-mechanical washer, which depends on the action of pressure to force the gas through the liquid, and increases the back pressure to the extent of 3 inches or more, is out of the question. A mechanical washer actuated by a small gas motor may be practicable under some circumstances; but what is really required is an arrangement that is non-mechanical, and, at the same time, gives no back pressure. There are a few appliances on the market that fill the bill in this respect.

An exhauster has become almost indispensable, even in the smallest works, on account of the heavier holder pressure that is now demanded. In the days of the flat-flame burner and no day consumption, it was possible to get along with a counterbalanced holder, giving 20-tenths when the weights were on and 25-tenths when unloaded. But with the introduction of the inverted incandescent burner, pressures of 35-tenths or more are called for at night, and if gas cookers and engines are to have a good supply, there must be 30-tenths or so from 6 a.m. to dusk. The demand for more supply pressure is general, both in large and small towns, and the removal of the counterbalance weights from the small holder synchronizes with the introduction of the boosting fan at the outlet of the larger. The result is that without an exhauster it is impossible to work with less than 6 to 8 inches on the retorts, whereas formerly it was possible to get through the hours of daylight at least with about 4 inches.

The difficulties in connection with running a boiler and steam engine at a small works need not arise, because the gasholder will supply the source of power. A small gas engine and exhauster on one bed-plate take up very little room, and the small amount of attention required is not too heavy a tax on the energies of the man in charge, who has a considerable amount of idle time on hand. The quantity of gas required to drive the engine will not exceed 1 to 2 per cent. on the make, and the additional yield of gas secured by it will be 5 to 10 per cent., so there is ample margin for earning a good interest on the outlay. The engine will also drive a small pump for the scrubber.

The connecting pipes throughout, from retorts to gas-holder, should be ample, but not necessarily excessive in size. Large pipes leave more room for accumulation of pitch before a stoppage takes place, but they do not secure immunity from such trouble. In fact, pipes, and especially seal traps, that are too large for the work are more apt to choke, because the liquids move more slowly through them. The pipes should be in straight runs, with cleaning doors at each end, and should be readily accessible at all parts. Every bend or curve that is avoided is not only an assistance towards the comfort of the man in charge, but improves the efficiency of the plant. The importance of easy access to all cleaning doors is evident when we remember that there is only one man in charge, and in the event of stoppage he does not want to lose an hour or more in excavating to strip the pipes. If the pipes must of necessity be underground, pits with flap covers can be provided where necessary. And these remarks also apply to the pipes leading from the seal traps to the tar well. It is possible to so arrange the seal traps that they can be cleared out without interfering with the make of gas.

A thorough wash-out every summer is a great help towards getting through the winter without trouble; and sometimes the design is blamed for negligence in this respect. In the course of a few years' working, pitchy matters are bound to accumulate at bends, etc., and often the troubles that are supposed to be unavoidable are simply due to the fact that the whole plant is in a foul and dirty state. All the outlets from the seal traps should converge into one common cesspool, in preference to being carried direct to the tar well. If gas should by any possibility force a seal, the fact at once becomes evident. But small quantities of gas may get into the tar well for some time before they are discovered, and there is not only loss of gas but risk of serious explosion.

Very important improvements have lately been made in the way of simplifying and cheapening the arrangements incidental to dry purification. In place of the set of four small boxes with water lute seals for the covers, contained in a two-storey building, a centre valve, and tortuous series of pipes to each box, one can now have dry-faced covers, and valves resting snugly on the top of the purifiers, with no connecting pipes to speak of. The old arrangement was so costly that the size of the vessels was cut down to the lowest point, and they were so small as to necessitate frequent changing, perhaps several times a week in the winter, which means waste of gas, material and labour, to say nothing of the risk of sending out bad gas. The modern arrangement consists of boxes let into the ground so far as is consistent with a proper drainage from the bottom to the tar cesspool, and with the exception of small pipes for this purpose there is nothing else below ground, the gas pipes being all on the top. A light roof is all that is required, a building being quite unnecessary, and in some respects undesirable. The upstairs arrangement was supposed to economize ground, by leaving a floor space underneath the vessels for preparing lime or exposing oxide, but this space was too circumscribed to be of any great use. And there is now no excuse for stinting the size of the vessels. They should not be less than six feet square, and preferably eight. Oxide of iron is usually considerably cheaper than lime, and with efficient washing plant, it answers every purpose.

A station meter is a necessary item, even in the smallest-sized works, as without it there can be no proper check on the make or the output.

A usual rule in regard to storage capacity is that it should be equal to twenty-four hours' maximum output. This rule may well be extended to the extent of 50 per cent. in small works, not so much as an increased security as to leave a margin for variation in make, and thus avoid idle time on the retorts. With a small storage, the make must closely follow the consumption, with the result that at the end of the week the supply is short, and in the beginning there is no room for the gas, and one or more charges must be missed. Ample storage means getting along with fewer retorts under fire, and all these in full operation. There should not be less than two gasholders, and preferably they should be of unequal size. One should be large enough to take care of the night consumption without necessitating change of valves, and the other may be a small one for occasional use or emergency. If the storage is divided between two holders of equal size, it is possible that one will not last out the whole of a long winter evening, and careful watching is necessary to avoid a sudden stoppage in the supply to the district. Sometimes it will be an advantage to couple the two holders, adding stops to the top of the columns of the lighter one, to prevent it from rising so high as to blow. Before adopting this plan, it is well to be assured that the bases of the columns are well secured to the tank, and that the brickwork is strong enough to stand the strain. In a slightly built tank, I have known the columns to be lifted. Both inlet and outlet valves are always open, and there is some similarity to a telescope holder, the lighter holder acting as the inner and the heavier as the outer lift. In like manner, the former fills first and then the other, and the reverse in emptying.

As there is apt to be considerable variation in the quality of the make from hour to hour, the inlet and outlet pipes should not be too close together. If the gas can short cut from inlet to outlet, this variation may be carried out into the district. In one case, a defect of this kind was cured by suspending a piece of wrought-iron pipe, larger in diameter than the inlet, from the crown of the holder, in such a manner that it fitted like a sleeve over the inlet pipe. Projecting pieces were provided to keep it central, and clear of a socket joint on the pipes; and the top end was about 12 inches from the crown. By this means the inlet gas was delivered at the top, immediately under the crown, and had to traverse the whole content of the holder before reaching the outlet.

It may be urged that a steam boiler is an advantage, because hot water is sometimes required for washing out foul pipes or thawing water lutes and gasholders. In cold climates, where prolonged frost is experienced every winter, there is something in this; but the requirement may be more efficiently and conveniently met by a small portable boiler mounted on a bogey that can be moved from one place to another. Under some circumstances, a fixed boiler is preferable, with pipe laid on to the purifier house and the gasholder tank. A very small consumption of steam, when a good ejector is used to keep the water in motion, is sufficient to prevent trouble in the holder tank. The plan of using crowbars to break the ice is barbarous, and likely to injure the plant.

CHAPTER V.

DISTRIBUTION.

MANY small works suffer a permanent tax by reason of want of a proper design for the mains. There are managers who are continually being harassed to reduce a leakage account for which they are in no sense responsible, and, further, which is beyond their control, or to conform to the conditions of modern supply with an old-fashioned and, from this point of view, utterly insufficient plant. The subject of the proper sizes of mains is affected so much by local conditions that it cannot be treated in detail ; but there are one or two leading considerations that may be noticed. It is no use to give a blacksmith the contract to lay the pipes in the first place, and to select the sizes by guess, rather than by intelligent consideration of the duty they are required to perform, and then to advertise for some genius to come and reduce the leakage.

The first desideratum is an accurate map of the district. In the United Kingdom this is provided by the Government Ordnance Survey maps. The scale of 25·344 inches to the mile is a convenient one for laying out mains. These maps can be obtained from booksellers and stationers in every town, who will furnish a key-plan from which the distinguishing numbers of the sheets desired can be selected. They have always proved reliable for measuring the length of pipe required to be ordered, or for setting out distances in contracts for excavating or pipe-laying. The details given on them afford a great deal of useful information. From the contour lines and bench marks, a sufficient idea of the levels all over the district can be obtained to enable the positions for drip boxes to be located. One can also locate the principal thoroughfares and the class of property throughout the district.

The skill and care exercised in setting out the mains will have a decided and permanent effect on the item of unaccounted-for gas. But that is not all. The pipes should also be laid by experienced men who have some knowledge of the conditions necessary to ensure a proper supply. I was once consulted about difficulties that had arisen in respect to a run of main of about three miles, which I was assured was laid by a thoroughly competent and experienced man. But further inquiry showed that his experience had been confined to water pipes, and that he did not understand the object of providing drip boxes, and had not used a level or taken any means to secure a proper "run" for the pipes.

The usual plan is to lead off from the works with a single line of pipe, and to gradually reduce the size towards the far end of the district. But this is not always conducive to a sufficient but not excessive pressure in all parts, which is the object of efficient distribution. If the works is at one end of, or outside the district, the desirability of carrying a trunk or feeding main to a central position should be considered. The same applies to any part of the district that may present special features as to altitude, as being substantially above or below the remainder, or to a specially large consumer, such as a factory that works night shifts. It is not good management to keep seven-eighths of the district under an excessive pressure, to ensure that the remaining one-eighth gets a sufficient supply, or to keep the whole district under full evening pressure for the benefit of one consumer who uses the gas throughout the night. It may mean more pipe, but an extra half mile or so of pipe is well spent if it saves an excessive pressure over the bulk of the district.

Admitting the full necessity for having pipes large enough, there is no sense in waste, and it is not good engineering to put down a 6-inch pipe where a 4-inch will answer every purpose. The conditions of supply in an average district lead up to a very complicated problem that can only be treated very superficially. In theory, the governor outlet pressure was supposed to represent that obtaining all over the district, and possibly it did so when the number of consumers was small and the requirement per head much lower than at present. The actual pressure at the inlet of a consumer's meter will be the governor pressure, less a variable quantity represented by the force required to drive the gas from the works to the point of consumption. When the demand is small, the difference is negligible, but as the demand becomes large in proportion to the size of the pipe, a point is reached at which the driving pressure increases by leaps and bounds. In theory, also, the governor at the works is a machine by which the pressure can be regulated in proportion to the consumption. When the demand increased, more pressure was put on, which, in effect, was a rough and ready way of providing more driving pressure. So long as gas was required for lighting only, it was possible to keep in touch with the con sumption in this manner. It is also possible to provide for other periodical requirements, and there are few gasworks that do not consider, in addition to the evening demand, such questions as breakfast pressure, dinner pressure, Sunday morning cooking, or engine pressure. But apart and beyond these, there are variations that cannot be forecast. A large gas engine may be started and stopped at any hour in the twenty-four; and the same as regards apparatus for special technical purposes, now so generally used.

The considerations that should govern the selection of the diameters of main pipes are something more than the delightfully simple plan of making them as large as you can for the money. From the way in which this point is sometimes discussed, one might almost imagine that the skill of a gas engineer was to be judged by the size of his pipes, and that one who lays a 6-inch pipe is more up to date than one who chooses a 4-inch. Taking up an existing main is a troublesome and costly business that cannot come on every year, or once in five years. But conservatism in respect to mains can be carried too far. After they have been in regular use for sixty to seventy years, the question of re-laying may well be considered. In the course of that period they will have accumulated a considerable amount of rust and naphthalene deposit, and many of the joints will be weak and unsound. There are hundreds of miles of old main in use throughout the country that might be replaced or relaid, with advantage to the company.

The pressure at the outlet of the governor is used or dispersed in three ways :—(*a*) in carrying the gas to the consumer's meter ; (*b*) in carrying the gas from the meter to the burner ; (*c*) in supplying the requisite pressure to feed the burner. It should be clearly understood that a very appreciable portion of the governor pressure is required to do the work of carrying the gas to the burner. We can put any desired pressure, up to the full weight of the holder, at the governor outlet. We know that a flat-flame requires 8-tenths, a bunsen burner a minimum of 12-tenths, and incandescent burners about 15-tenths, to ensure satisfactory results. If the consumer gets this pressure, and not less, at all times, he says the gas is good. If he does not, he pronounces the gas to be "bad"; and also expresses considerable doubts as to the ability of the gasworks manager. (*a*) and (*b*) will vary according to the rate of consumption and the size of the pipes. The initial or governor pressure will always be equal to $a+b+c$. Matters can and should be so arranged that *b* does not exceed 5-tenths, including the pressure required to work the meter.

The tendency has been, and still is, towards an increase on all these items. The district tends to expand, and the area of supply is increased, while new consumers and additional lights for existing ones are continually coming in. Added to this, the consumer will not be satisfied with less than 20-tenths at the inlet of the meter. Fifty years ago he would be satisfied with 13-tenths. As the result of increasing *c*, the other factors are reduced. If the initial pressure is 25-tenths, and $b+c=13$ there is a margin of 12-tenths left for *a*. But we have seen that under present conditions $b+c=20$. *a* will, therefore, be reduced to 5-tenths, which is not a safe margin for contingencies. For this reason, it is rarely practicable to work satisfactorily with an initial pressure of less than 30-tenths. There is here an additional reason for seeing that the mains and services are well and soundly laid.

The relation between the sizes of main pipes and satisfactory conditions of supply can be illustrated by selecting any fixed quantity and distance, and noting the pressure required (*a*) for various sizes of pipe. Suppose we take 1,000 cubic feet of gas per hour to be conveyed a distance of 500 yards. Referring to a table giving the discharge of gas per hour through pipes of various sizes, and remembering that the quantity delivered varies in proportion to the square root of the inlet pressure, we get the following values :—

For 2-inch diameter . .	$a=40$-tenths.
,, $2\frac{1}{2}$,, ,, . . .	$a=11$,,
,, 3 ,, ,, . . .	$a=5$,,
,, 4 ,, ,, . . .	$a=$ less than 2-tenths.

To give a satisfactory supply, viz., $b+c=20$, the initial pressure must be—

With 2-inch diameter	$a+b+c=60$
,, $2\frac{1}{2}$,, ,, ...	,, $=31$
,, 3 ,, ,, ...	,, $=25$
,, 4 ,, ,, ...	,, $=22$

Or suppose 2,000 cubic feet per hour is to be delivered to a similar distance

With a 4-inch diameter pipe . .	$a = 12$-tenths
,, 5-inch ,, ,, . .	$a =$ less than 2-tenths

It should further be observed that a and b are independent of the initial pressure. If the latter is insufficient, c will suffer to a corresponding extent.

Next let us note the effect of varying the rates of consumption under a constant initial pressure, say from 1,000 cubic feet to 2,000 cubic feet and 25-tenths pressure. With a 5-inch pipe the variation in the values of a would not be noticeable, but with a 4-inch pipe we find—

With a consumption of 1,000 cub. ft. per hour, $a=2$ and $b+c=23$
,, ,, 2,000 cub. ft. ,, $a=12$ and $b+c=13$

This example brings out the fact that for every size of pipe there is a condition which we will call the carrying limit. This will be reached in the example above quoted when the rate of consumption is such that $a = 5$-tenths, or, in other words, when :—

$$\text{Initial pressure} - a = \text{less than 20-tenths.}$$

A very important point is that as we approach and exceed the carrying limit, the value of a advances by leaps and bounds.

These simple illustrations serve to explain the distribution troubles that so often arise in practice. When we consider the difficulty in forecasting the maximum hour's consumption, the effect of variations in altitude, of bends, curves, tees and other obstructive influences, it is evident that the distribution problem is a very complicated one, and that the main pipes must be sufficiently large to clear the peak of the load.

We have already noted the effect of varying conditions, and the problem is not simplified by the changes that are continually taking place. Even if a satisfactory distribution scheme is carried out, things may so alter in the course of ten years that a rearrangement to suit the new conditions is called for.

Suppose a new by-road is opened up, and a main laid. The first year there will not be more than half-a-dozen consumers, as residences will not be built faster than they are wanted, and the district continues to develop slowly, adding, say, three or four new consumers per annum. At first, a is an infinitesimal quantity, and the consumers get the full initial pressure. But, as more consumers are added, and the existing ones begin to adopt cookers, gas fires, geysers, etc., a limit is arrived at when a comes into evidence, first at periods of maximum consumption, such as Saturday night, and as the carrying limit is approached the advance in a becomes rapid. Can one wonder that some of the earliest consumers begin to complain that the gas is not so good as it used to be?

The initial pressure and the value of *a* are matters determined once for all by the original design of the plant. Suppose a manager having 500 yards of 4-inch pipe and a maximum available initial pressure of 25-tenths is called upon to supply 2,000 cubic feet per hour at 20-tenths, he cannot do it. The remedy is to take up the 4-inch pipe and put down a 5-inch.

An established rule as to the depth at which main pipes should be laid is, or was, a clear 18 inches, and sometimes only 15. But there is good reason for re-considering this matter. The heavy motor and traction engine is a power in the land. Even in the smallest villages the large engine, with its train of two or three timber trucks, loads of bricks, furniture, pantechnicons, etc., is seen to pursue its lumbering, noisy way, and the heavy studded wheels cause a perceptible vibration as they pass. The road authorities have developed a fancy for 20-ton road rollers, and do not always employ either the quality or the thickness of road metal that is consistent therewith. And they believe in making up the roads with a rise of several inches on the crown, into the shape, in section, of the segment of a circle. Sometimes this result is obtained by re-metalling the centre of the road only and rolling down the sides. I have known roads to be put down three inches or so at the gutters, and the authorities did not seem at all perturbed at the risk of injury to the service pipes. Mains and services do not have such an easy and comfortable time as they used to get, but are subject to more strain and to more vibration.

In country districts it is rarely practicable to have more than one line of main in a road. In towns with wide streets, fully occupied on each side, a main on each side of the street may be provided, but in the country, one line of main has to serve both sides of the road. A very usual plan is to lay it on the most populous side. Where there are likely to be connections on both sides, it should be well out towards the middle, and not hugging the gutter or in the footwalk. Very often it happens that the business is confined to one side of the road, as, for instance, a thoroughfare skirting a private estate, or a public recreation ground. Under these circumstances, of course, there is no advantage in keeping out towards the centre of the road. Probably, the district surveyor may have something to say on the point. If there is a long stretch of main to be laid along a road having a border of grass on one or both sides, as frequently happens in the South of England, it may be desirable to lay the main under the turf, and not in the road. There is a considerable saving in cost of excavation, and the pipe is not exposed to the vibration of passing traffic.

The pipe must be laid deep enough not only to ensure protection from frost and vibration, but to give the service pipes a smart fall towards the main. In my experience, 18 inches depth is not sufficient for modern requirements. It does not afford sufficient protection from vibration, and the service pipes must be laid nearly level, or else almost out of the ground at the gutter. Yet I have seen pipes laid in the footwalk, on one side of a 36 feet wide road, and only 18 inches deep; with the result that services carried over to the far side had to be laid with a fall away from the main, and a bottle syphon fixed at the lowest part. A depth of 24 inches clear is far preferable. It adds to the cost of excavation, but the advantages secured are well worth the extra outlay.

Over the greater part of my career the cast-iron main pipe has been the invariable rule, but within the last ten years I have laid several miles of wrought tube, both with screwed and with socket joints. The advantages of wrought or steel tube, as compared with cast-iron, are elasticity, fewer joints and greater strength. Against these, there is the bugbear of durability. It is remarkable that engineers who have always been accustomed to lay long lengths of wrought-iron pipe up to 2 inches diameter will oppose wrought-iron mains on this ground. There is no evident reason why a 4-inch or 6-inch pipe should be more exposed to corrosion than a 2-inch, and, to be consistent, if it is considered that wrought-iron main pipes will not stand, the whole of the service pipes should be laid in cast-iron. Most of the objections to wrought-iron, as to many other things, come from those who have never tried it. I have frequent occasion to examine wrought-iron main pipes that have been laid for some years, and have seen nothing whatever to indicate that their working life will be short. There is some advantage as regards first cost, size for size. A run of 4-inch steel, or wrought, when laid, will cost appreciably less than cast. But the delivery capacity is greater. The pipe being smooth inside, and the breaks for joints less frequent and pronounced, there is very much less skin friction on the inside of the pipe, and under similar circumstances as to diameter, length and initial pressure, wrought pipes will deliver quite 25 per cent. more gas than cast. The difficulty of making sound service connections is another fancied objection. Of the two, the advantage is in favour of the wrought pipe, because the whole thickness is used, whereas with cast iron the hole is apt to be chipped. Two complete threads on a wrought-iron main will be as strong and as sound as the average joint on a cast-iron pipe $\frac{1}{2}$-inch thick. If preferred, saddle pieces may be used at the junction of main and service, and they certainly afford support at a weak place.

My experience has been confined to lead joints for cast, and lead and screwed for wrought. I have never used turned and bored, or cement joints, and, therefore, cannot say anything as to their advantages. For wrought or steel pipe, I prefer lead wool to cast lead. It wants more setting up than the run joint to make a sound job, but it gets all the way home. The advantage of cold lead in wet weather is obvious, as lead wool can be set up even under water. It also has the advantage of doing away with the main-layer's fire basket, which is a great annoyance to inhabitants or passers by in windy weather, when the smoke and dust blow about. I also buy up all old roofing lead that is available, as it is much better quality for mainlaying than new pig lead. Wrought-iron or steel pipes offer the advantage that the whole of the jointing work can be done above ground. No jointing holes are required, and the work can be done in comfort and is subject to easy inspection before being lowered into place.

In the old days, the gas company practically had sole possession of the subsoil, but now the smallest towns have their water and sewerage systems, and the mainlayer is lucky if he can set out his run without coming dead on to an inspection chamber or elevator. A strong point in favour of wrought-iron is that it can be diverted a foot or more to one side or the other without the use of special castings. The use of such castings not only adds to the cost in the first place, but to the risk of complaint or stoppages afterwards. Suppose that the mainlayer has to get round an inspection chamber 4 feet square in plan. This will mean, if cast-iron is being used, four sweeps, two on each side. This little diversion from the straight line means a very substantial reduction in the delivery capacity of the pipe.

Bridges are a great nuisance to the mainlayer, and are a cause of many heated discussions with the county surveyor, who sometimes goes so far as to refuse point blank to have the arches cut into. In many old stone bridges, the crown of the arch almost shows through the road, and there is not more than 3 or 4 inches clearance. Sometimes the footwalk can be raised sufficiently to cover the pipe, or permission obtained to make it up to the desired extent. Wrought-iron tubes can be flattened to the extent of about two-thirds the diameter, for a small charge per pipe, being changed from the circular to the oval form in section; and, wlth an eye to future possibilities, it is well to put them in rather larger than the run of pipe to which they are attached. Sometimes the bridge is narrow and has no footwalk, and there is no other way than to skirt the parapet outside, or even to support the run of pipe independently. In the latter case, a water-tight and non-conducting covering is desirable.

At this point we leave the subject of distribution, having dealt with it to the extent to which the constructing engineer is concerned. Services and internal fittings will be taken in hand in a subsequent chapter, and there is also something to say about distribution and the manager's responsibility in regard thereto.

CHAPTER VI.

COMMENCING OPERATIONS.

So far, I have been dealing with an embryo gasworks, and dating my remarks from some period anterior to the date of construction. Consideration of design, etc., however, is not much help if the works has already been provided and is ready for use, and it is more a question of utilizing available material to the best advantage. Now it is proposed to move on to a later stage, and to assume that the construction has been completed, and that the contractor, after his work has been accepted and passed as satisfactory and in accordance with contract, by the engineer, has removed his scaffolding and all belongings, leaving everything complete and ready for use.

The next step is to engage a competent working manager, capable of being left in charge, to carry on the daily operations. He will regularly or occasionally require the help of unskilled labour, according to the scale of operations, but no further technical assistance will be called for. He must, to some extent, be a "jack of all trades," but not necessarily a "master of none," as it is well that he should be able, in addition to carrying on the regular operations at the works, to advise consumers, attend to complaints, lay services and fix meters. Sometimes a local plumber or ironmonger takes up the outside department, but the result is not so satisfactory, because it divides the responsibility, and the manager has not enough to do to fully occupy his time. The local tradesmen is more interested in making a trade profit on the job than in selling gas, so that if the manager does not understand gas cookers and fires, incandescent burners, etc., the concern is at a disadvantage. A man who has been employed at a large gasworks has not enjoyed the facility for acquiring a general all-round knowledge of the conditions of gas manufacture and supply. It can be obtained in an 8,000,000 or 10,000,000 cubic feet country works, where he may be called upon to lend a hand at anything and everything. A competent gasfitter, who has been accustomed to assist at the works when required, and has thus picked up a fair acquaintance with ordinary gas-works routine, or an all-round man at the works, will usually find little difficulty in qualifying, but a man from a large works, as a rule, has had practical experience of one particular department only.

In a works of 3,000,000 cubic feet per annum or less, there is not enough work to occupy the time of one man, for a considerable part of the year, and it will be well if he can be encouraged to take up some useful occupation, such as cultivating a garden, working a poultry run, keeping bees, or any interesting and remunerative hobby, as idle time is apt to lead to more tobacco and more beer than is good for the interest of the man or of his employers. This difficulty is not so evident now as formerly, because with the advent of incandescent burner maintenance, letting stoves on hire, etc., there is more detail in the small as well as in the large works, and there is no district so small or so poor but that the manager can put in a little time at missionary work.

The finances, purchase of materials, etc., will be under the control of a board of directors, who may appoint a managing director or a small sub-committee, and only have a full meeting twice a year, or on any special occasion. In this connection, it should be remembered that there is not necessarily wisdom in numbers, and that quality rather than quantity tells. A weak board of three members is not improved in any way by the addition of three more of similar calibre. In non-manufacturing districts, there is a difficulty in meeting with men of suitable qualifications to take a really sound grasp of the business and its possibilities. All moneys received should be paid into the bank, and all payments be made by cheque, a wages cheque for each month being drawn in advance. The board should have a report from the manager at regular intervals, giving such simple details as tons of coal and lime used, gas made and sent out, products sold, etc., but beyond that, any elaborate table of costs or calculations is of little value. When the primary quantities are estimates, or cannot be accurately calculated, there is no advantage in figuring to the extent of a decimal point per thousand cubic feet on them. A complicated form of statistics may tend to conceal, rather than to make prominent, any defects in the management or working. The manager should also be held responsible for furnishing, when desired, an accurate statement of the stocks of coal, lime, residuals, materials, etc.

The question of remuneration is one that calls for the exercise of reasonableness and a sense of justice on both sides, and circumstances vary so much that no fixed rule can be laid down. But the practice of putting the job up to the cheapest bidder, by advertising for candidates to state salary required, is not to be commended. A really competent man does not take a job at bread and cheese wages, unless he is in reach of starvation, and then only regards it as a temporary makeshift, to enable him to look round, and he does not put any heart into the work. The cost of living differs in various localities, and a respectable man expects to pay his way and to be a little to the good. Philanthropists anxious to benefit mankind, men of means to whom salary is a secondary consideration, or men who can live on sixpence a day and get fat and save money, do not figure in the lists of applicants. A good master goes a long way towards making a good man, and the converse also holds good. If a man is not at least fairly remunerated, he cannot be expected to put forth his best abilities in the interest of his employers, or to be over anxious to give satisfaction. The best rule is, having found a capable applicant, to pay him a salary that will make it worth his while to do his best, and to feel that the position is worth having and worth retaining. Wages to a man are something like oil to machinery. If the supply is meagre, both are apt to go rusty, and give a poor working duty. To get the full working capacity out of a machine, it must be carefully tended as well as properly oiled.

The question has lately acquired considerable prominence, whether a fixed wage, even if liberal, is the last word, regarded as a means of getting the fullest possible value from an employee. In this connection, it is only fair to the numerous body—probably by far the larger proportion of the population—who receive a fixed wage, to say that, as a rule, they conscientiously give their best. But something is wanted beyond a mere slavish performance of routine. There is room for initiative, improvement, economy in every direction, and, obviously, the best means of developing energy along these lines is to give the man a more direct interest in the profits than is afforded by the fixed wage. As much has been recognized from a very early period, by means of various more or less crude arrangements, such as the back shilling (a shilling a week held back and payable at six or twelve months intervals, subject to good conduct), an annual present at Christmas, a bonus on every 100 cubic feet per ton made beyond an agreed standard, on increases in gas sold, or on the net profit. It remained for the late Sir George Livesey to gather up these broken threads and weave them into a complete fabric, and his scheme of co-partnership is now generally admitted to be the best known means of meeting the requirement. As there are no works too large for it, so there is none too small. A strong plea for its application to the small works is the absence of anything like complete supervision. Sometimes one of the directors happens to have leisure time on his hands, and makes a hobby of the gasworks, but otherwise the profits do not warrant daily or even weekly attendance, and the working manager may be left to himself for months at a time.

As a rule, the remuneration takes the form of an inclusive weekly or monthly wage, inclusive in the sense that no extras in the way of overtime or Sunday work are allowed. And the custom of allowing perquisites, such as free gas, a cwt. of coal or coke per week in the winter, etc., has now practically died out. A week's free holiday in the summer is very usual. This is simply an equivalent of the six days' holiday in a year that are, by custom, granted to persons in receipt of fixed wages. Apart from this, and while there is no possible objection to a joint of beef or a goose at Christmas, it is not desirable that the wage should include anything in the form of gifts—it is putting the man in a false position. He is entitled to receive the full, fair market value of his labour, and his employers cannot be expected to pay more.

Sometimes the manager undertakes to find all extra labour required for a fixed addition to the wage for his personal services, but the plan has several objections. One is, that it gives him a direct interest in keeping down the output of gas, and, as such, is the antithesis of co-partnership as above instanced. It certainly offers the advantage of encouraging economy in the matter of additional help, but whether the ultimate result is really an addition to the profits of the concern is another thing.

Contracts are usually entered into for the purchase of coal and purifying material, and there is too commonly a practice of regarding this question solely from the point of view of price. It is a very simple matter to pick out the lowest price, or to try to obtain a small cash discount. But competent buying goes further than that. The question "What value will be gained from the material in working?" is more important than the cost price. A simple way of getting at the comparative values of two kinds of coal is to compare the respective yields of gas and of coke. Suppose the cost of gas in the holder, exclusive of capital charges, to be 2s. 6d. per thousand cubic feet, and the yard price of coke 9d. per cwt. The two coals, respectively, yield 10,000 cubic feet of gas and 14 cwts. of coke and 9,000 cubic feet of gas and 12 cwts. of coke per ton. These results, it is assumed, are not a laboratory analysis or a working test on the large scale under totally different conditions, but as obtained at the works in question, or from one of similar size, and preferably from coal supplied in the regular way of business, and not as a special sample for testing. Suppose that the prices of the two samples, respectively, delivered into coal store, are 15s. and 14s. per ton. The value of the products divided by the cost of the coal gives a factor that represents the value to the purchaser, and the coal that gives the higher factor is the one that will give the better results, irrespective of cost.

		£	s.	d.
No. 1.	Gas, 10,000 cubic feet, at 2s. 6d. . .	1	5	0
	Coke, 14 cwts., at 9d.	0	10	6
	15)	1	15	6
			2·37	
No. 2.	Gas, 9,000 cubic feet, at 2s. 6d. . .	1	2	6
	Coke, 12 cwts., at 9d.	0	9	0
	14)	1	11	6
			2·30	

No. 1 gives a higher factor, and is, therefore, the more economical coal at the prices named.

Frequently we require to know the value of No. 2 in terms of No. 1, *i.e.*, the price that might be paid for No. 2 to make it as cheap as No. 1. This is a simple proportion sum. If x = value required,

$$14 : 2{\cdot}37 :: x : 2{\cdot}30 \therefore x = 13\text{s. } 7\text{d.}$$

The yields of gas and of coke are the chief, but not the only, conditions that determine the comparative values of coal. Questions such as the quality of gas and coke, amount of impurities to be removed, proportion and quantity of clinker, as affecting the proportion of coke required for carbonizing, and other working conditions, must have due consideration. Sometimes the works are so located as to be dependent on one particular field or district for a supply of coal, or even upon one or two collieries. If there is only one line of delivery, either by rail or water, the situation is in the hands of those collieries best situated as regards delivery. At other places it is possible to buy from two or more different districts, according to the fluctuations of the market. In any case, it is a convenience to have two different qualities of coal in store, giving a marked difference in the yield of gas, as affording means for varying the make per charge. At Christmas, or at other times when there is a full demand for gas, the better kind may be used exclusively. In light weather, or on early closing nights, when the demand is less, only the inferior kind is used.

CHAPTER VII.

THE MANAGER ON THE WORKS.

THE operations commence in the retort house, and here the usual working conditions are such as not to warrant high heats and short period charges, and the six-hour charge finds general favour. Sometimes it will be found that eight-hour charges give better results, especially when the heats are rather below par. Some care should also be taken in the way of finding out the best weight for each charge; and skill in this respect will tell at the end of the year. If the scale of operations does not warrant the employment of more than one man, and banking up at night is, consequently, a necessity, it is desirable to spread the charges as widely as possible. It is more convenient for the man to work 6 a.m., 12 noon and 6 p.m., but better for the retorts and for the working results if they are spread to 6 a.m., 2 p.m. and 8 p.m.

Some judgment must be exercised in arranging to keep the retorts fairly clean, as there is no economy in running dirty retorts. Not only is the gas yield reduced, but there is a larger consumption of fuel and increased wear and tear on the retorts and settings. For small works, I am strongly in favour of the 5-inch air pipe at the back of the retort, extending through the back wall and provided with a cast-iron cap and screw clip. When the retort is to stand off for cleaning, the cap is removed, and a spreader inserted in the pipe from the front. The mouthpiece lid is screwed up, and the cap on the top of the ascension pipe is removed. A brisk draught is created through the retort and up the ascension pipe, which speedily loosens the carbon and at the same time clears the pipe. The manager of a small works is rather apt to get into slovenly habits in this matter, particularly during the winter months; but he cannot expect to get through the heavy season comfortably with dirty retorts. And one of the reasons for enlarging on the utility of the exhauster, even on the small scale, is that it reduces the frequency of standing off for cleaning. It is a good plan to make a note in the carbonizing book of the dates on which particular retorts are cleaned; and for this purpose the settings may be indicated by letters, and the retorts by numbers, starting on the left hand as one stands facing the retorts. To prevent confusion, it should be understood that particulars respecting the retorts should always be taken in this way. A left-hand mouthpiece, for example (*i.e.*, a mouthpiece with the outlet for gas on the left hand, not on the top), has the pipe thus: . Much confusion and trouble has been known to arise from neglect of this simple rule.

The same applies to the flues of the furnaces. If they are not cleaned periodically, the draught and the heat must suffer. Some kinds of coke give a very considerable quantity of dust, which may be easily raked out when fresh, but after a time will fuse and bake hard. A slovenly worker will be inclined to adopt the simpler plan of giving the furnace another inch of damper, a proceeding that, perhaps, saves him some trouble, but does not tend to a long life for the setting, or to economy of fuel. The old-fashioned plan of cleaning a setting by throwing a bucketful of water into the furnace is simply barbarous, and should never be tolerated. There must be something radically wrong with the design, or with the system of working, to let the setting get in such a state as to call for a violent remedy of this kind, which not only moves the obstruction but strains the arch and the end walls. All excess of draught should be carefully avoided, by adjusting the dampers to give the heat required, and no more.

Neglect of these simple precautions means that the retorts and the settings get into bad condition at what ought to be an early period in their working life. A frequent cause of bad working results is that the retorts are in bad condition, and that more on account of neglect than of age. It is a mistake to try to get too long a working life out of the setting, and some of the ingenuity devoted towards patching cracks or weak places might well have been directed, at an earlier period, to the preservation of the retorts and settings in good condition. A setting that, of necessity, has to be banked at night cannot, under any circumstances, give so long a working life as one that is run continuously, nor can it have the careful and systematic working that is possible when the men have no duties other than those connected with the retort house, and are under the watchful eye of a head stoker or foreman. The arches and side walls are, as a rule, not so strong and substantial as those in larger works. But soundness and absence of leakage of air into the setting is just as important in small beds as in large ones, so far as economy of fuel is concerned. The arches and side walls should never comprise less than 9 inches thickness of fire-brick set in fire-clay, and every time the bed is renewed the arch and side walls should be carefully repaired and made good.

With regard to the weight of each charge and the consequent yield of gas, some judgment is necessary, according to the size of the retorts and the quality of the coal. The charges usually range between 2 to $2\frac{3}{4}$ cwts., and with coal of fair average quality there should be no difficulty in working off 6 to 8 cwts. per retort, with three charges per day and banking up at night, or 10 to 11 cwts. with continuous working and four charges per twenty-four hours. This would give a make of 2,800 cubic feet to 3,600 cubic feet per retort per day, when banking up at night, or about 5,000 cubic feet under continuous working. Much depends on the care and attention bestowed on the working. Some men, left to themselves for years, perhaps, are apt to develop very lackadaisical methods in the matter of drawing and charging, and they should be encouraged to avoid them, and to exercise smartness and alacrity in the work. For example, in order to save himself trouble, a man slacks the lids of three retorts at once, and proceeds to draw all three, and extinguish the coke before charging. This will occupy eight, or perhaps, ten minutes, and another eight minutes is occupied in charging. The average time that each retort is slack and doing nothing is about fifteen minutes. This repeated three or four times in the day comes to nearly an hour a day. But if each retort was dealt with singly, it could be drawn and charged within five or six minutes. And while all three retorts are standing open, they get chilled, with the result that the fresh charge takes longer to heat up. Several similar little details might be mentioned which at first sight appear trifling and insignificant, but which really go to make up the difference between a fat dividend and a lean one.

Smart, systematic habits of working are as necessary in a small works as in a large one. Charges should be in to the minute; and the clinkering, wheeling out ashes, making up ash-pan with water, etc., should be done at fixed times.

The filling of the ash-pans is apt to be neglected, with the result that the labour of clinkering is greatly increased. The fire-bars get overheated, bent and warped, and clinker that under proper working would come away easily must be attacked vigorously with a heavy crow-bar, perhaps assisted by the persuasive arguments of a sledge-hammer. All material in and out of the works should be weighed as far as possible, and the same as regards coal used. A small 5-cwt. platform weighing machine is not over costly, and soon pays for itself. Anything in the way of loose guessing or estimating, such as charging a retort with so many shovelfuls, or selling residuals by the "load," or by the "sack," should be sternly discouraged, as likely to lead to slack habits; nor should tar or liquor be sold on such lines. I have seen a strong, able-bodied man coming out of a small works staggering slowly and painfully homewards under the weight of a so-called "bushel" of coke, and found that the bushel, in course of time, had come to be regarded as a sackful, irrespective of the capacity of the sack. Of course, a cart or waggon weighbridge is out of the question, and some difficulty may arise over checking weights if there is not a bridge at the railway goods yard. But it is little more trouble to weigh coke in a sack or basket on the platform weighing machine than to measure it by the bushel. Even clinker, burnt brick and used lime should be weighed, and should not be given away if it can be sold at 6d. per ton. Considerable looseness in this matter is not uncommon, not only the clinker, but also the pan breeze, having come to be regarded as of no value, and given away.

The quantity of lime or oxide required to make up a purifier can be carefully ascertained once and for all, and the consumption of material checked by the number of boxes changed in the course of a year.

There is frequently some difficulty in connection with the night man, whose services are required during the winter months. He must, perforce, be left in sole charge for several hours; and it is needless to say that a qualified, experienced retort house hand is not obtainable. Sometimes there is a very small choice, but it is poor economy to engage inferior labour at a cheap rate. The grate furnace, which requires firing every hour or so, is more liable to suffer from neglect than the generator furnace, which need only be filled up once or twice during the night. And if the heats are let back, it may take twelve hours, or more, to get them into normal condition. Under these circumstances, it is preferable to delay or to miss a charge rather than to expect an under-conditioned furnace to carbonize its full quantity of coal, and at the same time to recover lost ground. The small manager has his peculiar difficulties and anxieties, and it is in view of these that the need for simplicity in design and construction has been insisted on.

There is an old saying, which like others of the same kidney is much less frequently quoted now than in my young days, to the effect that there is a place for everything, and everything should be in its place. The word "time" might be substituted for "place," for there is also a time for everything, and everything should be done at the proper time. Too often it is found that the manager has a number of odd jobs on hand that are to be done at some uncertain and indefinite future period. He intends to paint the gasholder—when he has time. The drip boxes and connections have not been cleaned out since the week after the Fair time before last, but this is to be done soon; in fact, it is about time they were done. Details that are shelved in this indefinite way are apt to be left too long, if not entirely forgotten. Matters such as repairs of retorts and furnaces, painting, cleaning up, etc., should be considered as a part of the year's routine, and each have its allotted period. Sometimes it will be convenient to do the work in the spring or autumn, at the termination or the commencement of the winter hand's time of service, when his assistance will be available for a week or so. Once a year, all the connections, drip pots, seals, etc., should be thoroughly cleaned, dry-faced valves examined and the faces put in good condition, slide valves oiled, and purifier covers and gasholder lutes painted or varnished on the wind and water line. A good skin on all the ironwork adds as much to its working life as rust and dirt tends to reduce the same; and there is room for some judgment in the matter of painting. With regard to paint, it is especially true that the best is the cheapest; and the cost should be judged by the covering power and durability rather than by the price per cwt. Paint laid on to a dirty or damp surface may be safely regarded as more than half wasted. Economical and successful painting of outdoor ironwork, or that exposed alternately to air and to water, involves four indispensable conditions, viz., (1) thorough cleaning of the surface from all loose scale, rust, etc.; (2) the surface, when the paint is applied, should be perfectly dry and moderately warm—a sudden fall of temperature between cleaning off and repainting may cause it to sweat; (3) the paint must be finely ground, and both it and the mixing oil absolutely free from moisture; (4) the new coating should not be exposed to rain or contact with water until it has had time to get completely set. It is difficult to secure all these conditions, perhaps, in our climate, but that is no excuse for mopping paint on anyhow in any weather, whenever the manager happens to be seized with an industrious fit; and this is frequently the cause of the woe-begone, discreditable appearance of the holders and apparatus in a small works.

The hydraulic main is usually a weak spot, especially where there is no exhauster. Under such circumstances, everything possible should be done to reduce the back pressure on the retorts, and an inch or more added at the hydraulic is a serious item. My experiences of anti-dip devices have not been encouraging. One point made evident is that the hydraulic seal does a considerable amount in the way of condensation and removal of tar, and that more work is thrown on the condensers in its absence. Before doing away with the hydraulic seal, therefore, the foul main and condenser should be brought quite up to date in the matter of size and efficiency. But, judging from what one actually sees, there would appear to be a common idea that any discarded fragment of hydraulic from the scrap heap at a larger works is good enough. If, as is too often the case, the hydraulic is circular or square, and none too large in section, with a plain weir overflow, and carried on crutches resting on the division walls of the setting, the working results will not take a first place. Its replacement by a modern section of large size, supported clear and independent of the brickwork on cross girders connecting the front and back buckstaves, and with adjustable overflow and flushing cock, will be money well spent.

The systematic use of a pressure gauge is also apt to be neglected, and, if one asks for such an appliance, an old one in bad condition, covered with dirt and dust, is fished up from some odd corner. If an exhauster is used, there are usually gauges fitted with it, but, in any case, the proper place for a gauge is the immediate outlet of the hydraulic, particularly when there is no exhauster. Cocks should be fixed at various points, such as hydraulic, inlet and outlet of condenser, ditto of washer and of each purifier, and the gauge should be fitted in a metal case, so that it can be conveniently shifted from point to point.

While an elaborate regulation of the hydraulic seal is not to be expected, there is no difficulty in adjusting it to less than one inch.

Self-sealing retort lids are rather too great a refinement for the average small works, but there is no occasion to use all clean lime for luting. It can be mixed with a good proportion of clay, loam, or spent lime, and sometimes other refuse material is obtainable.

One often meets with the expression, "a good carbonizer," used by people who do not understand the meaning of the term. It is strict and careful attention to details such as the above that constitute good carbonizing, rather than any special talent or genius.

For testing the ammoniacal liquor, a No. 1 Twaddel hydrometer is used, having a scale extending from 0° to 24°. A degree is equivalent to 2 oz. strength. A 5° liquor is, therefore, 10 oz., and a 6°, 12 oz. Care must be taken to see that the hydrometer is fairly accurate, as sometimes the instrument is found to be as much as 1½° or 2° out; which is a serious matter if the liquor is to be got up to a particular strength, or when it is sold at so much per degree or per ounce. If there is any appreciable quantity of light oil or tar in the liquor, the result will not be reliable; and the same applies to tests taken on a flowing stream, such as at the seal box at outlet of scrubber. I have found it a good plan, if there is any doubt about the accuracy of the hydrometer, to get the nearest chemist to weigh 16 fluid ozs. ($\frac{1}{10}$ gallon) of the sample, equal to 7,000 grains, or 1 lb. avoirdupois, of clean water. Since 1° Twaddel = 0·005 in specific gravity, each degree on 16 ozs. should increase the weight $7{,}000 \times 0{\cdot}005 = 35$ grains. The following are the weights for 1° to 10° liquid:—

1°	2 ozs.	7,035 grains.	
2°	4 ,,	7,070 ,,	
3°	6 ,,	7,105 ,,	nearly ¼ oz.
4°	8 ,,	7,140 ,,	
5°	10 ,,	7,175 ,,	
6°	12 ,,	7,210 ,,	nearly ½ oz.
7°	14 ,,	7,245 ,,	
8°	16 ,,	7,280 ,,	
9°	18 ,,	7,315 ,,	nearly ¾ oz.
10°	20 ,,	7,350 ,,	

Approximately, each increase of ¼ oz. in weight above 16 ozs. indicates 3° strength.

Suppose 16 ozs. of a liquor is found to weigh 7,210 grains. The hydrometer, if correct, should indicate 6°. If it registers any other figure, it is high or low, as the case may be. No important decision should be based on the reading of one hydrometer without corroboration. In a larger works with a laboratory at command, the distillation test would be used, because the specific gravity, even when accurately ascertained, is not necessarily a correct indication of the proportion of ammonia present.

The usual practice is to test the gas for one impurity only, viz., sulphuretted hydrogen, and to leave the others to take care of themselves. The gas is tested with lead paper at the outlet of the purifiers, and a change is made as soon as there is a sign of a foul test. The preparation of the lead solution is a simple matter, consisting of dissolving pure crystallized acetate of lead in clean rain or distilled water. The Gasworks Clauses Act 1871 specifies 60 grains of the crystals to one fluid ounce, equivalent to about $2\frac{3}{4}$ ounces to the pint. If the solution is not quite clear, a few drops of acetic acid may be added. The stock bottle should not be kept in the purifier house, but a small 2-oz. wide-mouthed bottle should be used for the test, and replenished as required, and both bottles should be kept reasonably clean. For some reason or other, the lead bottle will usually be found in the purifier house, and in a disgracefully dirty state, caked with lime dust and black stains from foul gas. Why this should be I do not know, as the efficiency of the solution cannot be improved thereby. A neater way of working is to use the ready prepared books that can be obtained at about a shilling a dozen, sufficient for a year's work, and to keep them in a box with a closely fitting lid. A little bottle of pure water is all that is needed, and a slip is torn out and moistened when required for use.

Daily testing with lead paper should never be neglected, as the proportion of H_2S remaining to be removed from the gas is liable to fluctuate, and the efficiency of the material used is not always the same. So it is not safe to depend upon some primitive arrangement such as changing a purifier once a week in the winter and once a fortnight in the summer. If the boxes are exposed to the weather, a sudden snap of cold will usually be found to prejudice the working, as neither lime nor oxide is so active at a temperature of 40° or less as it is at 50° to 60°. If the purifiers are enclosed in a building, it should be the rule to keep all doors and windows shut up during cold weather, except, of course, during the process of changing. The great point of successful purification is to keep ahead of the requirement, so as to avoid such a predicament as having a foul test at the last box and no material ready or in fit condition to go in. Take care to keep a step ahead, by always having one charge in readiness, and as soon as it is used, bring up another.

The efficient preparation of purifying material, whether lime or oxide, is not a matter that can be learnt from books. Some practical experience is necessary, in order to get the maximum of work from the minimum of material. Cheap and effective purification is not to be done with matchboxes, but with vessels of a sufficient size; and the areas usually quoted in text-books may advantageously be exceeded in works having a maximum of less than 25,000 cubic feet per diem. If lime is the material used, it should be known that a good building lime is not necessarily a good material for the purification shed. The ingredient required is chemically pure lime, Ca_2O, and carbonated lime (incompletely burned lime) or silicate (over-burned lime) is as valueless as a brickbat. So, if there is any doubt about the quality of a lime, it is well to get it analyzed for percentage of Ca_2O. A good lime slakes actively, swells to quite double the original size, and breaks up and crumbles to a coarse powder. If it does not come up to this standard, but is sluggish and cold in slaking, does not swell or crumble, or retains hard fragments that absolutely refuse to break up, it is insufficiently or improperly burned, and inferior in respect to percentage of Ca_2O. A good lime will not need passing through a screen. It is sufficient to throw it up against a wall, and to break up the lumps that roll to the bottom edge of the heap. It should retain a considerable quantity of water in addition to that which combines chemically with the lime, and the more it will take, without becoming sodden or soppy, the better. It should be moist enough to cohere when squeezed in the hand, but not too wet to lie lightly in the box. And some limes are improved by admixture with fine coke ashes that have been through a ½-inch mesh. This course is preferable, if the lime is apt to give a heavy back pressure, to reducing the thickness of the layers, which must necessarily shorten the working life of each charge. The slaking must be thoroughly complete, and the lime quite cool, before being laid in; and some limes continue to heat for a long time after the first violence of the action has passed away. If the lime is put in warm, it will continue to swell in the box, and then up goes the back pressure. With attention to these points, and assuming that the gas reaches the inlet of the purifiers properly condensed and free from tar, there should be no trouble from back pressure.

Some limes are apt to be extremely offensive when removed from the box, and continue so for several hours, or even days. To minimize this nuisance, the material should be spread thinly, so as to avoid heating up, and all lumps should be broken. The spent lime is usually in demand for agricultural purposes, and it should be thoroughly well weathered by exposure before being used.

If lime is fairly cheap, and the spent fetches a decent price, there are many reasons for preferring it to oxide. A charge of lime is more effective than a similar bulk of oxide, so the latter requires somewhat larger boxes than the former. But if lime is costly or the spent is a nuisance, oxide may be preferable. There should be a sufficient supply of oxide to leave at least two charges outside for revivifying; and it must be remembered that oxide does not come round properly, especially when it begins to get old, without turning and watering. It is a mistake to suppose that directly it changes colour it is completely revivified. If a few small lumps are cut through and examined under a magnifying glass, it will be seen that the revivification is on the surface only, and that the middle is quite black. And this surface revivification should not be confounded with through or complete revivification, but the oxide should be worked for some time after changing colour. If there are three boxes, sufficient oxide should be provided for five; and it is a good plan to keep each heap separate, and to distinguish it by a small lettered label. A proper record of purifier changes being kept, it is possible at any time to see the age and the work done by any particular heap, and to judge the position as to requirement of new oxide. After a time, the heap may swell to such an extent that a surplus remains after filling the box. This can be put on one side for admixture with new oxide. After eight or ten alternate foulings and revivifications, the material shows signs of getting old, and in a small works this usually happens when it has accumulated 40 to 50 per cent. of sulphur. There is a general idea that oxide cannot be worked up to 50 per cent. or more on the small scale, but there is no foundation for it. The explanation is that it does not get so much attention in the matter of revivification, and as the oxide gets old the action gets more feeble. The buyers of spent oxide require 50 per cent. or more of sulphur, and it is as easy to get the oxide up to this point, if the boxes are of sufficient capacity, on the small scale as on the large.

When an oxide purifier is opened, the contents should be removed without delay, and if the job cannot be finished before night and a part must be left till next day, the lid should be put on and the air valve closed. The exact treatment varies with the nature of the oxide. Natural ores, such as bog ore, clay iron ores, etc., differ somewhat in their action from the various artificial materials that are on the market. Some oxides are apt to heat up and fire if allowed to remain in a heap or thick layer, and large lumps, if present, facilitate the action, by rendering the heap open and more pervious to the contact of air. If the oxide fires to any extent, it suffers a serious and permanent injury, so far as gas purifying properties are concerned, and it should specially be observed that a temperature high enough to fuse the sulphur is objectionable. Some varieties of sulphur fuse at a very low temperature. So long as there is no fusing or priming, a moderate heating is an advantage, and if the oxide contains a large proportion of clay or sand, it may be an advantage to let it stand in the heap, and heat up slightly. There is a similarity between the slaking of lime and the revivifying of oxide, as in both cases the material gets warm. The freer the exposure to air the better, but there should not be a cutting draught on any one part of the heap, as that is a common cause of firing. The spent comes round quicker in the open than in a shed, and a gentle shower of rain does not hurt it. But in most climates a roof is necessary, as a protection against heavy rain. The sides of the revivifying shed should be as open as possible, and a few screens, perhaps 10 feet by 6 feet, of light boarding are a convenience as a protection against driving rain or wind. The roof should not be a close one, but provided with ventilation openings. The remarks previously made as to the ventilation of retort houses also apply to the revivifying shed.

CHAPTER VIII.

THE MANAGER IN THE DISTRICT.

THE manufacture of gas and its purification may be regarded as the primary operations, but the work of distribution is not less important. The days when the gasworks manager knew very little more about his district than the length and sizes of the mains have long gone by, and anyone who shuts himself up in the gasworks may shortly expect to be shut out of them, in favour of a more energetic and up-to-date successor. The old idea that all the manager had to do was to see the gas safely up to the boundary of the consumer's premises, and that a gasfitter would take care of the rest, is now obsolete, and it cannot be too clearly understood that the only way to get a really strong and vital business is to accept full responsibility up to the burner. The cooker and the incandescent light departments will not look after themselves, but call for continual nursing. Even if circumstances do not admit of a burner maintenance scheme, the manager must not only understand all the details himself, but be prepared to advise and instruct customers. Burners choked with dust and dirt, and broken or tipsy mantles, are not a good advertisement; and gas stoves are frequently partially or entirely discarded on account of some trifling defect that could easily be explained or remedied. In larger works, one can remember when the district occupied a seat a long way back, and there were ten or more men at the works for one on the district. Now the tendency is rather the other way, and the outside staff is equal in importance and numbers to the inside. So the small works manager of to-day must be always in evidence and accessible to consumers. He should have his pliers, his pressure gauge and descriptive pamphlets of gas appliances always in his pocket, and be competent to do the right thing for the customers and for the company.

The quarterly reading and booking up of the meter indices should be undertaken by the manager, as it affords excellent opportunity for getting in touch with the consumers. It is important, if the accounts are to be kept accurately, that each index should be taken promptly, and on the same day in each year. A fair estimate of the lost or "unaccounted-for" gas can then be arrived at, and the consumer is not annoyed by the irregularity of having a bill covering only eighty-five days at one time and ninety-five at another. But there is no necessity to rush round frantically, without time for a "Good morning," and annoying people by going into kitchens or living rooms without knocking, in the endeavour to get the whole thing done in one day. The usual closing time on the works carbonizing books is 6 a.m. on the first of the month following the quarter day, and the meter taking should be proportioned so as to give an equal margin before and after. For example, if there are 200 meters, 100 should be taken on the 31st, and the remainder on the 1st. Keeping this point in view, it is easy to spread the taking over two days or more. It is not to be expected, of course, that a lengthy discussion can be engaged in at any one house, but much can be done in a few minutes, and if necessary a subsequent appointment can be arranged. Notes or memoranda should never be made on the meter index sheets. They are liable to be overlooked or, if not rubbed off, to lead to confusion and mistakes in subsequent quarters. A separate note-book should be carried for entering changes, possible new customers, or extensions for old ones, complaints of all kinds, etc. A diligent man will be on the look out for and pick up a large amount of useful information of all kinds; and he should direct his attention towards keeping existing business, as being even more important than looking out for new. Frequently it happens that if as much attention was given to the existing customers as to soliciting new ones, as good an increase of sales could be shown, and that with no additional expense for services and meters. Particular attention should be given to all cases of discontinued or diminished consumption of gas, and the manager should be fully satisfied that such have arisen from unavoidable causes, or that they do not admit of remedy.

In the absence of an intimate knowledge of the district, the manager is at a great disadvantage in respect to the most important duty of regulating the supply pressure according to the requirements. We have already noticed that the old idea of regulating the pressure according to the expected consumption is going out of date. The tendency is towards maximum pressure right away from 6 a.m. to 11 p.m.; so the works governor tends to become a superfluity, except as a means of reducing the supply during the small hours of the night. In the case of a new and strange district, much useful information can be obtained by taking the hourly output, as shown by the height of the gasholder in use. With the aid of previous remarks on the elementary principles concerned in the supply pressure, and by ascertaining the actual conditions obtaining during the hours of maximum consumption in various parts of the district, there should be no difficulty in arranging a proper pressure schedule. A recording pressure register giving a twenty-four hour diagram, and in some cases seven consecutive diagrams, showing the difference on each day of the week, is the only way of accurately getting at the requirements. But a recording pressure gauge is rather a luxury for the small works, particularly as not more than two dozen diagrams are required in the course of a year. An enterprising firm could do a good trade in letting out portable pressure registers on hire. It must be remembered that the conditions, when accurately ascertained, only apply to the present state of affairs, and that alteration or additions may upset them entirely. A degree of pressure that gave satisfactory results ten years ago, or two years ago, will not necessarily do so now. If an important change takes place, such as the introduction of a large gas engine, the effect as regards pressure should be carefully ascertained.

Complaints of insufficient pressure should never be allowed to go by default, but should be followed up to a finish. If the defect is in the consumer's fittings, as it is in nine cases out of ten, and he refuses to have it remedied, he should be made to understand the real facts, and that the company are not responsible. If it is a question of a larger main, or service, it rarely happens that the cost of this is such as to render it wiser to allow the complaint to continue than to effect an alteration or enlargement.

Consumers do not hesitate to invite the gas company to go to any amount of expense, but if they are asked to renew or extend their own fittings, the tables are turned. A short time ago a personal friend was ragging me as to his gas supply. When he lit the geyser at any time in the evening, he could not get a decent light in his sitting-room, and his deduction was, of course, that the works pressure or else the size of the mains was utterly inadequate. Going fully into details, I explained that he was trying to get 200 cubic feet per hour through a service and meter only large enough to supply 100 cubic feet, which was the same thing as trying to pour a quart of liquid out of a pint pot. After a time, he fully saw the point, and then surmised that if he had the pipes enlarged to supply the 200 cubic feet, the quarterly bill would increase. I made it clear that whether he used 100 cubic feet or 200 cubic feet, he would have to pay for it. After a pause, he said that there was not much the matter, and things had better stay as they were. Some people who talk loudly about bad gas and bad supply are already getting as much as they are willing to pay for.

The manager will also find it desirable and necessary to control his temper. Occasionally, a customer has a grievance against the company, the most common being the result of an intimation that the limit of credit has been reached and a request for prompt payment of arrears. In one case a gas manager happened to attend a club dinner held at an inn, and the landlord had only a few days before received a "final application." The room was lighted with gas, and the main tap at the meter turned back half way, so that the supply was not good, and immediately before dinner the landlord bustled in with a large oil lamp, which he placed before our friend, remarking loudly that it would enable him to see. But before the toast list was completed, the lamp went out, for want of oil, and the tables were turned by the victim, who quietly suggested that the main tap might now be put on full. This is an example of the necessity for preserving an easy front under irritating circumstances. The manager who can establish a character for truthfulness, fairness and competence in the district is more than half way towards a full dividend for the shareholders.

Another permanent duty is to keep the system of mains clear and free from condensed water, by periodically pumping the drip boxes provided for the purpose. A frequent defect in a small district is the insufficiency of drip boxes. There is a plug or two at certain localities, which are removed when necessary, and the liquid allowed to flow out. This is a very unsatisfactory arrangement, and a proper drip box should be inserted at the earliest opportunity. If a run of pipe has sagged or got out of level in places, and allows water to accumulate, it should be re-set and levelled. The manager should be provided with an accurate list, showing the location of every drip box, including not only those on the mains in the highway, but any bottle or service syphons on consumers' premises. Wherever the location, the object of the drip box is to provide means for extracting the condensed water without interference with the supply of gas, and it should not be neglected until there is a stoppage or a short supply. Under normal circumstances, and with all in proper order, this is not a very arduous duty. If the mains are soundly and skilfully laid at a proper depth, two or three times in a year should be quite often enough for the round with the syphon pump. In any case, the date, and the quantity of fluid taken out, should be noted, as it affords useful information. One hears sometimes of a drip box that requires to be cleared once a week, in a neighbourhood where the main is waterlogged. This may be accepted as evidence that the main is leaky, probably at a joint, because where water can get in gas can get out. It will pay to examine the main during the next dry season.

The liquid pumped from the drip boxes should consist of fairly clean water. There is sure to be a little rust, and evidence of its gassy origin, but it should not be specially offensive, or contain any quantity of tar or of oil. This remark applies particularly to English coal and English climate. I have never known trouble to arise from deposits of naphthalene in a small district, and, therefore, do not consider it a part of the present subject to deal with the methods usually adopted for its prevention or removal.

In the early days, when the appliances for consuming gas were limited to, perhaps, half a dozen flat-flame burners, and the maximum consumption to 30 cubic feet per hour, the size of the service supply pipe was not of much consequence. But the introduction of gas fires, gas cookers and geysers has largely increased the maximum hourly consumption. For convenience of calculation, the maximum consumption is usually stated in terms per hour, although it may only extend to a few minutes. And the gas manager should be prepared to advise as to the proper size of service pipe. The bare statement that a certain size of meter is to be fixed should not be accepted as evidence of the size of service required. The matter is further complicated by the ridiculous practice of stating the size of the meter as so many "lights," an obsolete expression that gives no useful information. If instead of supplying a "5-light" meter, the maker would supply one guaranteed to pass anything up to 40 cubic feet per hour without abnormal increase of pressure, there would be something to go upon. It is usually understood that each light represents 6 cubic feet per hour, that a 5-light will pass 30, a 10-light 60 cubic feet per hour, and so on. Also that a meter may be depended upon to pass nearly double its nominal capacity. But it can only do this at a sacrifice of pressure, and we have already noticed that there may be no margin for this. For example, with a pressure of 20-tenths at the inlet of meter, *i.e.*, $b+c=20$-tenths and $b=5$-tenths, $c=20-5=15$-tenths. But if b is increased to 8-tenths, c falls to 12-tenths, too close to the point at which incandescent burners begin to flicker to be safe.

The hourly consumption of any gas appliance can usually be ascertained from the maker's list, but a little actual experience with a test meter will soon put anyone in a position to prepare an estimate of the maximum consumption. It is no uncommon thing to find a geyser, cooker, gas fire, and, say, six lighting burners, coupled up to a fairly long ¾-inch service and 10-light meter. If it happens that two out of the three fuel appliances are required at one time, during the evening, the pressure, c, at the lighting burners is bound to fall, and they will flicker and bob, to the great annoyance of the users. The most that can be expected from 40 feet of ¾-inch service and a 10-light meter, while maintaining pressure, c, at a proper figure, is 80 to 90 cubic feet per hour—barely sufficient for the geyser alone. The following is an example of a maximum consumption estimate :—

	Cubic Feet
Geyser, forty No. 2 flat-flames	80
Cooker	50
Gas fire	20
Six incandescent burners, say	25
Total . . .	175

Having arrived at this figure, a table of the quantities of gas supplied through pipes of various lengths and sizes may be consulted. On page 195 will be found a table of this kind calculated for a loss of 4-tenths pressure. It was drawn up over thirty years ago for use with flat-flame burners, and in applying it in connection with incandescent or atmospheric burners, there are many positions, such as the far end of the district, or a low-level position, where even a loss of 4-tenths may be objectionable. The table allows no margin for such contingencies as accumulation of rust in the pipe or for the obstructive effect of bends or curves. The meter, in the course of years, works stiffer, and absorbs more pressure than when it was new. There must be no sailing close to the wind in the matter of the size of the service pipe; and there is no reason for niggardliness in regard to this matter, because the difference in cost as between one size of pipe and the next larger is a mere trifle. If, in the above example, the service is 36 feet long, the table shows that a $\frac{3}{4}$-inch pipe would supply 180 cubic feet per hour. But no competent fitter would think of laying less than 1-inch pipe. To get a satisfactory result, it is well to take about twice the maximum consumption shown in the table. If 200 cubic feet is required, look out the size and length of pipe for 400 cubic feet.

The table is also useful for calculating the size of pipe required for a gas engine, a cooker, or any other appliance.

Sharp bends and elbows should always be avoided when practicable. A right-angle turn has a very appreciable effect as regards delivering capacity, and it also offers facility for accumulations of rust. A straight run of pipe can be satisfactorily cleared with a force pump, but if there are two or more elbows, the result is different. The force of the pump drives the rust into the corners, and to make a good job the pipe must be taken apart. An elbow at the bottom of a long run of perpendicular rising pipe is sure to give frequent trouble.

The smell of escaping gas is one of the greatest drawbacks to its use, and, whether in the roads or on the consumers' premises, should never be allowed, if it can be avoided. On account of the carelessness of fitters, many people have an impression that an occasional stink of gas is unavoidable, and some will not use it on this account. It is quite possible to connect up a service pipe, or to clear an obstruction, without letting all the neighbours know of it. Such carelessness as emptying fluid out of a meter, or the contents of the drip boxes, into the gutter at the side of the road may cause a great deal of annoyance, and certainly does not prejudice people in favour of gas. All complaints of escapes should be carefully followed up; and most gas companies are willing to stop escapes in the consumers' fittings. The consumer wants a lot of attention nowadays, but it pays.

CHAPTER IX.

SELLING PRICES AND TERMS OF BUSINESS.

THERE is no difficulty in arriving at a mutually satisfactory schedule of prices, if regard is had to the rights and requirements of both parties concerned. The gas undertaking is in no sense a public or philanthropic undertaking, to be carried on for the benefit of the public or for the relief of public expenditure, but should be run on business lines, at a fair but not excessive profit. The consumer is entitled to efficient service, at a moderate price, but the price should not be cut so fine as simply to pay the bare dividend. Unless a fair provision is made for depreciation and contingencies, a time will come when the capital outlay stands at its full value on the books, but nowhere else. It may be that a large outlay for renewals is necessary and there is no balance at the bank. The wise manager is not satisfied with merely providing the dividend, but he takes care to keep up the structural value of the property. Small undertakings do not at any time earn large profits, especially if the capital outlay is already excessive, and there is too great a tendency to divide up every penny of the available balance. Too frequently it will be found that the shareholders have received 5 per cent. when the concern has really earned only 3. Thi, explanation is necessary, because there is a very general idea that the working expenditure plus the sum required for dividend will represent a fair selling price. Moreover, the gas business is one that, to use the slang of the day, "has come to stay," and therefore the main object is to establish a permanent business on mutually fair and satisfactory lines, and the schedule of prices should be framed, not on a blind imitation of the practices elsewhere, but on an intelligent appreciation of the needs and requirements peculiar to the district. There is no greater mistake than the assumption that a plan which has answered well in one place is to be recommended as a general rule for adoption in all places of similar size. It is well to know what neighbouring towns are doing. Such information is useful in a way, but it is in no sense a substitute for a knowledge of the needs of the district, and should always be subservient thereto. Having these points in view, I purposely refrain from setting a special value on any one rule as compared with another. Everything depends upon local conditions and circumstances, and I am at present interested in concerns where each of the plans to be mentioned has proved to be a success.

As to residuals, coke will usually fetch a price not far short of the current local price of coal. A market can be readily found for the small make of tar, but the profitable disposal of the liquor is usually a difficult matter. Very often the disposal of the liquid products has simply been allowed to go by default, no effort having been made to find a market for them, and a little energy and push will show that things are not so bad as they may appear. For instance, I have known the ammoniacal liquor to be often run to waste when there is a larger undertaking within carting distance where sulphate is manufactured. When two or three small works are situated only a mile or two apart, the advisability of a combination arrangement for the manufacture of sulphate is worthy of consideration. The business-like manager will not confine his efforts to the sale of gas, but will also search out the best and most profitable outlets for the residuals that he has to dispose of.

For many years there was a strong prejudice in favour of one uniform price for gas, and many boards of directors firmly refused to consider any other system of selling. At first sight, and especially to those who are not familiar with the intricacies of manufacturing costs, distribution costs, establishment expenses, and the balance available for dividend, it appears to be the only fair and just method. But further inquiry shows that an absolutely equitable charge to each customer, as represented by his actual cost, plus an aliquot proportion of profit, is as complicated and uncertain a problem as the valuation of a gas undertaking for assessment. But modern practices in business have rendered differential rates a necessity, and to-day there are few who can claim a strict and unexceptional adherance to the uniform rate. In speaking of differential rates, it will be a convenience to follow the usual practice of regarding the highest price as the current rate, and the lower prices as discounts or rebates. Discounts may be based on the purpose for which gas is used, with a view to the encouragement of particular lines that are more profitable than others, such as day consumption; or on the quantity consumed, with the object of increasing the consumption per consumer; or on prompt or short-period payment, in the hope of reducing the floating or working capital. In all cases where discounts are introduced, it should be done as a tentative plan, on the strict understanding that its object is to attain certain results, and that if for any reason the experiment is not successful, it will be withdrawn. I make this remark because it is no unusual thing to find, let us say, a special discount for engine consumption in a district where the bulk of this business is small and intermittent and in any case could probably be had at the ordinary rate; or a discount, according to quantity, allowed to the owners of a factory that use no gas to speak of for six months of the year, and add to the permanent charges by the necessity for having a plant equal to their requirements over December and January, a considerable part of which is idle and earning nothing during the remainder of the year; or a rule of discount for cash in a month, which has gradually been slackened until nobody thinks of paying before the end of the quarter. The discount is a concession made with a view of securing a larger advantage, a sprat to catch a mackerel, and it should be carefully watched to see that it does not take the form of a large sprat and a microscopic mackerel. The discount system, in all forms, is at times apt to lead to dissatisfaction and complaint. If there is a special allowance for cooking or motive power, the manager is sure to hear from some person who runs a night trade, and uses a larger quantity of gas than the average cooking customer, which he contends is specially for industrial purposes, and therefore entitled to the lowest terms. When the discount is on the quantity used, say 2½ per cent. on 50,000 cubic feet and over and 5 per cent. on 100,000 or over, there is the customer who happens to have used 49,800 cubic feet or 99,900 cubic feet, as the case may be, to be considered. Or if discount is allowed on cash in a month, there is sure to be a cheque tendered for the net amount, some two or three weeks late, accompanied by some more or less plausible excuse. And if it is returned the party is aggrieved, and takes the longest possible credit in future. Reasonable latitude, and the exercise of tact and judgment, are occasionally called for in all matters relating to allowances or rebates. While one does not want to convert a friend into a life-long enemy, simply for the sake of strict adherance to red tape, there must not be an impression that the company are wanting in firmness, and can be bullied into concessions of one kind or another. Sometimes there is a tendency, especially where electric competition exists, to try and set one company against the other, or to adopt an aggressive, not to say threatening tone, as a matter of policy. The customer is always complaining that the service is bad and the price high, that the meter and stove rents are excessive, and so on. If on the slot system, and supplied with two lights and a cooker free of first cost, he goes into elaborate calculations as to the schedule rate for gas, with a view of showing that the company are making 50 per cent. profit on the outlay, or he quotes another company that is alleged to give four lights and a gas fire. All this must be taken for what it is worth, and dealt with tactfully, but sometimes firmly. It is not wise to pooh-pooh every unreasonable complaint, or to make too elaborate a reply. As a rule, there is no difficulty in maintaining satisfactory relations with the consumer.

Unless the rules relating to discounts are very carefully drafted, prolonged experience will show that many people get the advantage of them without any corresponding benefit to the company. An engine rebate should be accompanied by a minimum consumption limit, and special purposes allowances should specify clearly the means for arriving at the special, as distinct from the ordinary consumption. Discounts on quantity should apply to each quarter independently. A large winter user should not be supplied with a small quantity during the summer at the winter rate, and it should be understood whether quantity is arrived at by taking all the meters on one particular block, or whether it includes premises in various parts of the town, the partners' private houses, etc. I once met with a case of a factory supplied at a special rebate, and not only the private account of each partner, but also those of the accountant and of two or three employees were included in the trade bill.

If the manager does not understand slot meters, hire and maintenance of stoves and appliances and gasfittings, he is at a disadvantage, because the business cannot be properly developed without assistance of this nature.

Ordinary meters are supplied on hire terms, and this should not be regarded as a separate department of the business, to be run at a profit. The chief object is to sell gas, and the hire of meters or anything else should be regarded as subservient to that end, and not as an independent investment. For obvious reasons, it is desirable that the company should have full control over the meters, and the only way to get that is to supply them on such moderate terms that the consumer is not tempted to buy his own meter, or that no third party should be led to consider the desirability of taking up meter hiring as a remunerative line of business. If the meter belongs to the consumer, difficulties arise when it gets old and slow, as he is not inclined to go to the expense of a new one. But I do not believe in supplying meters gratis, or at a loss, at any rate in the absence of a minimum consumption clause, because a consumer of less than 1,000 cubic feet per quarter, or one who keeps a large meter for intermittent use, would not pay the cost of the meter. The charge should cover interest on outlay, wear and tear and depreciation. Taking 5 per cent. for interest, and a life of twenty years, a quarterly charge equivalent to 10 per cent. per annum on the actual cost of the meter, including fixing in position, will cover expenses.

Taken over long terms of years, I have found that the following rates per quarter are fair to both parties:—3-light size, 9d.; 5-light, 1s.; 10-light, 1s. 3d.; 20-light, 1s. 8d. Meters smaller than the 3-light are not to be encouraged; and if there is a good cooking connection, the line may be drawn at the 5-light. A customer not likely to use up to 3-lights is not worth having, and the only use for small meters is for single lights, either public or private.

There has been too much slavish adherence to established usage in the matter of quarterly collections. A good share of the business now put to the credit of the slot meter could have been secured on monthly or weekly collections, and the quarterly system is a too long credit period for weekly wage earners, or for weekly or monthly tenants. A short-period collection secures some of the advantages of the slot system, and avoids the extra cost of the slot meter.

I have no sympathy with the doctrine that the slot meter is a means of carrying the advantages of gas to the submerged tenth. It is desirable to confine business to customers of satisfactory character, and if this rule is not observed, a large amount of expense and loss, from careless usage and robbing of cash tills, is the necessary consequence. The patronage of shady or of criminal characters is not worth having at any price. Nor do I see much advantage in providing burglar-proof cash tills. If a man determines to rob a meter, it is just as well that he should do so at a damage of 1s. or so to the appliance, as if he finds it necessary to take it into the back yard and operate on it with a crowbar, he will do more damage and cause more loss on one meter than he could inflict on half a dozen less substantial articles. Of course, the lock should be reliable, strong, and not easily tampered with. There is a reasonable margin in this, as in other things. In a small district, where it is possible that the clearance times may be irregular and not so frequent as is practicable when the business is of sufficient extent to admit of the employment of one or more full time collectors, this point is the more important.

Too much has been made, in my opinion, of the catch words "penny-in-the-slot." Except where the initial price is very low, lower than is likely to obtain in any of the districts under consideration, the penny is too small a unit for the convenience of the customer, and the daily demand for pennies is trying to his patience. Especially where a cooker is used, such an incident as the gas failing during the progress of the Sunday morning preparations, at a time when another penny may not be at hand, is not likely to add to the popularity of the system. The penny is equally inconvenient to the company, involving considerable extra trouble in collection and changing. A shilling unit is much more convenient to both parties. I know there is a very general prejudice in favour of the penny, and it is supposed that paying by the pennyworth is likely to lead to a more liberal use of gas than when a larger unit is used. After considerable experience, both with the 1s. and with the 1d. unit, I am strongly in favour of the 1s., and that especially where the slot collection has to be done at odd times. The slot user class, as a rule, draw weekly wages, and the insertion of 1s. on Saturday night carries matters on without further trouble. In two small districts, about ten miles apart, of similar character, there are about an equal proportion of slot users, but in one place the 1s. is used, in the other the 1d. But there is no evidence that the business in the first-named place is prejudiced. In fact, the average consumption per consumer there is the better of the two.

If the slot business is worth taking up at all it is worth doing thoroughly. The meter and service represent the greater part of the outlay, and an additional 15s. or 20s. is money well spent if it increases the annual consumption. It is more advantageous to do a turnover of £2 per annum on an outlay of £5 than of £1 per annum on an outlay of £3. Customers should be provided with a good cooker, having an oven at least 14 inches by 12 inches, that is capable of doing all that is required in the culinary line. Boiling rings and grillers need only be recommended in special cases, where there is some reason for not using the cooker. Two lights are as many as the average customer will use regularly, but it is better to fix three lights for a customer who really requires them than two for a person who will use only one. There has also been too much reliance upon the 3-light meter. A 5-light costs only 6s. or 7s. more, and will have a useful effect on the average consumption. Where the consumer can by any means be induced to extend his requirements beyond the cooker and two lights, the 5-light should always be provided. In the small district, it is easier to establish a personal contact with the customer than it is in the large one, and an intelligent, pushing, manager will succeed in finding a place for a few ironing stoves and other appliances.

One is surprised to find people who ought to know what they are talking about arguing in favour of the same price for the slot as for the ordinary user. Taking the extra outlay as £5 for each slot consumer, it is evident that an additional income, to the ordinary price, of about 10s. per annum is required to put both classes on all fours. The loading or addition to the ordinary price must, therefore, be $\frac{10s.}{\text{average consumption}}$. If the average is 12,000 cubic feet per annum, the loading should be 10d. The actual figures, as shown by the result of a year's working, may be substituted for the foregoing; and in any case, it is evident that if the slot department is to be of any benefit to the concern the average consumption should not be less than 10,000. But a profitable short-period collection might be done on a lower average.

Sometimes the company may be in a position to take 2d. or 3d. per thousand cubic feet off the loading, because the cost of the additional make will be less than the average. This aspect of the case is worth considering when the ordinary price is so high that the loading brings the gas up to the position of a costly luxury, rather than an every-day necessity. Take the case of a gas company doing 3,000,000 cubic feet per annum, at a net cost of 3s. 6d. per thousand cubic feet delivered at the consumers' meters. If the consumption goes up to 4,000,000 cubic feet, the average cost will be less than 3s. 6d. Possibly the addition would not necessitate any appreciable outlay on the works or mains, and would mean little more than extra tonnage of coal, and wages.

The observations respecting hire of meters may also be extended to include any appliance for using gas. The real reason why the gas companies took up the supply of meters on hire in the first place was because the possible consumers would not buy them, and preferred to do without the gas rather than incur the expense. The same thing has been found to apply to gas cooking stoves. Not one consumer in ten will pay down the full cash value of a gas cooker, but two out of every three will hire one. And the company must therefore be prepared to assist the consumer, and indirectly themselves, in regard to anything and everything that can be hired out on remunerative lines. I am not in favour of hire-purchase schemes. The appliance is usually badly worn by the time the last instalment is reached. Indeed, I have known careless customers who had knocked the cooker to pieces before they had paid for it. One often hears that the advantage of hire-purchase is that when the consumer has secured the ownership of the appliance he is more likely to continue to use it. But there are two sides to the argument. He does continue to use it—long after it should be consigned to the scrap heap, and when it is an annoyance to himself and a discredit to the use of gas. The advantages of simple hire as compared with hire-purchase is that the company keep the full control. No doubt it costs more, but the consumers are satisfied, and the company get more business. If the company are responsible for keeping the stove in repair, the consumer does not allow one or more burners to go for months unused because they need repair; but it is another thing when he knows that the repairs will be at his expense.

The method of calculating a fair charge for hire of stoves or fittings is the same as for meters. It must cover (1) interest on first outlay, (2) renewal and depreciation, (3) special expenses, such as inspection, cleaning, etc. The working life may be anything from five to twenty-five years, apart from the possible frequent renewal of parts that wear rapidly. A charge of 12½ per cent. for cookers and 15 per cent. per annum for fires, payable quarterly, based, as in the case of meters, on the net cost, including fixing, is sufficient to cover all costs. If the consumer will pay for the fixing, well and good; but in most cases anything in the way of a first charge is a hindrance to business.

No apparatus should be placed out on hire that does not bear some distinguishing mark or badge notifying that it is the property of the company, or without a proper signed agreement. The exact form to be used must be carefully drafted to suit local circumstances and conditions, but a few forms are given at the end of this chapter, as specimens that have been found satisfactory in practice.

Apparatus on hire should never be regarded as having gone out of the family, but should receive the same care and attention that is extended, or should be extended, to the plant at the works. It should be clearly understood that all appliances hired out are supplied on the understanding that they are to be used regularly. For one thing, apparatus standing idle deteriorates more rapidly than that in careful and proper usage. If the books show that a stove is not frequently used, inquiry should be made; and frequently it will be found that there is some absurd prejudice that is easily explained away, or some trifling defect that can be set right in a few minutes. Gas fires should be cleaned every autumn, and freed from the six months' accumulation of dust and dirt that they have attained to during the summer. It does not pay any company to have a large investment in idle apparatus, whether the same is stored on the works or out in the district. In my experience, it rarely happens that a customer will allow a gas stove to be taken out. He usually promises to use it more frequently, and very often develops into a first-rate customer.

The hire and maintenance of appliances involves a stock of parts for renewal, and a workshop and store room, and from this it is not a wide step to a stock of fittings for sale. A small company cannot run a large or extensive stock, but they can keep anything that is in regular demand. Every endeavour should be made to meet the requirements of the district, so that no inhabitant can say that he wanted to use gas but could not obtain the necessary fixtures.

In no case should the gas supply be connected up to a suction gas plant, to be used as a stand-by, without a flexible connection that can be transferred from one branch to the other, or other arrangement that will make quite sure that the engine and connections are under atmospheric pressure before the town gas cock is opened. In one case a serious annoyance and risk of accident was occasioned, and all the lights within a quarter of a mile jumped out, by opening the town gas cock before shutting off the suction, the idea in view being to make the change without stopping the engine. There is a disposition to fall back on town gas just when there is extra heavy work to be done, which is very convenient for the user of the engine, but not for other consumers in the neighbourhood, and it is desirable, if possible, to have no connection with suction plants.

Whatever the position of statutory companies may be towards ordinary customers, non-statutory companies have a free hand in respect to parties who retain a large meter for stand-by or other irregular usage; and in either case they can include a minimum clause in the slot agreements. In dealing with unprofitable customers, the object is not so much to get rid of them as to induce them to use more gas, and it is only after efforts in this direction are found to be useless that the service should be cut off.

All services that are out of use, and likely to remain so, should be cut off at the main. If for any reason it is found desirable to leave a blind service on any private premises, it should be examined every quarter, to see that it is in sound order and condition.

[Copies of Forms Referred to.]

No. 1.

Agreement for Supply of Gas and Hire of Fittings, from The...........Gas Light and Coke Company.

Landlord's Agreement. I,.................................of..................................
being the Owner of the Dwelling-house known as No..
and situate in..
of which...is the Tenant
DO HEREBY AUTHORIZE the Servants of the above Company to enter and fix therein the Automatic Prepayment Gas Meter, Pipes, Stove, or other Fittings mentioned in the Schedule hereto, and hereinafter called the Scheduled Fittings, and likewise at any time thereafter to enter to add to, repair, renew, or remove the same, the Company bearing the sole cost thereof, and making good any damage done to the premises in the course of fixing or removal; AND I HEREBY ACKNOWLEDGE that the Scheduled Fittings are the property of the said Gas Company and that the same shall not be liable to distraint for any rent due from the present or any future Tenant of the said Dwelling-house.

Signed..Owner

Date...............................19

And I the said...
the Tenant, hereby agree as follows :—

Tenant's Agreement. 1.—That I will regularly consume Gas supplied by the above Company and pay for the same and for the hire and maintenance of the Scheduled Fittings, by depositing money in the Automatic Prepayment Meter provided by the Company. Before gas is turned on to the premises, I will place in the slot the coin required to start the meter and otherwise afford any possible facility for testing the soundness of the whole job. Any complaint respecting the work shall be delivered in writing at the office of the manager of the Gas Company within twenty-four hours after such testing, and the absence of such complaint shall constitute and be taken as evidence that the work has been efficiently and properly executed.

2.—I agree not to disconnect the Meter, and to protect the Scheduled Fittings from damage and also to give the

Company immediate notice of any defect in the Scheduled Fittings; and I undertake that the Scheduled Fittings shall not be sold, removed, or damaged (fair wear and tear excepted).

3.—That should I conclude the Tenancy or for any other reason wish to cease consuming the Gas at the above premises, I hereby agree to give the Company seven days' notice in writing, and that this agreement holds good until forty-eight hours after the expiration of such notice.

4.—That the Servants of the Company may enter at all reasonable times to collect the money, or to inspect, repair, or renew the Scheduled Fittings.

5.—That should the Company desire to cease the supply of Gas to me, or to remove the Scheduled Fittings for any other reason than that of improper use or fraud, they shall be at liberty to do so on giving me seven days' notice in writing, and the servants of the Company shall at any time thereafter, during my occupation of the said premises, be at liberty to enter to remove the Scheduled Fittings.

Dated the............................day of............................

Signed..............................Tenant.

....

SCHEDULE.

Schedule of Fittings, etc., in House.

...............Automatic Prepayment Gas Meter No.........

...............Main Cock and Connections.

...............Pendant.

...............Brackets.

...............Burners.

...............Cooking Stove.

...............Boiling Stove.

...............Feet of Connecting Tube.

Feet of Compo. Pipe with Blocks and all connections.

....

....

....

....

....

No. 2.

.... Gas Light and Coke Company.

Agreement to take Apparatus on Hire.

I agree to hire from the above Company ....
....
for one year certain and so on till determined by three months' notice in writing, at a rent of s. d. per............, payable quarterly, in advance, ...
....
....
The apparatus remains their property, and they will make good all reasonable wear and tear. In the event of vacation of premises, non-payment of rent, careless, negligent usage, or failure to use the apparatus regularly, they may remove it without notice.

Signed...

Dated...

No. 3.

...............Gas Light and Coke Company.

....

....

Sir,

Slot Meter Agreements.

One of the conditions of these Agreements is that Gas shall be used regularly.

Your consumption for the year ended 30th June last was only...............shillings-worth. Unless you are prepared to use not less than Sixpenny-worth of Gas per week, the Meter and fittings will be removed after seven days from date.

Yours respectfully,

....

Manager.

CHAPTER X.

PUBLIC LIGHTING.

THE gas manager is usually called upon to arrange and fit up the public lamps, and in the majority of cases to replace the old-fashioned flat-flame burners with a more modern type. Incandescent light is now so generally adopted, even in the smaller districts, that any place where the batswing or union jet is maintained in use is at a great disadvantage. People go to neighbouring places and see modern installations of incandescent gas burners and make comparisons on their return; and the chances are that they do not recognize the real explanation of the difference, but set it all down to the quality of the gas, and want to know why they cannot have as good gas as other places. A well-lighted district is an excellent advertisement for gas, and the converse is also true, but apart from that, it is excellent practice as a step towards inside maintenance. If the street lamps are properly cared for, people are sure to want clear, brilliant lights, equal to those in the streets, for inside lighting. I know many instances where a good maintenance business is now established which originated on the lines of (1) public lighting; (2) places of worship, assembly rooms, markets, etc.; (3) some leading shops; (4) all classes of inside lighting. And in no case has maintenance proved a failure. Where a scheme is properly worked, both consumers and shareholders are satisfied.

The last twenty years have seen a marked increase as regards public opinion and requirement in the matter of public lighting, and now even the smallest towns are insisting on a complete and efficient system. I can remember when the lighting of a small country town was not worth the name. A few lamps at the principal corners and in the chief streets were considered sufficient, and the by-streets or courts were not lighted at all. The time schedule was ridiculously short, and the whole scheme was shaped with regard to economy. Sometimes this was unavoidable, because the lighting was a matter of private, voluntary subscription, and the scheme had to be shaped to suit the amount in hand. The shortest scheme I ever met with was for 360 hours a year; 120 nights and 3 hours per night, eight evenings off being allowed for each full moon, at the period when, if the sky is clear and cloudless, moonlight nights may be expected. The moonlight clause is never satisfactory. Even when the moon is up, the narrow streets and courts may be in complete shadow; but the chief objection is that the moon is liable to be obscured by clouds at any moment without notice, and to remain hidden for an indefinite time. Sometimes the lamplighter is allowed some discretion, and is supposed to exercise a give-and-take plan, lighting up for an extra night in dull weather and taking his own when it is fine. But the uncertainty of the weather renders his position under these circumstances a most unthankful one. The moonlight clause is a difficulty in the way of mechanical lighting. One way of meeting it is to add an additional tap below the mechanism, to be shut off and turned on by hand. This is used when the lamps are off for the moon, the controllers being left in action, and is a better plan than interfering with the controllers by stopping them. In a small district, where the manager or his helper has to do the lighting and extinguishing, and the lamps are widely spaced, I am strongly in favour of using one of the excellent and reliable systems now obtainable on hire terms. There is no initial outlay, and the responsibility is limited to the charge for hire. These lamps are turned on or off at schedule time, economizing gas to the extent of at least 10 per cent. If incandescent burners are used, the lever and pawl are more gentle to the mantle than a heavy-handed stoker, in a hurry to get back to the works.

The first outlay is very often an objection to the introduction of incandescent gas lighting. The local authority have no funds available beyond the annual lighting rate or subscription, and the gas company have no capital to spare for the purpose. Under these circumstances, a satisfactory arrangement can be made on the following lines :—(1) A contract to be made for at least seven years on the present terms, if these are inclusive of lighting, extinguishing and repairing. If not, a fresh schedule should be arranged on the basis of an inclusive price per lamp. (2) The company to replace an agreed number of lamps with new lanterns and incandescent burners at the beginning of each lighting season. The public get the benefit of modern lighting without extra expense, while the gas company get the saving in gas represented by a No. 2 or a "C" burner as compared with the batswing, to go towards the cost of maintenance and of the new lamps. The improved lights are fitted on the principal crossings and streets to begin with, and gradually extended to the less important parts of the district. The usual custom in country towns is to extinguish the majority of the lamps at 11 p.m., leaving a few on all night, and also not to light at all for about three months in the summer.

It is a mistake to endeavour to utilize old pattern and possibly badly worn lanterns for the incandescent burner. If this burner is adopted at all, it should be done on sound and substantial lines, so as to ensure complete success; and decrepit lanterns and accessories will not only be a bad advertisement, but will greatly increase the trouble and expense of maintenance. If a well-designed modern make of lantern is already provided, and is in a sufficiently good state of repair to warrant the outlay, there is no difficulty in converting it, at a small expense. But an old type, with frames an inch wide, is not worth retaining. One frequently finds the lanterns supported in loose frames or cradles, instead of being firmly secured to the top of the column by the medium of a frog. The arrangement saves trouble when taking the lanterns into store for the summer, but has nothing else in its favour, and it will not do for the incandescent burner. Not only must the lantern be rigidly secured, but there must be a reasonably substantial and sufficiently stiff or rigid support to carry it. Light rolled tube pillars, or slightly made brackets, are dear at any price, for modern lighting.

When contemplating buying new lanterns, it is well to remember that there is now no reason for adhering to the old fashioned four-post bedstead type of lantern. Hemispherical or egg-shaped globes diffuse the light much better, cast no shadows, and cost less for maintenance. Various forms of adapters, for enabling lamps of this pattern to be fixed to ordinary lamp pillars, are on the market.

CHAPTER XI.

UNACCOUNTED-FOR GAS.

THIS subject is taken separately, as being an important matter that is frequently a source of trouble and anxiety. There are several reasons why a small undertaking cannot expect to reach the limits that are practicable in large towns. It is usual to express the loss as a percentage of the total output. While this is convenient for statistical purposes, it is apt to be misleading when applied to technical considerations, because the connection between quantity used and quantity lost is extremely remote. Frequently one hears that the leakage has been reduced, when, as a matter of fact, it remains exactly the same. One year the output may be 3,000,000 cubic feet, and the unaccounted-for 500,000 cubic feet, or 16 per cent. The next year the output is, say, 4,000,000 cubic feet, and the unaccounted-for remains as before, but is now 12½ per cent. It is misleading to say that the unaccounted-for gas has been substantially reduced. Matters that directly affect the loss are extravagance at the works, waste or excess of schedule quantity for the public lighting, mileage of mains, number of services and meters, and the percentage of meters that show a consumption of less than 1,000 cubic feet per quarter.

But there is too great a tendency to suppose that a loss of 15 to 20 per cent. must be accepted as unavoidable.

Some of the causes may be beyond control, but others are not, and by working on the lines to be indicated, there is no difficulty in getting and keeping the unaccounted-for below 10 per cent. of the output. The apparatus at the works is in sight and in evidence, and if it is neglected, attention is attracted to the matter. But with the mains, services and meters, it is a case of out of sight and out of mind. Occasionally, the neglect is the result of ignorance on the part of the directorate, who imagine that sound business policy consists in cutting down the expenditure, and refusing sanction to any outlay that does not show an immediate and positive result. If nothing has been done in the way of systematic renewal of meters for the last fifty years—and it is not an exaggeration to say that this is sometimes so—can we be surprised if the loss is high?

The unaccounted-for gas is sometimes spoken of as "leakage." While more "leakage" takes place than might be supposed, owing to the fact that gas is completely deodorized by some kinds of soil, the actual loss by escape from the pipes is only one cause amongst many. If a crack or puncture exists, the leakage is continuous for 8,760 hours per annum. A respectable pin-hole will pass 1 cubic foot per hour; so it is evident that a very small fault will get rid of 10,000 cubic feet per annum.

There will be a loss or deficiency between the quantity of gas measured at the station meter and the aggregate of the consumers' meters, even if the mains are bottle-tight, and all the meters correct, due to the difference in temperature. The average temperature at the consumers' meters will be less than at the works meter. Gases expand nearly 1 per cent. in bulk for a rise of 5° Fahr. in temperature, or contract in similar proportion under a reduction, and, therefore, 1,000 cubic feet at 70° will only measure out at 990 at 65°, 980 at 60°, 970 at 55°, and so on. The bulk of the gas is also affected by variations of the barometer, but as these apply equally to all the meters, they do not affect the question. Sometimes one meets with an impression that a certain amount of condensation or reduction in bulk takes place in the mains, apart from, and independent of, reduction in temperature, and that gas will not measure out so well at three miles from the works as it will close by. A large deposition of liquid from the gas would be attended with a loss in bulk, corresponding to the vapour of such liquid, but under ordinary circumstances the quantity of liquid taken from the various drip boxes will not account for any appreciable percentage of the bulk of the gas. The average temperature at a works meter will be about 60°, and that at the consumers' meters less than 50°. The average temperature at a distance of 2 feet below ground level, over the entire year, in the South of England, is 48°, and the larger proportion of the output is supplied during the cold weather, perhaps 30 per cent. in December and January. Many meters are situated in cellars and other cold localities, so the average temperature at which gas is actually sold will not greatly exceed 40°, and the loss from this cause, which is unavoidable, will be 3 to 4 per cent. on the sales.

If there is any large amount of actual leakage, or escape of gas from the inside to the outside of the pipes, at any point between the works meters and the consumers' meters, or through defective joints, the mains have not been skilfully or carefully laid in the first place, or perhaps corrosion has taken place subsequently. Sometimes this is due to some local cause, such as trade refuse liquids charged with salt or acid coming in contact with the pipe, or through part of the ground through which they are laid being made up with ashes or town refuse. Localities where there is reason to suspect damage of this nature should be watched, and if another locality for the pipe is unobtainable, it should be protected by being packed in a bed of good fresh earth, or carefully prepared tar and fine, dry ashes. Corrosion is more apt to occur in wrought-iron than in cast; in fact, I know of only one instance of the perishing of cast-iron in virgin soil, and in that case there was reason to suspect the quality of the castings. I have had occasion to take up cast pipes that have been in use for over fifty years, and found them as good as new. Nor have I ever known internal corrosion, such as is sometimes experienced with water pipes. Wrought-iron is liable to corrosion in low-level damp localities, or near the sea, where the soil may at parts be exposed to tidal influences. I have a greater faith in carefully coating the pipe with Dr. Angus Smith's solution than in using galvanized iron pipe. Sometimes it happens that wrought-iron cannot be trusted to remain sound for more than twenty to twenty-five years, and under such circumstances preference should be given to cast-iron. But for many purposes wrought-iron can be safely used, if proper care is taken in the way of applying a preservative.

More care may advantageously be given to tapping the main and making the connection thereto than is usual, particularly where the joint is subject to vibration; and if the use of saddle pieces and clips was more general, the unaccounted-for gas would be appreciably lower. The old-fashioned plans of cutting out the hole with a hammer and diamond point chisel, or drilling it with a chisel edged drill and cramp, should be discarded. Both of them are open to the objections that they do not secure an accurately round hole, and that practically the whole of the cuttings fall into the main. A proper set of drilling tackle, with a hollow drill that cuts out a disc of metal, and tap on the same tool that cuts the screw without loss of gas, is a good investment, even if there are only a few services to put down in a year; and in the case of a very small works, arrangements can be made to borrow from a neighbouring works.

Prevention is better than cure, and it is not a difficult matter to test for soundness a length of main or service when laid, and before it is covered in. Various kinds of apparatus for this purpose are on the market. I have done some good work with a small gasholder containing one cubic foot, which can be filled with gas or air, and loaded to any desired pressure, say 50-tenths or 60-tenths. The pipe to be tested, having been carefully blocked at each end, and services disconnected, or the main taps shut off—disconnecting is the safest plan, or unscrewing the meter inlet and putting a cap on the outlet of main cock, because I have known a good deal of trouble to arise by a main tap passing a foot or so per hour when nominally shut off—the holder is connected to it, and if there is any leakage, the extent of it can be determined by timing the descent of the holder. Another test is to put a pressure gauge on, and to charge the pipe up to the required pressure with gas or air. If the latter is used, a small bellows or foot blower is preferable to blowing up with the breath. I have a strong prejudice against blowing from the lungs into gas pipes, under any circumstances. If the pipe is sound, the pressure or the holder (whichever is used) will not fall. The apparatus can also be applied to the testing of consumers' supply pipes and fittings.

With the continuous demand for gas at all hours of the day that is now the general experience, there is some difficulty in arranging for systematic tests, section by section, all over the district, and especially as regards leading mains. If done at all, it is worth doing well, as tests taken in a hurried and perfunctory manner are worse than useless. Stopping off sections by the use of bags or bladders is not reliable, and there is still room for a dependable stopper that could be used for this and other purposes. If the pipe is old and dirty, there is great difficulty in getting a perfectly tight plug. I have used Lyon's diaphragm syphon boxes on a small district with satisfactory results, and find them most effective for isolating sections of main in a few minutes and reinstating as promptly, without any cutting or screwing other than removing the plugs. With this apparatus, tests can be taken early on summer mornings, or during an hour or two in the afternoons.

In country districts, the consumption between midnight and 6 a.m. is so small that it can be closely estimated, and in that case it is possible to get a fair idea of the loss by leakage by noting the quantity sent out during the small hours of a summer morning, say 2 a.m. to 4 a.m., as obtained by reading the height of the gasholder. The use of a thermometer is necessary, to prevent error from variations of temperature during the test.

Some good work can be done in the way of discovering leakage by the use of an indicator and pointed bar. Find a joint to start with, by excavation, and then measure off 9 feet, or whatever the length of pipe may be, and drive the bar close down to each joint.

The actual loss each quarter should be carefully estimated as nearly as practicable, and recorded for future reference. A comparison with the corresponding quarter of previous years will give much useful information. Any unusual circumstance likely to influence the result, such as taking the meters a day late, should be noted.

The public lights, for one reason or another, invariably use more gas than is represented by the nominal consumption of the burners multiplied by the hours of burning, even if every care is taken in the matter of prompt lighting and extinguishing, which is not always the case. Particularly is this so if the burners are free and ungoverned, and the use of a reliable dry regulator, such as Sugg's or Borradaile's, should never be neglected. I have known instances where, by reason of lack of funds, the public lighting was dispensed with for one winter, and the result was invariably a few units to the credit of the unaccounted-for gas. Lamps standing off for the summer season should be securely capped, in addition to tightening the tap.

In addition to gas sold by contract, there is that used at the works or in the manager's house. If any lights are supplied free for advertising purposes, they should be included under this head. Sometimes a high-power burner in the centre of the market place or at the mayor's house is supplied at ordinary rates. As to the consumption at the works, it should be impressed on everybody concerned that the gas used in the retort house costs just as much to make as that which is sold to the customers, and that as much care should be taken to turn off lights that are not wanted as is exercised by any ordinary consumer. Too often one finds a light or two burning continuously behind the retort bench, or in some similar position where it is not needed once a week. For occasional use about a gasworks, an electric torch is to be recommended, and it is also useful for meter taking. I once knew an astute old man who used to make a great show of reading the meter and figuring out the consumption every week—and incidentally found out that he did not understand anything about it. But he considered the performance effective in checking waste! In a similar manner, the providing of meters and taking the index each quarter will have a marked effect in checking waste on the works, and it does away with the necessity for an estimate. I have known 3, 4 or 5 per cent. of the total make written off for use at works, but, under ordinary working, 1½ or 2 per cent. is quite sufficient.

All gas supplied gratis should be metered as far as practicable, and the burners at the gasworks kept in good repair and in such an efficient state as will serve for a pattern to the consumers. Frequently they are more in the way of an example of waste and negligence, the burners being old and so badly corroded that they use three or four times more gas than is necessary.

The last and most important item is the consumer's meter, which I consider is responsible for the larger half of the so-called leakage. Some people seem to suppose that a meter is like a grandfather's clock, and will act accurately for a century or so. It is true that excellent examples of patriarchal age can be cited, but it is not reasonable to suppose that a meter under regular, steady usage will keep within the limits of the Sale of Gas Act for more than twenty-five years, and if the usage is erratic or irregular, the accurate working life is very much shorter. If anything like accurate registration is to obtain, a regular proportion, say 5 per cent. of the meters, must be replaced each year.

The management must keep a sharp look out for slow meters, because the consumers, as a rule, do not report them. The general impression seems to be that a man is honestly entitled to as much as he can get. In the course of forty years' experience, not one consumer in ten thousand returns an account as not being large enough, although the slow meters are more than one in a hundred. With the variation in consumption that now obtains as between one year and another, it is more difficult to detect them, but it is very necessary that the accounts should be carefully looked through and compared with corresponding quarters of previous years, and doubtful cases should at once be attended to. A *bête noire* of the gas company, small or large, is the small or irregular user, who only requires a light for five minutes a day, or for "stand-by" purposes. He is more common in small districts than in large, and a connection can always be traced between the percentage of unaccounted-for gas and the proportion of customers who show less than 1,000 cubic feet consumption per quarter. If from any cause the consumers of this class increase, up goes the unaccounted. I am strongly inclined to regard this line of business as unremunerative. The small consumer is unprofitable, and contributes to nothing but the wastage; and a minimum charge of 1,000 cubic feet per quarter for every meter connected up to the mains, whether used or not, would be no more than ordinary justice to the gas company.

It should always be remembered that the unaccounted-for gas may be lost at any point between the works meter and the consumers' meters. It is no use exploring the district when the crown of the holder is like a pepper box. A start should be made from the beginning, by seeing that the holders are perfectly sound and tight.

CHAPTER XII.

THE DISPOSAL AND UTILIZATION OF RESIDUALS.

THERE is rather too much of a disposition in small works to let the residuals take care of themselves. There is always something to be done in the way of improving the market for them. Of course, in works of the size under consideration, such operations must be on a simple scale, as mechanical power is out of the question, and the small amount of material to be handled precludes anything of a costly or elaborate nature. A small hand coke breaking machine is usually a good investment; and something can be done in the way of manufacturing tar asphalt, both with the aid of the waste ashes on the works, or with stone chippings purchased for the purpose. The material can be thoroughly dried in a warm corner of the retort house and the tar boiled in a small portable boiler. Really good tar asphalt cannot be made without thoroughly drying and warming the aggregate and boiling the tar. If there is any difficulty in getting rid of the tar, or the cost of carriage bulks largely as compared with the price received, the supply of asphalt, laid complete for playgrounds, coach-houses, yards, garden walks, footwalks, etc., is well worth consideration.

The usual plan is to run the whole of the liquid products into one store well, and trust to the separation of the tar by gravity. Very often an old and disused holder tank is utilized for the store well, and it is worth while, not only to ascertain that it is perfectly sound and tight in the first place, but to test it every few years. In the early days of gas lighting, when the liquid products were regarded as of little or no value, no particular trouble was taken to make a perfectly sound tank. And not unfrequently it will be found that the low returns for liquid products suggest the existence of serious leakage. Apart from the waste of material, the penalties for fouling wells and water courses are onerous.

Difficulties often arise from want of efficient separation of water and tar. If there is only one well, and the contents are periodically disturbed by flushing the scrubber, the chances are that there will occasionally be claims, if the tar is sold to distillers, for reduction in respect of water in the tar. And if the ammoniacal liquor is utilized on the works, trouble may arise from tarry matter in the liquor. To avoid agitation of the liquid, all inlet pipes should be carried well down below the surface. It is evident that a flow of liquid falling into the well from a height perhaps 6 feet above the surface of the contents will agitate them to an extent sufficient to interfere with the proper settling down of the tar. And there is no advantage in keeping tar in stock. It should be disposed of, or sent away as soon as a quantity sufficient to make up a cargo accumulates.

The utilization of ammoniacal liquor has, in my experience, been confined to the manufacture of sulphate. In some parts of the world, a concentration process for the production of liquor ammonia is used, but I never heard of its application in England. In Germany, the use of a portable sulphate apparatus, mounted on trucks, that can be hauled about the country by a road traction engine, has been suggested. It is quite possible that by this means it would be possible to utilize the liquor in works too small to warrant the erection of a plant. Considerable business is done in the way of collecting liquor from neighbouring small works. At Salisbury, for instance, we have for years taken the total make of three neighbouring small works. The apparatus must necessarily be of the cheapest and simplest form available, as there is not much margin for interest on the outlay, but a toy apparatus is not of much use as a commercial venture. If the plant is not equal to a minimum of about 5 cwts. of sulphate per twelve hours, the profits are eaten up by wages and incidental expenses, and what is saved in interest on outlay is lost in other ways. If practicable, it is better for a few neighbouring works to combine, so as to secure an aggregate of 30,000 gallons a year or so; but it may pay to put down a plant for dealing with even as little as 4,000 gallons.

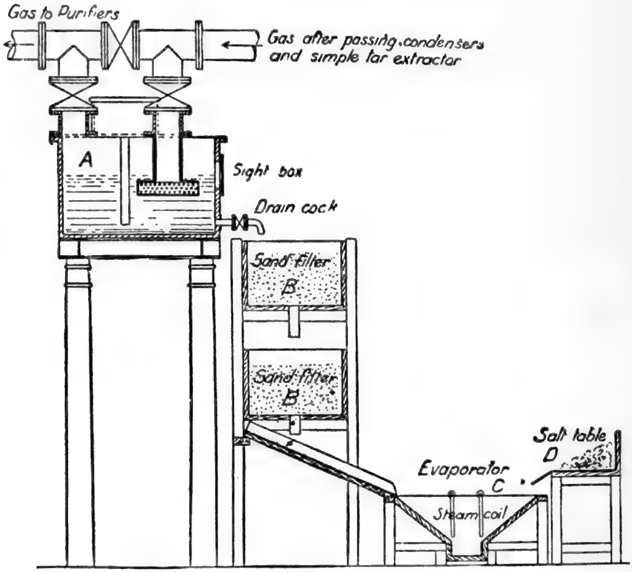
One frequently hears the yield of ammonia spoken of as a fixed quantity, but, as a matter of fact, it varies widely with different classes of coal, and according to the methods of carbonization. Somerset and Welsh coals give a much lower yield than Derbyshire or Staffordshire. In larger works, a yield of one ton of sulphate per 100 tons of coal is obtained, but I never heard of that proportion being reached in a small works. 17 lbs. weight of pure ammonia requires 49 lbs. of pure sulphuric acid to neutralize it, and the result is 66 lbs. of sulphate. Commercial oil of vitriol runs 70 to 80 per cent. pure, and can be tested by the hydrometer. An acid that is sold as 80 per cent. pure should make something more than its own weight of sulphate. Pure sulphate of ammonia contains about 25¾ per cent. ammonia and 74¼ per cent. acid, and the commercial salt as produced at a gasworks will be 98 or 99 per cent. pure. A properly made sample will be fairly white, and will dry readily on exposure to air. If it remains sodden and damp, and is of a bad colour, there is some mistake in the working. I have heard a great deal about trouble in this connection, and of "blue," "dirty," or damp salt, but have had very little trouble in practice. By careful attention to a few simple rules, these troubles can be avoided.

A small works using 300 tons of coal per annum may expect to make about 4,500 gallons of 6° or 7° liquor, from which can be obtained about 2½ tons of sulphate. Taking the cost of acid at £3 per ton, and the net selling price of sulphate at £11, we have a gross income of £27, 10s., less £7, 10s. for acid, which leaves £20 for labour, incidentals and profit. So that even under these circumstances an outlay of £80 to £100 for apparatus would be a good investment. The necessary apparatus comprises a boiler capable of containing 800 gallons of liquor, saturator, acid tank, mother liquor or draining tank, tipping board, lead-lined store, cooling coil and oxide purifier. The boiler is usually a second-hand one, picked up at a low price, mounted over a furnace with narrow bars and plenty of air space, to admit of using ashes or breeze as fuel, and the condenser may be made up out of second-hand 3-inch or 4-inch pipe, while a heap of oxide in a corner will serve as a purifier. I have also found that where an excess of boiler capacity is available, excellent results can be obtained on the small scale by the use of wet steam, instead of direct firing. An inverted V, formed by old purifier grids built up over the mouth of the pipe, serves as a distributor. The saturator and other lead work should be obtained from one of the firms that specialize in this line, as there is no economy in trying to make this up at home. If a building or shed is not available, the plant can be placed in a sheltered corner under a lean-to roof, care being taken that the sulphate store is perfectly weather-proof.

If there is only one store tank, a fairly large settling tank is required, to admit of the liquor being practically free from tar. And it should be remembered that all wells or tanks containing ammoniacal liquor must be perfectly sound and tight. The smell of ammonia is objectionable and injurious, and also a very appreciable money loss may occur through leaky covers. The boiler having been charged with the appropriate quantity of clear liquor, preferably of about 6° strength, the saturator is made up by running in acid till a strength of 60° is shown on the hydrometer. If the saturator is already charged with mother liquor remaining from a previous day's working, care should be taken to see that the apertures in the coil are not clogged with crystals. The hydrometer used for testing liquor is known as a No. 1, and has a scale from 0° to 24°. Another size, No. 3, scale 48° to 72°, is used for the saturator. The liquor is brought steadily up to the boil, and as soon as ammonia begins to come over, any scum that rises to the surface of the acid in the saturator is carefully skimmed off. Negligence in this respect, or waiting till the liquid is thickly charged with salt, may result in a dirty product. As soon as salt begins to collect, more acid is run in, and care is taken not to let the strength of the liquor fall below 56° or 54°. The boiling is steadily maintained, and the salt fished out as soon as possible. The secret of making white salt is acid liquor and not too long exposure in the saturator. If the boiling is slack, or the supply of acid deficient, or the liquid not properly skimmed, a bad yield of dirty salt may result. Sometimes lime or soda is added to decompose the fixed ammonia, but it is rarely practicable to give the liquor sufficient boiling to get the full advantage. A boiling of several hours is required to effect the complete decomposition of the fixed ammonia. Lime gives trouble from deposits in the boiler and settling tanks, and soda is costly, and I question whether it is much advantage on the small scale. I have found as good results without it as with it, and I think that in many small works where it is used the result of a test of the spent liquor would show that the decomposition of the fixed ammonia is far from complete. In large towns, there is some difficulty in disposing of the spent liquor, but this trouble rarely arises in the country.

The art of making sulphate is not easily learnt from books. A beginner at it is strongly urged to spend a day or two at the nearest sulphate works, and to carefully watch the operation from first to last.

This portion of the subject would not be complete without some reference to a paper read by Mr. P. G. G. Moon, of Bournemouth, at a meeting of the Southern District Association of Gas Engineers (see THE GAS WORLD, 12th November 1910, p. 585). This describes a simple method for the direct production of sulphate, as in use at Wareham, and also a process for dealing with the whole of the ammonia produced, as in use at Dunstable and elsewhere. I am informed by the makers (the Chemical Engineering Company and Wilton's Patent Furnace Company) that the approximate cost of the Wareham plant is £50 and of the Dunstable complete set £100. The difference between this and the ordinary process is that the gas, freed from tar, but containing ammonia, is passed through weak acid contained in a lead-lined washer, and here a solution of sulphate is gradually formed, in the same manner as in the ordinary saturator. As in the ordinary manufacture of sulphate, care must be taken to maintain an excess of acid, but a much lower proportion. The excess must not be greater than a strength represented by 3° Twaddel. To secure this result, small quantities of acid are added at frequent intervals through a tapped U-tube and funnel. This looks like an elaborate business, but in



Sulphate Plant at Wareham Gasworks.

practice is as easily managed, with the aid of litmus paper and an hydrometer, as the working of the ordinary saturator. Any ammonia in the gas is readily absorbed by the weak acid, and sulphate gradually accumulates in the liquid. The presence of the salt is no objection so long as the saturation point is not reached, but as this is approached, there is a liability to deposit crystals. The specific gravity of the contents of the washer is tested from time to time, and when it reaches 50°, a part is drawn off, and clean water added in its place. In practice, liquid is drawn at convenient intervals. The solution is passed through two filter boxes containing sand, and the clear liquid runs into a shallow evaporating tank. A very small amount of heat, such as that furnished by the waste from the exhauster engine, is sufficient to concentrate the solution and secure the precipitation of the sulphate, which is fixed and drained in the usual way. By the courtesy of Mr. Harold W. Woodall, proprietor of the Wareham gasworks, and Mr. Moon, I have had the opportunity of a personal examination of the process, as in operation at Wareham, and at the time of my visit an excellent clean, white salt was being produced.

Considerable confusion is caused by the use of several methods of expressing the ammonia content of a gas-works liquor. What one really wants to know is the yield of sulphate per gallon. Each degree as indicated by the Twaddel hydrometer is considered to be equivalent to 2 ozs. of pure oil of vitriol, *i.e.*, to be capable of neutralizing that quantity. This includes the fixed as well as the free ammonia. Since 49 ozs. of pure oil of vitriol combine with 17 ozs. pure ammonia to form 66 ozs. of sulphate, it follows that 1 oz. will form $\frac{66}{49} = 1{\cdot}347$ ozs. of sulphate, or that a 1° liquor will form $1{\cdot}347 \times 2 = 2{\cdot}694$ ozs. To get at the yield of sulphate from a liquor, multiply the strength per degree Twaddel by 2·694. This gives the yield per gallon, and the content of the well being known, the total can be calculated.

Example:—A well contains 10,000 gallons of 6° liquor. What yield of sulphate may be expected?

$$6 \times 2{\cdot}694 \times 10{,}000 = 161{,}640 \text{ ozs.} = 90 \text{ cwts. } 22 \text{ lbs.}$$

The indications of the hydrometer are only approximate. If an accurate determination is required, the distillation test must be used.

CHAPTER XIII.

COMPLAINTS.

The subject of gasfittings and appliances is rather outside the plan of this work, but a few words on the best way of dealing with ordinary complaints may not be out of place, especially as, in the average small district, there are one or two consumers who are always in a chronic state of dissatisfaction. Incidentally, we have referred to some of the causes which account for this state of affairs. In all cases, the rule should be not to drop a complaint without arriving at a complete and permanent cure. The first thing is to be sure of the cause, or rather of the causes, for it usually happens that there are more than one. One source of the chronic dissatisfaction just referred to is the perfunctory manner in which complaints are attended to. A complaint comes in, the manager calls and stops a leak, or blows out the service; things are said to be better the next night, and so matters are left. Sometimes the cause is ridiculously simple, and on other occasions considerable difficulty may arise in definitely locating it.

People are now getting extremely fanciful on the matter of "smells," and therefore frequent leakage, if allowed to go unchecked, is likely to do serious harm. The system of testing fittings for soundness is by no means general, but it is indispensable under modern conditions. Very frequently it happens that the gasfitter is sent for, and he finds one leak, which he repairs, and goes away. The objectionable smell still continues, and the process is repeated. No wonder if the consumer, after the second visit, gives up the matter in despair, under the impression that nothing further can be done. Probably the real reason is that the fittings want a general overhaul, especially as regards the taps, hinges and movable parts, which have not been examined perhaps for twenty or thirty years. Any lubricant applied to the moving parts has long since disappeared, leather washers have shrivelled and hardened, and the pipes have been disturbed by exposure to variations of temperature, to shock of vibration, or to strain. The old-fashioned water-slide is not yet extinct, and is a source of continual trouble, not to say risk. Amongst the causes of leakage may be instanced the gnawing of pipes by rats, the action of lightning, and injuries unwittingly caused by carpenters, house decorators, etc., in the course of carrying out additions or renovations. Iron pipes may be corroded by the action of salt and other chemicals, by sewer gases, or by condensation of moisture. Complaint of leakage at certain times, when the wind is in one particular direction, should never be allowed to drop till the cause is found. In these days of the general use of the steam road roller, and of tarring the surface, escaping gas may travel a long distance, through loose or made-up subsoil, before it finds an outlet. Considerable difficulty and expense may arise if this outlet happens to be a public sewer.

The most common difficulty is the complaint of insufficient supply, perhaps only at one particular time of the day, week or year; and it is not infrequently aggravated by the fact that the consumer refuses to recognize that the fault, under these circumstances, may be in his fittings. He argues that if such were the case, the trouble would be always evident, and that the fact of the supply being satisfactory at times is a proof that the fittings are all right. The trouble is sometimes increased by the indefinite and unreliable nature of the information sent to the gasworks, which may be by means of a servant or lad who knows nothing about the facts, and is apt to throw in a few details that are more or less imaginary. Every gasworks manager knows what it is to get a complaint that the gas is bad from 6.30 to 7 p.m. every evening. He calls at 6.40, and finds that there is not much the matter, and that for some inexplicable reason the supply is much better. It may be darkly hinted that he has "done something" at the works. The fact that the trouble may be, and probably is, due to the consumer's fittings will be evident to anyone who has attentively perused Chapters V and VIII; and the remarks made there in respect to the size of service pipes may also be applied to the consideration of the size of the internal fittings.

Complaints are most frequent in respect to detached houses standing in their own grounds, and probably some considerable distance back from the road. The service pipe has been included in the builder's estimate, and one often finds ¾-inch pipe specified for a twenty-room house. The position is aggravated by taking the service to the back of the house, where the meter is fixed; with the result that the lights in the principal rooms, which are in the front part of the house, are situated farthest from the meter, and are the first to suffer if there is any shortage. Frequently there is a good light in the kitchen, and the cooker always gets sufficient gas, but the drawing-room supply is indifferent—if incandescent burners are used, there is not sufficient pressure to give a steady light. It must be difficult to avoid occasional trouble of this sort until architects and builders can be induced either to leave arrangements as to size of pipes and position of meter to the gas company, or to take sufficient interest in the matter themselves to see that the work is designed and carried out in a competent manner.

The piping of a building like a factory, a school, hospital, or workhouse, an hotel, country mansion, or other large establishment, must be arranged on lines entirely different from that of a four-roomed cottage. But one frequently finds long runs of small-sized pipe. And another common difficulty is that a small service and supply system was put in, in the first place, for, perhaps, half a dozen lights, and that in course of time one has been added after another till there are now eighteen or twenty, to say nothing of a cooker, gas fires, wash-boiler or geyser. Since incandescent burners have become general, complaints are received that are really due to nothing more than dust or dirt in the burners.

A satisfactory solution of the difficulty is frequently hindered by mutual recrimination and ill-feeling; and in common candour it is only right to say that the consumer is not always in the wrong. There is such a thing as the supply pressure or the sizes of the main pipes being at fault; and if all parties concerned work together good humouredly, with a determination to get at the root of the difficulty, a satisfactory settlement is greatly facilitated. And this is sufficient to illustrate why I have repeatedly insisted on the manager being familiar with the use of the pressure gauge, and with the proper pressure required for cookers, gas fires, incandescent burners, etc. Gas cookers were never a general success until the gas companies undertook to fix them and to provide supply pipes of the proper size; and the example thus afforded has been of great general benefit. If the gas company are at fault, the defect should be promptly admitted, and some understanding arrived at as to when it will be remedied.

In dealing with the consumers, a strong point should be made of a strict adherence to promises. A great deal of unnecessary annoyance and ill-feeling against the company may be traced to negligence or forgetfulness in this respect. A gasfitter, or other workman, who receives a message in the street would possibly be abused as a churl if he replied that it was not his business to take messages, but that they must be sent to the office. But he is preferable to the man who courteously and attentively listens to a customer and then forgets all about him. In small towns, people have a loose and easy way of doing things. They do not send and complain about an escape, but when the meter inspector calls he is told there has been an awful smell in the house for three weeks. Great annoyance is always caused by negligence in respect to a promise. If a job is promised to be done at 9 o'clock on Wednesday morning, the fitter should be there to do it by 8.59. If events make it necessary to alter the arrangement, the earliest notice should be given, or if the fitter is stopped on his way, and told off to attend to a broken lamp-post or fractured main, he should not fail to explain the facts at the earliest opportunity.

Gas managers of the older school will remember that every quarter there would be two or three disputed accounts. The consumer was sure that he had not used half the quantity of gas charged for. But with the great improvements in cookers and fires, and the introduction of the incandescent burner, together with a more intelligent knowledge of the necessity for looking after and regulating the taps, there is not much trouble on this score. In fact, the difficulty is rather that the reduction in consumption introduces a large number of very small accounts of, say, 10s. or less, which means a large increase in the proportion of working expenses to income.

CHAPTER XIV.

ACCOUNTS, MEMORANDA AND TABLES.

EVERY manager of a gasworks is called upon to preserve a considerable quantity of records, whether he is responsible for the books or otherwise. And it is not too much to say that the extent of his commercial success will be influenced by his ability to keep methodical and systematic records of the various matters, financial, technical and informative, that are required, for reference at any time, either for his own use or for that of the directors. There is a very common prejudice, to the effect that a complete or systematized plan of noting down everything likely to be of use, in a place where it can be promptly found when wanted, must necessarily involve an enormous and unreasonable amount of labour, whereas the reverse is the real truth. The most troublesome system is the one that involves considerable time and patience before the most ordinary details can be extracted, or an immense amount of searching through unindexed pages. I can remember a time when the gasworks manager was apt to look upon those engaged in the office or laboratory as inferior beings, whom a just dispensation of Providence had placed in a position suited to their abilities, and so far as he was personally concerned he regarded bookkeeping and accounts as subjects scarcely calling for serious consideration. But he now finds himself at a great disadvantage, in the absence of something more than a speaking acquaintance with both. I have repeatedly had reason to be thankful that my early training included a few months in the office of a firm of accountants. A knowledge of accounts is indispensable if one would be able to accurately assess the present position and working, to make a fair and correct comparison of one year's working with another, to note where improvement has been effected, and especially the weak places or sources of leakage. Money will leak away, directly and indirectly, in as inexplicable a manner as gas. If one has nothing to invest on his own account, he is sure to be occasionally asked for an opinion on the position and prospects of a gas company, the value of shares, questions relating to letting on lease, etc.; and in the absence of a knowledge underlying the printed form of account, it is impossible to arrive at an accurate conclusion on these matters. There is, too, generally a disposition to regard a statement of accounts as a shibboleth only understandable by a professional accountant. Probably not one in a hundred of the statements that are annually issued to shareholders is intelligently read and understood. I have known managers and directors, and even chairmen of gas companies, whose ideas respecting the statement of accounts were hazy and indefinite, and comprised not much beyond a knowledge of where to find the balance available for dividend.

I do not propose to attempt anything in the way of a complete system of bookkeeping and accounts, because there are excellent books and treatises specially devoted to the subject, but to follow up the matter on the lines of previous chapters, assuming that the reader is already acquainted with the usual rules for entering, posting, etc., the difference between "Cr." and "Dr.," the objects and position of the journal, ledger, cash-book, etc. A usual plan is to start with a specimen of each class of transaction and to follow it through the books, till it gets somewhere or other, but it will be more convenient, for the present purpose, to take a specimen statement of account and to work backwards to the original transaction. And it is intended that the forms and tables given should be suggestive of the lines to be followed, rather than blindly copied, and that they may be of some assistance in enabling the existing accounts to be improved, or a new system laid out in a form suited to the size and other circumstances of the works concerned.

When the manager is also expected to act as clerk, accountant and collector, it should be clearly understood that he cannot practice the formalities and requirements that are quite proper, and, indeed, necessary, in an office where twenty or more clerks are engaged. This does not mean that he cannot keep accounts accurately and carefully, but that every endeavour should be made to assist and facilitate his labours, so that the office and clerical work does not encroach too much on the managerial department, the proper control and supervision of the daily operations and of buying and selling. Loose leaf ledgers and meter books, duplicate books, cards and other modern improvements, are a great help, if not ridden to excess; but it is quite possible to spend two hours in saving the work of one. Using a suitable system, the whole records incidental to a small gasworks can be properly entered up in the course of an hour or two each day. Of the two evils, it is better to have large profits indifferently recorded rather than poor results elegantly kept, but there is no obligation to go to either extreme. The office is not the place where the profits are earned, and a manager worth the name will be something more than a recording angel. But sometimes the clerical work seems to fill all his time. He is at the books from morning to night, entering up in copperplate style, ruling and balancing, while the real business at the works and in the district is suffering from want of competent supervision. The books are in excellent order, but as much cannot be said for the working results or the profits, and it is a poor look-out if the manager is really only the clerk. Frequently, this state of things is brought about by the lack of a proper grasp of the position on the part of the directorate, who require very elaborate reports and returns, and regard an error of 2d. in the cash account, or an incomplete ruling in the ledger, as matters of vital importance. They may be apt to imagine that the manager is best kept up to concert pitch by continual overhauling of the books, and long wordy disputes and discussions. I once knew a manager who was so harassed by the directors who met every week, and, in effect, conducted an incompetent, pettifogging, ill-tempered sort of informal audit, that he lost all interest in the work, and at last the results were so unsatisfactory that both parties were anxious for a change. Under more favourable surroundings, he proved a most capable and satisfactory officer. I have said that profits are not earned in the office; and as much applies to the board-room. While the manager is explaining to the directors, he is not earning anything for the company. It is surprising that many who would at once see the absurdity of setting a stoker to wheel a barrow-load of coke or coal round and round the yard entirely fail to see the desirability of encouraging the manager to apply his time to the best advantage.

The chief, and to some people the only, accounts are those relating to cash. But the manager has materials and products to look after as well as money. He can no more account for the proper disposal of the coal, lime, gas, coke, tar, etc., without proper technical accounts than he can record the receipts and expenditure without a cash-book. And, more than that, he requires a considerable amount of information, such as make per ton of coal carbonized, cost per thousand cubic feet of gas sold, etc. Whatever the nature of the account, the object is an accurate record, either as between "Dr." and "Cr.," or as an item of information. And for purposes of account it is necessary to have impersonal items. In order to keep account of the coal used, for example, it is necessary to have a coal account, in which "Coal" is debited with the coal purchased and credited with that carbonized or sold, just as Mr. Smith or Mr. Brown may be credited with coal bought from them or debited with gas sold to them. It is also necessary that the books should show, or at least furnish easy means of ascertaining, the profits and position, and enable an intelligible annual statement to be prepared, in a form that enables the reader to get some insight into the character of the business done, and to ascertain if the operations have been properly or skilfully conducted. To that end, the principal items of income and expenditure are set out as in the following example (p. 148). The usual form in which the accounts are set out is the double page or ledger, the "Dr." on the left-hand and the "Cr." on the right-hand page. But it is convenient for many purposes to have the records on one page. The "Cr." is in all cases entered first, because money must be received before it can be spent.

——— GAS COMPANY. Year ended 31st December 1910.

	Capital.	*Dr.* £	s.	d.	*Cr.* £	s.	d.
	3,750 shares				3,750	0	0
	20 debentures				1,000	0	0
	Expended to 31st Dec., 1909	3,950	0	0			
	Expended since . .	568	0	0			
	Balance unexpended . .	232	0	0			
		4,750	0	0	4,750	0	0
	Revenue.						
*21,22,23	Gas sold, 5,500,000 cub. ft.				1,047	8	2
24	Meter rents				55	19	6
25	Stove ,, ...				24	1	2
27	Coke sold, 150 tons . .				111	0	4
28	Tar ,, 35 ,, . .				25	10	6
29	Liquor sold and sundry sales				9	2	6
41	Coal used, 700 tons. .	607	5	3			
42	Purifying material . .	25	19	2			
43	Wages	207	8	4			
44	Salaries and fees . .	25	0	0			
45	Repairs to works, mains, etc.	78	16	10			
46	Public lamps	15	17	2			
47	Rates, taxes and incidentals	44	5	0			
	Balance to profit and loss	268	10	5			
		1,273	2	2	1,273	2	2
	Profit and Loss.						
	Balance last year £237 1 2						
	Less dividend 187 10 0				49	11	2
	From Revenue . . .				268	10	5
	Interest on debentures .	40	0	0			
	,, other loans .	...					
	Balance available for dividend	278	1	7			
		318	1	7	318	1	7
	Balances, 31st December 1910.	*Dr.*			*Cr.*		
	Amounts due to Company.				310	3	4
	Stocks—						
	Coal, 50 tons . .				36	0	0
	Coke, 10 tons . .				6	0	0
	Tar, 8 tons . . .				5	0	0
	Sundry				26	0	0
	Cash in bank				201	18	3
	Cash in office						
	Capital	232	0	0			
	Profit and loss . . .	278	1	7			
	Amounts owing by the Co.	75	0	0			
		585	1	7	585	1	7

For these reference numbers, see Forms II. and III., pp. 167–8.

Capital account.—Before any business can be done, the necessary land, buildings, plant, office, etc., must be provided, and for that purpose capital must be raised. The first section is, therefore, the capital account. As the money must be received before it can be expended, the account first shows that £3,750 has been paid in by shareholders, and £1,000 by debenture holders, making a total of £4,750. This sum has been received by the directors on behalf of the company, and the next thing is to show how it has been expended. The accounts for former years show that £3,950 was expended previous to the current year; we now learn that £568 has been spent during the year, leaving a balance of £232 in hand, and used as working or floating capital.

It is the exception rather than the rule, in a small works, to find that a detailed account of the capital expenditure has been kept. But I would enlarge on the advantage of keeping a record, such as Form I (p. 166). For this and most other purposes, paper specially ruled in the form shown can be obtained from any manufacturing stationer. Loose sheets may be used, if the scale of operations is such that one page is sufficient for the year's operations, these being preserved in a suitable portfolio or case, or, if preferred, they may be bound in one or more books. Loose sheets are the more convenient for handling and reference. Any number of cash columns, from five upwards, may be had. The form given contains fifteen, which I have found to be a convenient number for the purpose. Form I. is not ruled off each year, but is always open. The expenditure each year is added as shown, and the total (15) will give the amount expended up to date.

With regard to expenditure generally, the greater portion is represented by statements rendered periodically, say once a quarter. Items such as wages or petty expenses are recorded in a proper book, the totals of which are treated exactly as a quarterly bill. It is a needless refinement, in a small works, to attempt to analyse the wages, or to allocate them to different headings, such as manufacture, purification, distribution, etc.; and the petty cash will mostly come under various items in the revenue. But sometimes both wages and petty cash expenses are incurred on account of capital, in which case they must be kept separate, and entered, not to revenue, but to the proper heading under capital.

So far as is practicable, all goods should be ordered, and contracts or agreements accepted, by written order. The orders should be written in an ink duplicating book, so that a *facsimile* can be preserved for reference; and sufficient detail as to quantity, price, etc., should be given to enable the order to be used as a check on the correctness of the account rendered. Every statement of account received, after being properly certified as correct, should be numbered, starting from 1 up, and the number should be entered against the name in the expenditure. After being paid, the statements for one year should be arranged in consecutive order, and clipped together at the left-hand corner.

Revenue Account, Cr., Form II, (p. 167).

This form shows an arrangement by which the items of income are recorded year by year for comparison, one line for each year. One double page of foolscap will last for over thirty years. It is a frequent difficulty to find, when one is consulted about the position of a small works, that full information about the expenditure has not been kept. Even some of the copies of the annual accounts have been mislaid, and cannot be found. The items 21 to 29 in the annual accounts are obtained from this form. Blank columns are purposely left to admit of any special items being introduced in future years, without upsetting the order of the numbering.

The quantity of gas sold, 5,500,000 cubic feet, includes that estimated to be supplied to the public lamps, but, as a rule, does not include that used at the works or at the manager's house. It is very convenient, however, to include this item as gas sold, and to charge it on the other side as an item of expenditure. The gas not paid for may be 100,000 cubic feet. This quantity is added as a finishing item to the last entry in the rental for the year, at the regular price, say 4s. per thousand cubic feet = £20, and a similar sum entered to expenditure, under sundries. By this means, the quantity of gas sold is also the total "accounted for," and it is easy to arrive, with the aid of the "Working Results" book, at the quantity unaccounted for. Later on, it will be seen that there are other reasons why the total accounted for should be plainly in evidence. It will be observed that a column, No. 38, is left for deductions. I prefer to show items such as allowances, discounts or bad debts in this form, rather than as items of expenditure, and thus to enable the income to show the actual amount received.

Revenue Account, Dr., Form III, (p. 168).

After the remarks on expenditure under capital, there is little to add in explanation of this form. The weight of coal and of purifying material should be inserted. Items 41–47 in revenue account (p. 148) are taken from it, and the last item, being the balance left after paying all expenses, is carried to profit and loss.

Profit and Loss.

"Capital" and "Profit and Loss" are always open and running accounts, but there is this difference—that whereas the capital account is never reduced, except under such circumstances as the sale of the whole or of a part of the plant, the profit and loss is reduced each year by a payment of dividend, made out of the profits for the preceding year. Early in 1910, for example, the general meeting of shareholders was held, and a 5 per cent. dividend was declared, and paid out of the balance shown in the 1909 accounts—£237, 1s. 2d. The interest due on debentures was paid, or reckoned as an item in the expenditure, and, therefore, need not be considered. After paying the dividend, a balance of £49, 11s. 2d. remains. To this is added the balance from revenue, and after paying debenture interest, there is a balance of £278, 1s. 7d. available for dividend. This, it should be noted, is not the profit earned during the year, but also includes the balance from the previous year. The balance of revenue account, £268, 10s. 5d., is the actual amount earned for the year 1910. If there should happen to be an overdraft at the bank on which interest is charged, this interest must be paid in addition to the interest on debentures, and entered below it.

Balances and Stocks, Form IV, (p. 169).

The necessity for this item is due to the fact that it is impossible to run each year as an independent transaction. If we could definitely settle up everything on each 31st December, there would be no occasion for it. But it is impracticable to use up every pound of coal in stock, and therefore a quantity remains, and it will be used in the following year. The balance available for dividend is carried forward to the balances account in the annual statement. First we have the balance from capital account (61). Next that from profit and loss (62). Later on the amount paid for dividends and the balance carried forward can be entered in columns 63 and 64. Column 65 shows the bills and accounts owing, but unpaid on 31st December—£75. These items go to make up the liabilities. The company owe the shareholders £232 and £278, 1s. 7d., and sundry creditors £75. The liabilities, it will be observed, are taken from the left-hand page in Form IV. Turning to the right-hand page, we have the assets—debts due to the company, stocks and cash. The debts comprise the quarter's income for the fourth quarter of the year and also any arrears unpaid from previous quarters. The stocks are carefully taken on 31st December, and each item is debited to its respective heading, if such is on the credit side, or credited to items on the debtor side. Coal, being on the debtor side of the revenue, is credited with £36, making that item £36 less. But coke, tar and sundry, being on the credit side, are debited, and are, therefore, increased to the extent of £6, £5 and £26, respectively.

Every item in the balances and stocks appears, not only in the current but in the next year's, 1911, account. The £36 "Cr." by coal in 1910 is "Dr." to coal in 1911, and the £6 "Cr." to coke in 1910 is "Dr." by coke in 1911. It is convenient to enter first the actual expenditure or receipts and to make the adjustment for stocks on 1st January and 31st December, as the closing entries.

The Books.

We now approach a subject respecting which everyone has his fads and his fancies. I have a strong preference for books of uniform size, and not too large. Foolscap is a convenient size for working on, without dodging and dancing about, or having to shift the book to get at the top of the page. Casting work can be done more rapidly on a page comprising thirty or thirty-five items than on one of fifty or so, as after the thirty-fifth item the carrying on of the total becomes irksome, and a small sum in arithmetic is necessary when the pence exceed 250. I also prefer the covers of books cut flush with the paper, as not taking so much room; and the space, or margin, when the covers project, is a harbouring place for dust and vermin. About half a dozen books foolscap size and as many about half those dimensions will contain the records of a small company, and can be packed snugly into a small, and not over costly, safe. Also, it is a mistake to lay in a stock of books covering the next half century. The number of pages in any one book need not be more than will suffice for ten years or so. A common cause of mistake and confusion is the habit of using a rough scribbling book, or, worse still, of hurriedly making memoranda on odd pieces of paper, as a record of matters that are intended to be properly entered up at a convenient time. The most convenient time in this case is the present moment. Entries should be made once and for all, carefully and legibly, in the proper place. The time and trouble necessary for hunting up, reading and accurately transcribing rough notes are out of all proportion to any saving of time effected by them, to say nothing of the risk of loss and error. The ideal plan is to get every transaction entered once in a place where it can be located at a moment's notice, as copying two or three times only increases the risk of error. All copying work should be capable of check or double check. Duplicate books which take two copies at once, writing with an ordinary pen, offer the great advantage that if one copy is correct the other is bound to be so. Stationery of all kinds is now so reasonable in price that there is no excuse whatever for using rough paper or inferior binding.

Settlements *per contra*, instead of by cash, are confusing to those not specially trained in accounts, and are, therefore, to be avoided, so far as may be possible. But in some parts of the country it is a very common custom. So it may happen that the manager receives 5s. cash and a receipted account of 5s. in settlement of a gas bill for 10s. The best way of dealing with this is to enter the full amount of 10s. as received, and to enter the *contra* of 5s. as paid out of petty cash. The same procedure is followed with respect to a larger account, say of £25 for gas and coke, settled by a receipted *contra* account of £13 and a cheque for £12. But the £13 is a larger sum than is usually paid out of petty cash, and, therefore, a cheque for the amount must be obtained at the next board meeting. The account is passed for payment in the ordinary way, but the cheque is drawn in favour of the company, and paid in to their account. The bill of £13 is, of course, entered in the expenditure book in the usual way.

The expenditure on revenue is recorded as shown with regard to capital, and a convenient way is shown in Form V (p. 170), which is very similar to Form III. In fact, Form III is simply a summary of the annual totals of Form V. The invoices or statements, having been arranged in consecutive order, are entered as shown by the two examples. 100 tons of coals have been purchased at a cost of £75, subject to a discount of 1¼ per cent. for prompt payment. The net amount is £74, 1s. 3d. Items that belong to capital are entered as a total under the head of capital, and it is not necessary to dissect them, as that is done in the capital account. All the invoices, etc., and the totals of the wages and petty cash cheques having been entered, the totals of the various columns give the expenditure for the year. Items such as weekly wages and petty cash are dealt with in a separate book, so as to avoid unduly enlarging the expenditure book, and the totals of these and any other subsidiary books must be transferred to expenditure before the same is ruled off for the year. The correctness of the figures can be checked by adding together the totals of columns 41 to 48, which should equal the total of 57. 58 and 59, added together, also equal 57. The total capital expenditure, 48, should agree with that carried to capital (Form I), and the balance shown by deducting 48 from 57 should agree with the total of the revenue (Form III). The total of 59 should agree with that of the cheques paid, if all the accounts have been settled during the year, and none remain from the previous year. It will usually happen that the amount under "Crs." (65, Form IV) for the preceding year must be added, and the similar item for the current year deducted. Suppose the "Crs." for 1909 were £100, the expenditure for 1910 £1,000 and the "Crs." for 1910 £75. The bank book should show £1,000 + £100 − £75 = £1,025.

The income is recorded in two principal books—see Forms VI, VII (pp. 171–2). The sales of gas book, commonly called the "Rental," requires special ruling. Form VI shows a convenient form for ordinary meters, two quarters on a double page, and Form VII for slot meters. The latter covers a year's receipts, two clearings each quarter. The ordinary consumption is entered first and the various columns totalled up. The total slot consumption is entered, and the cash may be dealt with as follows :—(1) To furnish the cost of the gas at ordinary rates; (2) meter rent; (3) apparatus. Assume the year's consumption of gas totals out 600,000, the cash is £150, and the ordinary price is 4s. per thousand cubic feet. We require £120 for the gas. The next item is meter rents. Suppose there are sixty meters, and we wish to charge 5s. each, we enter under meter rents the sum of £15. The remainder, £15, is entered under rent of apparatus. In addition to ordinary and slot meters, there will be public lighting, and also irregular sales, such as for special illuminations at times of rejoicing, or a week's supply to a cheap jack or travelling theatre. Meters that for any cause are taken out of the usual routine may be conveniently entered under this head, to avoid confusing the ordinary account. For example, a house may be shut up and the owner gone abroad for a few months, so that the index cannot be taken at the quarter with the rest. Rather than create confusion by keeping the whole quarter's account open, it is better to mark the name as transferred to the first page of the next quarter. Irregular accounts should be entered in the current quarter, not in the last. A week's supply taken in November belongs to the Christmas quarter, and not to the Michaelmas. The totals of the ordinary, slot, special and irregular consumption give the sales of gas for each quarter, and these are carried to an annual summary, which gives the totals (21 to 25) for the revenue account.

The sales of products are furnished from the sales of products book, Form VIII (p. 173), which, like the rental, may be conveniently totalled up quarterly. Each sale of coke or tar is entered in order, and the totals of the annual summary give the items (27 to 29) in the revenue.

Subsidiary books are also required, such as a meter index book for recording the consumption by each consumer, and a products voucher book for all material taken or delivered from the works. Forms IX and X (p. 174) show the meter index record for ordinary and for slots, respectively, which may conveniently be of the loose leaf type. With regard to these books, the name of the consumer should be written in the space at the left hand, not at the head of the page, and the particulars of meter and stove rent in the proper column. If Mr. Smith commences in June 1908 with 1s. 6d. meter rent and 2s. 6d. stove rent, and leaves in March 1909, one light line is ruled, and if he is succeeded by Mr. Jones, who has his own meter and cooker, and therefore pays no rent, the items are dotted out. If Jones leaves and the house is demolished, a thick double line indicates that the meter has been removed. The prevalent practice of entering the names on the top of the page, and noting alterations by scratching out the original and writing the new name above, is untidy, and gives no record of the date of the change.

Form XI (p. 175) shows the yard or products voucher book. It may be in duplicate, one leaf to be handed to the purchaser as a delivery note, and the other retained in the book for entry. The vouchers are numbered consecutively, and the numbers should appear in the products sales book. If there are twenty or more sales a week, of small lots, such as half hundredweights or single hundredweights of coke, it is a good plan to purchase rolls of tickets, which can be had very cheaply in rolls of 1,000, numbered 1 up. One ticket being given for each ½ cwt., the total number per month can be entered in the sales book, thus avoiding the occupation of space by a lot of small entries.

Each quarter, a list of the bills for products should be prepared, and the total should agree with that of the "Cr." column in Form VIII. The list may, for convenience, be entered in the sales of gas book at the end of each quarter, or on a separate sheet or book.

Form XII (p. 176) is a specimen gas bill. These must be varied according to the rules as regards discount, terms of payment, etc.

Arrangement should be made to get the accounts delivered promptly at the end of each quarter. But they should not be sent out until they have been properly checked, and the sales of gas book cast. If the bills are copied direct from the meter index book and the sales of gas book also written up direct, and both priced up independently, the correctness can be checked by calling over the bills with the sales of gas book. The totals of the columns for gas, meter and apparatus rent should be added together, and if they agree with the total column, the correctness of all the accounts on that page is proved. The accounts as paid should be entered into a collector's book, Form XIII (p. 177), from which they are posted to the sales books, and the total cash received and paid to bank should agree with the totals in the sales books. Supplementary accounts, such as cash sales that do not appear in the current quarter's sales, should be entered separately in the collector's book, and so arranged that they form the commencing entries for the next quarter.

In Form XIII will be noticed a column for fittings. If the business in this line is small, the fittings may be booked through the products yard book. But it is better to have a separate fittings day book in which the details are entered, and from which the bills can be prepared. A quarterly list can be prepared, similar to that for the products, from which the yearly totals can be taken. In a small gasworks, it is scarcely practicable to keep a separate fittings account, and the best way of disposing of the sum received for fittings is to credit it to repairs. All pipe and fittings purchased being charged to "Dr.," any fittings sold will go to reduce the amount to be carried to the annual statement.

It is important to distinguish between the primary records, such as the capital and revenue accounts, Forms I, II, III, and the secondary or auxiliary books, such as the wages, the sales of gas, etc. The manner of dealing with any item depends upon the number of accounts included. For instance, coal, comprising only about half a dozen items in the year, can be easily dealt with in the primary book. But wages, if entered every week, would fill up a lot of space. The same as regards sales of gas and coke. So the introduction of secondary books is entirely a matter of convenience.

How to Examine a Form of Accounts.

Accounts tell a great deal, but they do not tell every thing, and sometimes there is a disposition to believe that because the accounts have been audited, everything must necessarily be quite correct and satisfactory. The auditor can satisfy himself that the books are correct according to the vouchers, and that the assets and liabilities are reasonable under the circumstances. But, as a rule, the auditor deals only with the accounts, and does not go into matters such as good or bad buying and selling or incorrect valuing of stocks. If 1s. per ton too much was paid for coal, or coke was sold at 12s. per ton when 15s. could have been had for it, or if the quantity of coal or coke in stock is overstated, the audited accounts do not reveal it. So the working must be examined in the light of some knowledge of local circumstances, and the stocks must be verified by taking them at the end of the next month or quarter, before one can really guarantee correctness and satisfactory working.

The annual turnover (total of revenue) should not be less than one-fourth of the capital expenditure. Sometimes it happens that a large outlay is made during the current year, the benefit of which is not apparent till the following year, and in any case the full benefit of the current year's expenditure is not experienced. But in the ordinary way the current year's capital expenditure has been moderate, and the rule holds good. Then the balance carried to profit and loss should be 25 to 30 per cent. of the annual turnover. The total of the balance-sheet should not exceed half the annual turnover. A reasonable sum, at least 2 per cent. on the capital outlay, should have been expended on repairs and renewals, and it is necessary to ascertain details of this expenditure. One wants to know something about this item for the last five or ten years.

Useful information is also afforded by calculating the income and expenditure per ton of coal and per thousand cubic feet of gas accounted for. The first is arrived at by dividing each item of the revenue (21 to 47) by the number of tons of coal carbonized, in this case 700 (see 41) and the second by adding to the total (21 and 22) the quantity of gas used at works (if not already included) and dividing as before. If the cost of coal is considerably more than, say, three-fifths of the receipts for gas, bad carbonizing or a high "unaccounted-for" item may be expected.

The points to be remembered, if there is reason to suspect that an attempt has been made to show a high rate of profit (and there are several causes that tend in that direction), are to see that the stocks are not over-valued, to scrutinize closely the additions to the capital account, and to see that there has been a proper outlay on repairs and maintenance.

If these items are as satisfactory on the 31st December as they were on the 1st January, there is not much the matter. The practice of showing a large profit, by charging portions of repairs, renewals and depreciation to profit and loss or to a reserve account is not so usual with gas undertakings as with some other companies, but at the best it is disingenuous. The profit is the balance remaining after paying all expenses. If the balance of net revenue is £1,000, but £50 of this is required for income-tax and £200 for renewals, then the actual profit is £750, and not £1,000, and it is simply deceiving the shareholders if the accounts are so drawn, or the statements from the chairman at the shareholders' meeting so worded, as to convey the impression that the actual net earnings are £1,000.

Working Results.

Our examination must also extend to the working results, and it will be seen that the account affords information not only as to cash receipts and payments, but also as to bulk or weight of material purchased or sold. A slate and a working results book, such as Form XIV (p. 178), enable the daily results to be checked. The meter is taken every three or six hours, also the height of the holders, and the details, as shown, are entered up, one line for each day. Each double page records a month's operations, and quarterly or annual totals can be easily arrived at. The total coal carbonized, and purifying material used, should agree with the expenditure book. (Form V—41-42.)

Private Memoranda.

If one asks for details such as the working life of the retorts, or the number of purifiers changed in a year, they are usually forthcoming—but perhaps after a long search through pocket-books, diaries, etc. A suggestion that it is worth while to carry the same order and system observed in entering up the cash accounts to details of this nature usually rouses a somewhat impatient rejoinder, to the effect that "There is quite enough to do as it is." But no one who has once adopted the system will give it up. Various methods are available. Some may prefer a book of 200 to 300 pp., foolscap size, with alphabetical index at the commencement, such as may be obtained under the title of a minute book. The paper should be good, and the binding strong. Starting with a sufficient number of pages to leave two or three for each bed of retorts, and space for future extensions, pages are left for "Hydraulic," "Condensers," "Purifiers," "Gasholders," "Mains," "Services," and so on. As it is desirable to keep each subject by itself, plenty of room should be allowed. Or some may choose a cabinet of loose cards, with index letters. After a time, the scheme will shape itself to suit the individual requirements; and it will be found just as easy to keep memoranda by system and method as to scribble them anyhow and anywhere. Forms XV to XVII (pp. 179–81) are examples of the way in which systematic records can be kept. XV is a record of the working life of a bed of retorts. The dates of lighting up or shutting down being entered, the position of the setting as regards wear and tear is evident at any time, and when the bed is worked out, the total number of days in use is easily ascertained. From this, one can get at the coal carbonized. Form XVI is a purifier house record, with room for details of six heaps of oxide, lettered A to F. The number of the box, date turned on, date shut off, and the indication of the meter, enable the quantity of gas passed and the days in use to be entered under the proper letter. Under "No." is entered the number of exposures, from 1 up. From this form we get on one sheet a plain statement of the position in the purifier house, from which one can see what heaps are fresh, and what heaps are getting stale and spent.

At the end of this book may be kept a set of tables referring to data in frequent demand. These may, if preferred, be on separate loose sheets, or they may be written on stiff card. Tables I to III (pp. 182–6) enable the yield per ton from any quantity of coal to be ascertained at a glance. For example, if 30 cwts. of coal has been used in the twenty-four hours, and the yield is 13,800 cubic feet of gas and 18 cwts. of coke. Turn to Table I, find 30 cwts., follow the horizontal line till we come to 13,800 and the figure at the head of the column is 9,200, which is the yield per ton. Proceeding in the same manner with regard to Table II, we find the yield of coke per ton is 12 cwts. The tar and liquor well may be gauged, perhaps, once a month, and during that period the make of liquid is found to be 300 gallons. If the coal used is 20 tons, the make is easily traced, in Table III, to be 15 gallons per ton, by the same procedure as in Table I. The tables can also be used in another way. A coal is known to be capable of yielding 10,000 cubic feet of gas per ton and 13 cwts. of coke. If the quantity carbonized in twenty-four hours is 1 ton 13 cwts., we know from Table I that the yield of gas should be 16,500 cubic feet, and from Table II that the coke should be nearly 21½ cwts. If a close approximation to these quantities is not forthcoming, the reason for the discrepancy should be discovered. The uses of Tables such as IV, V and VI (pp. 187–9 for pricing out various quantities of gas or coke require no explanation. Table VII (p. 190) is useful for taking out wages at an hourly rate, the cost of various lengths of pipe, etc.; and Table VIII (p. 191) is for discounts and interest. Table IX (p. 192), which shows the circumference and area of circles from 1 to 100 diameter, is continually in demand. A gasholder is 40 feet diameter and 16 feet high—required the content. The area of a circle 40 feet diameter is shown to be 1,256·64, and this quantity multiplied by 16 gives the content of the holder. A run of foul main is 15 inches diameter by 90 feet long, required the superficial or cooling surface. The circumference of a circle whose diameter is 15 is 47·124, and this, multiplied by the length in inches will give the surface in square inches. The figures can be used for any desired unit; but if, as in the foregoing, there are two different units, such as length in feet and diameter in inches, both must be reduced to the lowest unit, viz., inches. A tar well is 12 feet in diameter, what is the content per foot depth? The area of a circle having a diameter of 12 is 113·1, and this multiplied by 6·25 (approximately the number of gallons in a cubic foot) gives the content, in gallons, per foot depth. A quantity of one dimension, such as length, is stated in lineal measure. A quantity of two dimensions, such as area, in square measure, and one of three dimensions, such as the content of a gasholder or tank, in cube measure.

Tables X and XI (pp. 193–4) are examples of another kind of information. The specific gravity, or the strength by hydrometer, being known, the percentage of pure substance is indicated. A sample of commercial oil of vitriol is found to be reasonably pure and to indicate 147° on the hydrometer. It contains 80 per cent. pure sulphuric acid. A solution of sulphate of ammonia indicates 68·2° Twaddel. According to Table XI, the percentage of pure sulphate present is 59. The use of Table XII (p. 195) is described on page 97.

FORM I.

	....................Gasworks. Capital Account.	*1.* Land.	*2.* Buildings.	*3.* Plant.	*4.* Gasholders.	*5.* Mains.
		£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
	Expended to 31st Dec. 1909	550 0 0	800 0 0	1,000 0 0	800 0 0	400 0 0
1910	Since—					
	new gasholder . . .				500 0 0	
	,, bed of retorts .			50 0 0		
1911	additional meters . .					

[*Left-hand side of sheet.*]

FORM I.—(*continued*).

6. Services.	*7.* Meters.	*8.*	*9.*	*10.*	*11.*	*12.* Sundry.	*13.* Total.	*14.* Deductions.	*15.* Net.
£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d,	£ s. d.	£ s. d.
200 0 0	250 0 0						4,000 0 0	50 0 0	3,950 0 0
							500 0 0		500 0 0
							50 0 0		50 0 0
	20 0 0						20 0 0	2 0 0	18 0 0

[*Right-hand side of sheet.*]

FORM II.

....................Gasworks. Revenue Account, Cr.	21 Consumers.	22	23. Public Lights.	24. Rent. Meters.	25. Rent. Apparatus.
	Cubic Feet.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Year ended 31st Dec. 1910	5,500,000	947 8 2	100 0 0	55 19 6	24 1 2
" " " 1911					
" " " 1912					

[*Left-hand side of sheet.*]

FORM II.—(*continued*).

26.	27. Coke.	28. Tar.	29. Sundry.				37. Total.	38. Deductions.	39. Net.
£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
	111 0 4	25 10 6	9 2 6				1,273 2 2		1,273 2 2

[*Right-hand side of sheet.*]

FORM III.

....................Gasworks. Revenue Account, Dr.	41. Coal.		42. Purifying.		43. Wages.
	Tons. Cwts. Qrs.	£ s. d.	Tons. Cwts. Qrs.	£ s. d.	£ s. d.
Year ended 31st December 1910	700 0 0	607 5 3		25 19 2	207 8 4

[*Left-hand side of sheet.*]

FORM III.—(*continued*).

44. Salaries.	45. Repairs.	46. Lamps.	47. Sundry.			57. Total.	5 Deductions.	59. Net Total.
£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s, d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
25 0 0	78 16 10	15 17 2	44 5 0			1,004 11 9		1,004 11 9

[*Right-hand side of sheet.*]

FORM IV.

.... Gasworks. Balances and Stocks.	61. Capital.	62. Profit and Loss.	63. Dividends.	64. Carry Forward.	65. Creditors.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Year ended 31st Dec.	232 0 0	278 1 7			75 0 0

[*Left-hand side of sheet.*]

FORM IV.—(*continued*).

66. Debtors.	67. Coal.		68. Coke.		69. Tar.					70. Sundry.	71. Cash.
£ s. d.	T. C. Q.	£ s. d.	T. C. Q.	£ s. d.	T. C. Q.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
310 3 4	50 0 0	36 0 0	10 0 0	6 0 0	8 0 0	5 0 0				26 0 0	201 18 3

[*Right-hand side of sheet.*]

FORM V.

......................Gasworks. Expenditure.	41. Coal. T. C. Q.	41. Coal. £ s. d.	42. Purifying. T. C. Q.	42. Purifying. £ s. d.	43. Wages. £ s. d.
Year ended 31st Dec. 1910.		607 5 3		25 19 2	207 8 4
1. Coal	100 0 0	75 0 0			
2. Lime.			10 0 0	8 0 0	

[*Left-hand side of sheet.*]

FORM V.—(*continued*).

44. Salaries.	45. Repairs.	46. Lamps.	47. Sundry.				48. Capital.	57. Total.	58. Deduct'ns.	59. Net.
£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
25 0 0	78 16 10	15 17 2	44 5 0							
								75 0 0	0 18 9	74 1 3
								8 0 0		8 0 0

[*Right-hand side of sheet.*]

FORM VI.

Sales of Gas, Ordinary Meters.	3rd Quarter, 191..								
	Arrears.	Cubic Feet.	Gas.	Meter Rent.	Apparatus Rent.	Total.	Cash.	Allowed and Bad.	Arrears.

[*Left-hand side of sheet.*]

FORM VI.—(*continued*).

4th Quarter, 191..								
Arrears.	Cubic Feet.	Gas.	Meter Rent.	Apparatus Rent.	Total.	Cash.	Allowed and Bad.	Arrears.

[*Right-hand side of sheet.*]

FORM VII.

	February 15.		April 1.		May 15.		July 1.		.... Slot Collections
	Cub. Ft.	£ s. d.	Cub. Ft.	£ s. d.	Cub. Ft.	£ s. d.	Cub. Ft.	£ s. d.	

[*Left-hand side of sheet.*]

FORM VII.—(*continued*).

............Gasworks. for Year 1910.	August 15.		October 1.		November 15.		January 1.	
	Cub. Ft.	£ s. d.	Cub. Ft.	£ s. d.	Cub. Ft.	£ s. d.	Cub. Ft.	£ s. d.

[*Right-hand side of sheet.*]

FORM VIII.

Date.	.... Gasworks. Products sold. Year Ended......	Cash.	Credit.	Coke.		Tar.		Liquor.	Sundry.
		£ s d.	£ s d.	T. C. Q.	£ s d.	T. C. Q.	£ s. d.	£ s d.	£ s d.

FORM IX.

	Name.	Date.	Index.	Consumption.	£ s. d.

FORM X.

	Name.	Date.	Index.	Consumption.	Meter.	Apparatus.

FORM XI.

.. ..Gas Company No. 1.

............................1911

Deliver to

....

Coke

Tar

....

Cash received

£ s. d.

FORM XII.

The Terms on which Gas is supplied are Quarterly Payments, due on delivery of Account.

M.....................................

....

Hours of Atttendance : 11 to 1 daily, at the Office.

Dr. to The .... Gas and Coke Company, Limited.

For Gas supplied during three months ending... ....191...

Present Meter Index.	Previously Charged.	Consumed.	£	s.	d.
... c. ft.	... c. ft.	... c. ft. at 3/8 1,000			
		Meter Rent			
		Rent of Apparatus . . .			

REGULATIONS.—Consumers discontinuing to use Gas must give a written notice at the Gasworks ; they will be held liable for all Gas used on the Premises until such notice is received. No unauthorized person may interfere with pipes or meters through which our Gas passes ; the Gas is our property until it has passed through a customer's meter.

FORM XIII.

Name.	Total Received.	Gas, etc.		Products.	Fittings.	Allowed.	Bank.
	£ s. d.	£ s. d.		£ s. d.	£ s. d.	£ s. d.	£ s. d.

FORM XIV.

January 1911.

Day	Retorts in Use	Furnaces	Men	Charges	Coal Received	Coal Used	Meter Index	Gas Made		Gas in Holders	Gas Sent Out	Make per Ton	Illuminating Power	Lime	Received	Used
1																
2																
3																
4																

FORM XV.

Bed No. .... 5 Retorts.

Date Lit Up.	Date Set Down.	Days in Use.	Number of Blowings.				
			A.	B.	C.	D.	E.

FORM XVI.

Purifiers 1, 2, 3 and 4.

No.	Letter.	On.		Off.		A			B		No.
		Date.	Meter Index.	Date.	Meter Index.	Gas Passed.	Days.	No.	Gas Passed.	Days	
1	A	1 Jan. '10	10·108	15 Mar. '10	22·146	12,038	74	1	—	—	—
2	B	1 Feb. '10	15·204	20 May '10	28·742	—	—	—	13,538	109	1

[*Left-hand side of sheet.*]

FORM XVI.—(*continued*).

C			D			E			F			
Gas Passed.	Days.	No.	Gas Passed.	Days.	No.	Gas Passed.	Days.	No.	Gas Passed.	Days.	No.	

[*Right-hand side of sheet.*]

FORM XVII.

PRICES.

	Coal, Per Ton.	Lime, Per Ton.	Oxide, Per Ton.	
	s. d.	s. d.	s. d.	
1910 . .	15 0	18 0	30 0	

[*Left-hand side of sheet.*]

FORM XVII—(*continued*).

PRICES.

	Gas.		Coke.		Tar.	
	Ordinary.	Slot.	Ton.	Cwt.		
	s. d.	s. d.	s. d.	s. d.		
1910	4 0	4 8	15 0	0 10	2d. gallon.	

[*Right-hand side of sheet.*]

TABLE I.

Make of Gas from a Given Weight of Coal. 10 cwts. to 3 tons.

Weight of Coal. T. C.	8500	8600	8700	8800	8900	9000	9100	9200	9300	9400	9500	9600	9700	9800	9900	10000	10100	10200	10300	10400
10	4250	4300	4350	4400	4450	4500	4550	4600	4650	4700	4750	4800	4850	4900	4950	5000	5050	5100	5150	5200
11	4675	4730	4785	4840	4895	4950	5005	5060	5115	5170	5225	5280	5335	5390	5445	5500	5555	5610	5665	5720
12	5100	5160	5220	5280	5340	5400	5460	5520	5580	5640	5700	5760	5820	5880	5940	6000	6060	6120	6180	6240
13	5525	5590	5655	5720	5785	5850	5915	5980	6045	6110	6175	6240	6305	6370	6435	6500	6565	6630	6695	6760
14	5950	6020	6090	6160	6230	6300	6370	6440	6510	6580	6650	6720	6790	6860	6930	7000	7070	7140	7210	7280
15	6375	6450	6525	6600	6675	6750	6825	6900	6975	7050	7125	7200	7275	7350	7425	7500	7575	7650	7725	7800
16	6800	6880	6960	7040	7120	7200	7280	7360	7440	7520	7600	7680	7760	7840	7920	8000	8080	8160	8240	8320
17	7225	7310	7395	7480	7565	7650	7735	7820	7905	7990	8075	8160	8245	8330	8415	8500	8585	8670	8755	8840
18	7650	7740	7830	7920	8010	8100	8190	8280	8370	8460	8550	8640	8730	8820	8910	9000	9090	9180	9270	9360
19	8075	8170	8265	8360	8455	8550	8645	8740	8835	8930	9025	9120	9215	9310	9405	9500	9595	9690	9785	9880
1 0	8500	8600	8700	8800	8900	9000	9100	9200	9300	9400	9500	9600	9700	9800	9900	10000	10100	10200	10300	10400
1 1	8925	9030	9135	9240	9345	9450	9555	9660	9765	9870	9975	10080	10185	10290	10395	10500	10605	10710	10815	10920
1 2	9350	9460	9570	9680	9790	9900	10010	10120	10230	10340	10450	10560	10670	10780	10890	11000	11110	11220	11330	11440
1 3	9775	9890	10005	10120	10235	10350	10465	10580	10695	10810	10925	11040	11155	11270	11385	11500	11615	11730	11845	11960
1 4	10200	10320	10440	10560	10680	10800	10920	11040	11160	11280	11400	11520	11640	11760	11880	12000	12120	12240	12360	12480
1 5	10625	10750	10875	11000	11125	11250	11375	11500	11625	11750	11875	12000	12125	12250	12375	12500	12625	12750	12875	13000
1 6	11050	11180	11310	11440	11570	11700	11830	11960	12090	12220	12350	12480	12610	12740	12870	13000	13130	13260	13390	13520
1 7	11475	11610	11745	11880	12015	12150	12285	12420	12555	12690	12825	12960	13095	13230	13365	13500	13635	13770	13905	14040
1 8	11900	12040	12180	12320	12460	12600	12740	12880	13020	13160	13300	13440	13580	13720	13860	14000	14140	14280	14420	14560
1 9	12325	12470	12615	12760	12905	13050	13195	13340	13485	13630	13775	13920	14065	14210	14355	14500	14645	14790	14935	15080
1 10	12750	12900	13050	13200	13350	13500	13650	13800	13950	14100	14250	14400	14550	14700	14850	15000	15150	15300	15450	15600
1 11	13175	13330	13485	13640	13795	13950	14105	14260	14415	14570	14725	14880	15035	15190	15345	15500	15655	15810	15965	16120
1 12	13600	13760	13920	14080	14240	14400	14560	14720	14880	15040	15200	15360	15520	15680	15840	16000	16160	16320	16480	16640
1 13	14025	14190	14355	14520	14685	14850	15015	15180	15345	15510	15675	15840	16005	16170	16335	16500	16665	16830	16995	17160
1 14	14450	14620	14790	14960	15130	15300	15470	15640	15810	15980	16150	16320	16490	16660	16830	17000	17170	17340	17510	17680
1 15	14875	15050	15225	15400	15575	15750	15925	16100	16275	16450	16625	16800	16975	17150	17325	17500	17675	17850	18025	18200

TABLE I.—(*continued*).

Make of Gas from a Given Weight of Coal

Weight of Coal. T. C.	8500	8600	8700	8800	8900	9000	9100	9200	9300	9400	9500	9600	9700	9800	9900	10000	10100	10200	10300	10400
1 16	15300	15480	15660	15840	16020	16200	16380	16560	16740	16920	17100	17280	17460	17640	17820	18000	18180	18360	18540	18720
1 17	15725	15910	16095	16280	16465	16650	16835	17020	17205	17390	17575	17760	17945	18130	18315	18500	18685	18870	19055	19240
1 18	16150	16340	16530	16720	16910	17100	17290	17480	17670	17860	18050	18240	18430	18620	18810	19000	19190	19380	19570	19760
1 19	16575	16770	16965	17160	17355	17550	17745	17940	18135	18330	18525	18720	18915	19110	19305	19500	19695	19890	20085	20280
2 0	17000	17200	17400	17600	17800	18000	18200	18400	18600	18800	19000	19200	19400	19600	19800	20000	20200	20400	20600	20800
2 1	17425	17630	17835	18040	18245	18450	18655	18860	19065	19270	19475	19680	19885	20090	20295	20500	20705	20910	21115	21320
2 2	17850	18060	18270	18400	18690	18900	19110	19320	19530	19740	19950	20160	20370	20580	20790	21000	21210	21420	21630	21840
2 3	18275	18490	18705	18920	19135	19350	19565	19780	19995	20210	20425	20640	20855	21070	21285	21500	21715	21930	22145	22360
2 4	18700	18920	19140	19360	19580	19800	20020	20240	20460	20680	20900	21120	21340	21560	21780	22000	22220	22440	22660	22880
2 5	19125	19350	19575	19800	20025	20250	20475	20700	20925	21150	21375	21600	21825	22050	22275	22500	22725	22950	23175	23400
2 6	19550	19780	20010	20240	20470	20700	20930	21160	21390	21620	21850	22080	22310	22540	22770	23000	23230	23460	23690	23920
2 7	19975	20210	20445	20680	20915	21150	21385	21620	21855	22090	22325	22560	22795	23030	23265	23500	23735	23970	24205	24440
2 8	20400	20640	20880	21120	21360	21600	21840	22080	22320	22560	22800	23040	23280	23520	23760	24000	24240	24480	24720	24960
2 9	20825	21070	21315	21560	21805	22050	22295	22540	22785	23030	23275	23520	23765	24010	24255	24500	24745	24990	25235	25480
2 10	21250	21500	21750	22000	22250	22500	22750	23000	23250	23500	23750	24000	24250	24500	24750	25000	25250	25500	25750	26000
2 11	21675	21930	22185	22440	22695	22950	23205	23460	23715	23970	24225	24480	24735	24990	25245	25500	25755	26010	26265	26520
2 12	22100	22360	22620	22880	23140	23400	23660	23920	24180	24440	24700	24960	25220	25480	25740	26000	26260	26520	26780	27040
2 13	22525	22790	23055	23320	23585	23850	24115	24380	24645	24910	25175	25440	25705	25970	26235	26500	26765	27030	27295	27560
2 14	22950	23220	23490	23760	24030	24300	24570	24840	25110	25380	25650	25920	26190	26460	26730	27000	27270	27540	27810	28080
2 15	23375	23650	23925	24200	24475	24750	25025	25300	25575	25850	26125	26400	26675	26950	27255	27500	27775	28050	28325	28600
2 16	23800	24080	24360	24640	24920	25200	25480	25760	26040	26320	26600	26880	27160	27440	27720	28000	28280	28560	28840	29120
2 17	24225	24510	24795	25080	25365	25650	25935	26220	26505	26790	27075	27360	27645	27930	28215	28500	28785	29070	29355	29640
2 18	24650	24940	25230	25520	25810	26100	26390	26680	26970	27260	27550	27840	28130	28420	28710	29000	29290	29580	29870	30160
2 19	25075	25370	25665	25960	26255	26550	26845	27140	27435	27730	28025	28320	28615	28910	29205	29500	29795	30090	30385	30680
3 0	25500	25800	26100	26400	26700	27000	27300	27600	27900	28200	28500	28800	29100	29400	29700	30000	30300	30600	30900	31200

TABLE II.

Make of Coke from a Given Weight of Coal. 10 cwts. to 3 tons.

Weight of Coal.	*0 11 0*	*0 11 28*	*0 11 56*	*0 11 84*	*0 12 0*	*0 12 28*	*0 12 56*	*0 12 84*	*0 13 0*	*0 13 28*	*0 13 56*	*0 13 84*	*0 14 0*
T. C.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs.
0 10	0 5 56	0 5 70	0 5 84	0 5 98	0 6 0	0 6 14	0 6 28	0 6 42	0 6 56	0 6 70	0 6 84	0 6 98	0 7 0
0 11	0 6 5	0 6 21	0 6 36	0 6 51	0 6 67	0 6 82	0 6 98	0 7 1	0 7 16	0 7 32	0 7 47	0 7 63	0 7 78
0 12	0 6 67	0 6 84	0 6 100	0 7 5	0 7 22	0 7 39	0 7 56	0 7 72	0 7 89	0 7 106	0 8 11	0 8 28	0 8 44
0 13	0 7 16	0 7 35	0 7 53	0 7 71	0 7 89	0 7 107	0 8 14	0 8 32	0 8 50	0 8 68	0 8 86	0 8 105	0 9 11
0 14	0 7 78	0 7 98	0 8 5	0 8 25	0 8 44	0 8 64	0 8 84	0 8 103	0 9 11	0 9 30	0 9 50	0 9 70	0 9 89
0 15	0 8 28	0 8 49	0 8 70	0 8 91	0 9 0	0 9 21	0 9 42	0 9 63	0 9 84	0 9 105	0 10 14	0 10 35	0 10 56
0 16	0 8 89	0 9 0	0 8 22	0 9 42	0 9 67	0 9 89	0 10 0	0 10 22	0 10 44	0 10 67	0 10 89	0 11 0	0 11 22
0 17	0 9 39	0 9 63	0 8 86	0 9 108	0 10 22	0 10 46	0 10 70	0 10 93	0 11 5	0 11 29	0 11 53	0 11 77	0 11 100
0 18	0 9 100	0 10 14	0 9 32	0 10 62	0 10 89	0 11 2	0 11 28	0 11 53	0 11 78	0 11 103	0 12 16	0 12 42	0 12 67
0 19	0 10 50	0 10 77	0 9 103	0 11 16	0 11 44	0 11 71	0 11 98	0 12 12	0 12 39	0 12 65	0 12 92	0 13 7	0 13 33
1 0	0 11 0	0 11 28	0 11 56	0 11 84	0 12 0	0 12 28	0 12 56	0 12 84	0 13 0	0 13 28	0 13 56	0 13 84	0 14 0
1 1	0 11 61	0 11 91	0 12 8	0 12 37	0 12 67	0 12 96	0 13 14	0 13 43	0 13 72	0 13 102	0 14 19	0 14 49	0 14 78
1 2	0 12 11	0 12 42	0 12 72	0 12 103	0 13 22	0 13 53	0 13 84	0 14 2	0 14 33	0 14 64	0 14 95	0 15 14	0 15 44
1 3	0 12 72	0 12 105	0 13 25	0 13 57	0 13 89	0 14 9	0 14 42	0 14 74	0 14 106	0 15 26	0 15 58	0 15 91	0 16 11
1 4	0 13 22	0 13 56	0 13 80	0 14 11	0 14 44	0 14 78	0 15 0	0 15 33	0 15 67	0 15 100	0 16 22	0 16 56	0 16 89
1 5	0 13 84	0 14 7	0 14 42	0 14 77	0 15 0	0 15 35	0 15 70	0 15 105	0 16 28	0 16 63	0 16 98	0 17 21	0 17 56
1 6	0 14 33	0 14 70	0 14 106	0 15 30	0 15 67	0 15 103	0 16 28	0 16 64	0 16 100	0 17 25	0 17 61	0 17 98	0 18 22
1 7	0 14 95	0 15 21	0 15 58	0 15 96	0 16 22	0 16 60	0 16 98	0 17 23	0 17 61	0 17 99	0 18 25	0 18 63	0 18 100
1 8	0 15 44	0 15 84	0 16 11	0 16 50	0 16 89	0 17 16	0 17 56	0 17 95	0 18 22	0 18 61	0 18 100	0 19 28	0 19 67
1 9	0 15 106	0 16 35	0 16 75	0 17 4	0 17 44	0 17 85	0 18 14	0 18 54	0 18 95	0 19 23	0 19 64	0 19 105	1 0 33
1 10	0 16 56	0 16 98	0 17 28	0 17 70	0 18 0	0 18 42	0 18 84	0 19 14	0 19 56	0 19 98	1 0 28	1 0 70	1 1 0
1 11	0 17 5	0 17 49	0 17 92	0 18 23	0 18 67	0 18 110	0 19 42	0 19 85	1 0 16	1 0 60	1 0 103	1 1 35	1 1 78
1 12	0 17 67	0 18 0	0 18 44	0 18 89	0 19 22	0 19 67	1 0 0	1 0 44	1 0 89	1 1 22	1 1 67	1 2 0	1 2 44
1 13	0 18 16	0 18 63	0 18 109	0 19 43	0 19 89	1 0 23	1 0 70	1 1 4	1 1 50	1 1 96	1 2 30	1 2 77	1 3 11
1 14	0 18 78	0 19 14	0 19 61	0 19 109	1 0 44	1 0 92	1 1 28	1 1 75	1 2 11	1 2 58	1 2 106	1 3 42	1 3 89
1 15	0 19 28	0 19 77	1 0 14	1 0 63	1 1 0	1 1 49	1 1 98	1 2 35	1 2 84	1 3 21	1 3 70	1 4 7	1 4 56

TABLE II.—(*continued*).

Make of Coke from a Given Weight of Coal.

Weight of Coal.	0 11 0	0 11 28	0 11 56	0 11 84	0 12 0	0 12 28	0 12 56	0 12 84	0 13 0	0 13 28	0 13 56	0 13 84	0 14 0
T. C.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs.	T.C. lbs	T.C. lbs.	T.C. lbs.
1 16	0 19 89	1 0 28	1 0 78	1 1 16	1 1 67	1 2 5	1 2 56	1 2 106	1 3 44	1 3 95	1 4 33	1 4 84	1 5 22
1 17	1 0 39	1 0 91	1 1 30	1 1 82	1 2 22	1 2 74	1 3 14	1 3 65	1 4 5	1 4 57	1 4 109	1 5 49	1 5 100
1 18	1 0 100	1 1 42	1 1 95	1 2 36	1 2 89	1 3 30	1 3 84	1 4 25	1 4 78	1 5 19	1 5 72	1 6 14	1 6 67
1 19	1 1 50	1 1 105	1 2 47	1 2 102	1 3 44	1 3 99	1 4 42	1 4 96	1 5 39	1 5 93	1 6 36	1 6 91	1 7 33
2 0	1 2 0	1 2 50	1 3 0	1 3 56	1 4 0	1 4 56	1 5 0	1 5 56	1 6 0	1 6 56	1 7 0	1 7 56	1 8 0
2 1	1 2 61	1 3 7	1 3 64	1 4 9	1 4 67	1 5 12	1 5 70	1 6 15	1 6 72	1 7 18	1 7 75	1 8 21	1 8 78
2 2	1 3 11	1 3 70	1 4 16	1 4 75	1 5 22	1 5 81	1 6 28	1 6 86	1 7 33	1 7 92	1 8 39	1 8 98	1 9 44
2 3	1 3 72	1 4 21	1 4 81	1 5 29	1 5 89	1 6 37	1 6 98	1 7 46	1 7 106	1 8 54	1 9 2	1 9 63	1 10 11
2 4	1 4 22	1 4 84	1 5 33	1 5 95	1 6 44	1 6 106	1 7 56	1 8 5	1 8 67	1 9 16	1 9 78	1 10 28	1 10 89
2 5	1 4 84	1 5 35	1 5 98	1 6 49	1 7 0	1 7 63	1 8 14	1 8 77	1 9 28	1 9 91	1 10 42	1 10 105	1 11 56
2 6	1 5 33	1 5 98	1 6 50	1 7 2	1 7 67	1 8 19	1 8 84	1 9 36	1 9 100	1 10 53	1 11 5	1 11 70	1 12 22
2 7	1 5 95	1 6 49	1 7 2	1 7 68	1 8 22	1 8 88	1 9 42	1 9 107	1 10 61	1 11 15	1 11 81	1 12 35	1 12 100
2 8	1 6 44	1 7 0	1 7 67	1 8 22	1 8 89	1 9 44	1 10 0	1 10 67	1 11 22	1 11 89	1 12 44	1 13 0	1 13 67
2 9	1 6 106	1 7 63	1 8 19	1 8 88	1 9 44	1 10 1	1 10 70	1 11 26	1 11 95	1 12 51	1 13 08	1 13 77	1 14 33
2 10	1 7 56	1 8 14	1 8 84	1 9 42	1 10 0	1 10 70	1 11 28	1 11 98	1 12 56	1 13 14	1 13 84	1 14 42	1 15 0
2 11	1 8 5	1 8 77	1 9 36	1 9 107	1 10 67	1 11 26	1 11 98	1 12 57	1 13 16	1 13 88	1 14 47	1 15 7	1 15 78
2 12	1 8 67	1 9 28	1 9 100	1 10 61	1 11 22	1 11 95	1 12 56	1 13 16	1 13 89	1 14 50	1 15 11	1 15 84	1 16 44
2 13	1 9 16	1 9 91	1 10 53	1 11 15	1 11 89	1 12 51	1 13 14	1 13 88	1 14 50	1 15 12	1 15 86	1 16 49	1 17 11
2 14	1 9 78	1 10 42	1 11 5	1 11 81	1 12 44	1 13 8	1 13 84	1 14 47	1 15 11	1 15 86	1 16 50	1 17 14	1 17 89
2 15	1 10 28	1 10 105	1 11 70	1 12 35	1 13 0	1 13 77	1 14 42	1 15 7	1 15 84	1 16 49	1 17 14	1 17 91	1 18 56
2 16	1 10 89	1 11 56	1 12 22	1 12 100	1 13 67	1 14 33	1 15 0	1 15 78	1 16 44	1 17 11	1 17 89	1 18 56	1 19 22
2 17	1 11 39	1 12 7	1 12 86	1 13 54	1 14 22	1 14 102	1 15 70	1 16 37	1 17 5	1 17 85	1 18 53	1 19 21	1 19 100
2 18	1 11 100	1 12 70	1 13 39	1 14 8	1 14 89	1 15 58	1 16 28	1 16 109	1 17 78	1 18 47	1 19 16	1 19 98	2 0 67
2 19	1 12 50	1 13 21	1 13 103	1 14 74	1 15 44	1 16 15	1 16 98	1 17 68	1 18 39	1 19 9	1 19 92	2 0 63	2 1 33
3 0	1 13 0	1 13 84	1 14 56	1 15 28	1 16 0	1 16 84	1 17 56	1 18 28	1 19 0	1 19 84	2 0 56	2 1 28	2 2 0

TABLE III.

Tar and Liquor per Ton of Coal.

Tons.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.
1	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
2	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
3	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	69	72
4	32	36	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96
5	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
6	48	54	60	66	72	78	84	90	96	102	108	114	120	126	132	138	144
7	56	63	70	77	84	91	98	105	112	119	126	133	140	147	154	161	168
8	64	72	80	88	96	104	112	120	128	136	144	152	160	168	176	184	192
9	72	81	90	99	108	117	126	135	144	153	162	171	180	189	198	207	216
10	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
20	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480
30	240	270	300	330	360	390	420	450	480	510	540	570	600	630	660	690	720
40	320	360	400	440	480	520	560	600	640	680	720	760	800	840	880	920	960
50	400	450	500	550	600	650	700	750	800	850	900	950	1,000	1,050	1,100	1,150	1,200
60	480	540	600	660	720	780	840	900	960	1,020	1,080	1,140	1,200	1,260	1,320	1,380	1,440
70	560	630	700	770	840	910	980	1,050	1,120	1,190	1,260	1,330	1,400	1,470	1,540	1,610	1,680
80	640	720	800	880	960	1,040	1,120	1,200	1,280	1,360	1,440	1,520	1,600	1,680	1,760	1,840	1,920
90	720	810	900	990	1,080	1,170	1,260	1,350	1,440	1,530	1,620	1,710	1,800	1,890	1,980	2,070	2,160
100	800	900	1,000	1,100	1,200	1,300	1,400	1,500	1,600	1,700	1,800	1,900	2,000	2,100	2,200	2,300	2,400
200	1,600	1,800	2,000	2,200	2,400	2,600	2,800	3.000	3,200	3,400	3,600	3,800	4,000	4,200	4,400	4,600	4,800
300	2,400	2,700	3,000	3,300	3,600	3,900	4,200	4.500	4,800	5,100	5,400	5,700	6,000	6,300	6,600	6,900	7,200
400	3,200	3,600	4,000	4,400	4,800	5,200	5,600	6,000	6,400	6,800	7,200	7,600	8,000	8,400	8,800	9,200	9,600
500	4,000	4.500	5,000	5,500	6,000	6,500	7,000	7,500	8,000	8,500	9,000	9,500	10,000	10,500	11,000	11,500	12,000

TABLE IV.

PRICE OF GAS: 3½d. TO 6d. PER 100 CUBIC FEET.

Cub. Ft.	3½d.			4d.			4½d.			5d.			5½d.			6d.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
100	0	0	3½	0	0	4	0	0	4½	0	0	5	0	0	5½	0	0	6
200	0	0	7	0	0	8	0	0	9	0	0	10	0	0	11	0	1	0
300	0	0	10½	0	1	0	0	1	1½	0	1	3	0	1	4½	0	1	6
400	0	1	2	0	1	4	0	1	6	0	1	8	0	1	10	0	2	0
500	0	1	5½	0	1	8	0	1	10½	0	2	1	0	2	3½	0	2	6
600	0	1	9	0	2	0	0	2	3	0	2	6	0	2	9	0	3	0
700	0	2	0½	0	2	4	0	2	7½	0	2	11	0	3	2½	0	3	6
800	0	2	4	0	2	8	0	3	0	0	3	4	0	3	8	0	4	0
900	0	2	7½	0	3	0	0	3	4½	0	3	9	0	4	1½	0	4	6
1,000	0	2	11	0	3	4	0	3	9	0	4	2	0	4	7	0	5	0
2,000	0	5	10	0	6	8	0	7	6	0	8	4	0	9	2	0	10	0
3,000	0	8	9	0	10	0	0	11	3	0	12	6	0	13	9	0	15	0
4,000	0	11	8	0	13	4	0	15	0	0	16	8	0	18	4	1	0	0
5,000	0	14	7	0	16	8	0	18	9	1	0	10	1	2	11	1	5	0
6,000	0	17	6	1	0	0	1	2	6	1	5	0	1	7	6	1	10	0
7,000	1	0	5	1	3	4	1	6	3	1	9	2	1	12	1	1	15	0
8,000	1	3	4	1	6	8	1	10	0	1	13	4	1	16	8	2	0	0
9,000	1	6	3	1	10	0	1	13	9	1	17	6	2	1	3	2	5	0
10,000	1	9	2	1	13	4	1	17	6	2	1	8	2	5	10	2	10	0
11,000	1	12	1	1	16	8	2	1	3	2	5	10	2	10	5	2	15	0
12,000	1	15	0	2	0	0	2	5	0	2	10	0	2	15	0	3	0	0
13,000	1	17	11	2	3	4	2	8	9	2	14	2	2	19	7	3	5	0
14,000	2	0	10	2	6	8	2	12	6	2	18	4	3	4	2	3	10	0
15,000	2	3	9	2	10	0	2	16	3	3	2	6	3	8	9	3	15	0
16,000	2	6	8	2	13	4	3	0	0	3	6	8	3	13	4	4	0	0
17,000	2	9	7	2	16	8	3	3	9	3	10	10	3	17	11	4	5	0
18,000	2	12	6	3	0	0	3	7	6	3	15	0	4	2	6	4	10	0
19,000	2	15	5	3	3	4	3	11	3	3	19	2	4	7	1	4	15	0
20,000	2	18	4	3	6	8	3	15	0	4	3	4	4	11	8	5	0	0
30,000	4	7	6	5	0	0	5	12	6	6	5	0	6	17	6	7	10	0
40,000	5	16	8	6	13	4	7	10	0	8	6	8	9	3	4	10	0	0
50,000	7	5	10	8	6	8	9	7	6	10	8	4	11	9	2	12	10	0
60,000	8	15	0	10	0	0	11	5	0	12	10	0	13	15	0	15	0	0
70 000	10	4	2	11	13	4	13	2	6	14	11	8	16	0	10	17	10	0
80,000	11	13	4	13	6	8	15	0	0	16	13	4	18	6	8	20	0	0
90,000	13	2	6	15	0	0	16	17	6	18	15	0	20	12	6	22	10	0
100,000	14	11	8	16	13	4	18	15	0	20	16	8	22	18	4	25	0	0

TABLE V.

Price of Gas per 1,000 Cubic Feet at varying quantities per Penny and Shilling, for Prepayment Meters.

Number of Feet per Penny.	Equivalent Number of Feet per Shilling.	Price per 1,000 Feet (calculated to the nearest Penny). s.	d.
10	120	8	4
11	132	7	7
12	144	6	11
13	156	6	5
14	168	5	11
15	180	5	7
16	192	5	3
17	204	4	11
18	216	4	8
19	228	4	5
20	240	4	2
21	252	4	0
22	264	3	9
23	276	3	7
24	288	3	6
25	300	3	4
26	312	3	2
27	324	3	1
28	336	3	0
29	348	2	10
30	360	2	9

TABLE VI.

PRICES OF COKE, ¼ CWT. TO 10 TONS.

			10s.			*10s. 10d.*			*11s. 8d.*			*12s. 6d.*			*13s. 4d.*		
T.	C.	Q.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
0	0	1	0	0	1½	0	0	1⅝	0	0	1¾	0	0	1⅞	0	0	2
0	0	2	0	0	3	0	0	3¼	0	0	3½	0	0	3¾	0	0	4
0	0	3	0	0	4½	0	0	4⅞	0	0	5¼	0	0	5⅝	0	0	6
0	1	0	0	0	6	0	0	6½	0	0	7	0	0	7½	0	0	8
0	2	0	0	1	0	0	1	1	0	1	2	0	1	3	0	1	4
0	3	0	0	1	6	0	1	7½	0	1	9	0	1	10½	0	2	0
0	4	0	0	2	0	0	2	2	0	2	4	0	2	6	0	2	8
0	5	0	0	2	6	0	2	8½	0	2	11	0	3	1½	0	3	4
0	6	0	0	3	0	0	3	3	0	3	6	0	3	9	0	4	0
0	7	0	0	3	6	0	3	9½	0	4	1	0	4	4½	0	4	8
0	8	0	0	4	0	0	4	4	0	4	8	0	5	0	0	5	4
0	9	0	0	4	6	0	4	10½	0	5	3	0	5	7½	0	6	0
0	10	0	0	5	0	0	5	5	0	5	10	0	6	3	0	6	8
0	11	0	0	5	6	0	5	11½	0	6	5	0	6	10½	0	7	4
0	12	0	0	6	0	0	6	6	0	7	0	0	7	6	0	8	0
0	13	0	0	6	6	0	7	0½	0	7	7	0	8	1½	0	8	8
0	14	0	0	7	0	0	7	7	0	8	2	0	8	9	0	9	4
0	15	0	0	7	6	0	8	1½	0	8	9	0	9	4½	0	10	0
0	16	0	0	8	0	0	8	8	0	9	4	0	10	0	0	10	8
0	17	0	0	8	6	0	9	2½	0	9	11	0	10	7½	0	11	4
0	18	0	0	9	0	0	9	9	0	10	6	0	11	3	0	12	0
0	19	0	0	9	6	0	10	3½	0	11	1	0	11	10½	0	12	8
1	0	0	0	10	0	0	10	10	0	11	8	0	12	6	0	13	4
2	0	0	1	0	0	1	1	8	1	3	4	1	5	0	1	6	8
3	0	0	1	10	0	1	12	6	1	15	0	1	17	6	2	0	0
4	0	0	2	0	0	2	3	4	2	6	8	2	10	0	2	13	4
5	0	0	2	10	0	2	14	2	2	18	4	3	2	6	3	6	8
6	0	0	3	0	0	3	5	0	3	10	0	3	15	0	4	0	0
7	0	0	3	10	0	3	15	10	4	1	8	4	7	6	4	13	4
8	0	0	4	0	0	4	6	8	4	13	4	5	0	0	5	6	8
9	0	0	4	10	0	4	17	6	5	5	0	5	12	6	6	0	0
10	0	0	5	0	0	5	8	4	5	16	8	6	5	0	6	13	4

			14s. 2d.			*15s.*			*15s. 10d.*			*16s. 8d.*			*17s. 6d.*			*18s. 4d.*		
T.	C.	Q.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d	£	s.	d.	£	s.	d.
0	0	1	0	0	2⅛	0	0	2¼	0	0	2⅜	0	0	2½	0	0	2⅝	0	0	2¾
0	0	2	0	0	4¼	0	0	4½	0	0	4¾	0	0	5	0	0	5¼	0	0	5½
0	0	3	0	0	6⅜	0	0	6¾	0	0	7⅛	0	0	7½	0	0	7⅞	0	0	8¼
0	1	0	0	0	8½	0	0	9	0	0	9½	0	0	10	0	0	10½	0	0	11
0	2	0	0	1	5	0	1	6	0	1	7	0	1	8	0	1	9	0	1	10
0	3	0	0	2	1½	0	2	3	0	2	4½	0	2	6	0	2	7½	0	2	9
0	4	0	0	2	10	0	3	0	0	3	2	0	3	4	0	3	6	0	3	8
0	5	0	0	3	6½	0	3	9	0	3	11½	0	4	2	0	4	4½	0	4	7
0	6	0	0	4	3	0	4	6	0	4	9	0	5	0	0	5	3	0	5	6
0	7	0	0	4	11½	0	5	3	0	5	6½	0	5	10	0	6	1½	0	6	5
0	8	0	0	5	8	0	6	0	0	6	4	0	6	8	0	7	0	0	7	4
0	9	0	0	6	4½	0	6	9	0	7	1½	0	7	6	0	7	10½	0	8	3
0	10	0	0	7	1	0	7	6	0	7	11	0	8	4	0	8	9	0	9	2
0	11	0	0	7	9½	0	8	3	0	8	8½	0	9	2	0	9	7½	0	10	1
0	12	0	0	8	6	0	9	0	0	9	6	0	10	0	0	10	6	0	11	0
0	13	0	0	9	2½	0	9	9	0	10	3½	0	10	10	0	11	4½	0	11	11
0	14	0	0	9	11	0	10	6	0	11	1	0	11	8	0	12	3	0	12	10
0	15	0	0	10	7½	0	11	3	0	11	10½	0	12	6	0	13	1½	0	13	9
0	16	0	0	11	4	0	12	0	0	12	8	0	13	4	0	14	0	0	14	8
0	17	0	0	12	0½	0	12	9	0	13	5½	0	14	2	0	14	10½	0	15	7
0	18	0	0	12	9	0	13	6	0	14	3	0	15	0	0	15	9	0	16	6
0	19	0	0	13	5½	0	14	3	0	15	0½	0	15	10	0	16	7½	0	17	5
1	0	0	0	14	2	0	15	0	0	15	10	0	16	8	0	17	6	0	18	4
2	0	0	1	8	4	1	10	0	1	11	8	1	13	4	1	15	0	1	16	8
3	0	0	2	2	6	2	5	0	2	7	6	2	10	0	2	12	6	2	15	0
4	0	0	2	16	8	3	0	0	3	3	4	3	6	8	3	10	0	3	13	4
5	0	0	3	10	10	3	15	0	3	19	2	4	3	4	4	7	6	4	11	8
6	0	0	4	5	0	4	10	0	4	15	0	5	0	0	5	5	0	5	10	0
7	0	0	4	19	2	5	5	0	5	10	10	5	16	8	6	2	6	6	8	4
8	0	0	5	13	4	6	0	0	6	6	8	6	13	4	7	0	0	7	6	8
9	0	0	6	7	6	6	15	0	7	2	6	7	10	0	7	17	6	8	5	0
10	0	0	7	1	8	7	10	0	7	18	4	8	6	8	8	15	0	9	3	4

TABLE VII.

Quantities 1 to 100 at 3d. to 8d.

	At.			At.			At.			At.			At.			At.			At.			At.			At.			At.			At.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
1	0	0	3	0	0	3½	0	0	4	0	0	4½	0	0	5	0	0	5½	0	0	6	0	0	6½	0	0	7	0	0	7½	0	0	8
2	0	0	6	0	0	7	0	0	8	0	0	9	0	0	10	0	0	11	0	1	0	0	1	1	0	1	2	0	1	3	0	1	4
3	0	0	9	0	0	10½	0	1	0	0	1	1½	0	1	3	0	1	4½	0	1	6	0	1	7½	0	1	9	0	1	10½	0	2	0
4	0	1	0	0	1	2	0	1	4	0	1	6	0	1	8	0	1	10	0	2	0	0	2	2	0	2	4	0	2	6	0	2	8
5	0	1	3	0	1	5½	0	1	8	0	1	10½	0	2	1	0	2	3½	0	2	6	0	2	8½	0	2	11	0	3	1½	0	3	4
6	0	1	6	0	1	9	0	2	0	0	2	3	0	2	6	0	2	9	0	3	0	0	3	3	0	3	6	0	3	9	0	4	0
7	0	1	9	0	2	0½	0	2	4	0	2	7½	0	2	11	0	3	2½	0	3	6	0	3	9½	0	4	1	0	4	4½	0	4	8
8	0	2	0	0	2	4	0	2	8	0	3	0	0	3	4	0	3	8	0	4	0	0	4	4	0	4	8	0	5	0	0	5	4
9	0	2	3	0	2	7½	0	3	0	0	3	4½	0	3	9	0	4	1½	0	4	6	0	4	10½	0	5	3	0	5	7½	0	6	0
10	0	2	6	0	2	11	0	3	4	0	3	9	0	4	2	0	4	7	0	5	0	0	5	5	0	5	10	0	6	3	0	6	8
11	0	2	9	0	3	2½	0	3	8	0	4	1½	0	4	7	0	5	0½	0	5	6	0	5	11½	0	6	5	0	6	10½	0	7	4
12	0	3	0	0	3	6	0	4	0	0	4	6	0	5	0	0	5	6	0	6	0	0	6	6	0	7	0	0	7	6	0	8	0
13	0	3	3	0	3	9½	0	4	4	0	4	10½	0	5	5	0	5	11½	0	6	6	0	7	0½	0	7	7	0	8	1½	0	8	8
14	0	3	6	0	4	1	0	4	8	0	5	3	0	5	10	0	6	5	0	7	0	0	7	7	0	8	2	0	8	9	0	9	4
15	0	3	9	0	4	4½	0	5	0	0	5	7½	0	6	3	0	6	10½	0	7	6	0	8	1½	0	8	9	0	9	4½	0	10	0
16	0	4	0	0	4	8	0	5	4	0	6	0	0	6	8	0	7	4	0	8	0	0	8	8	0	9	4	0	10	0	0	10	8
17	0	4	3	0	4	11½	0	5	8	0	6	4½	0	7	1	0	7	9½	0	8	6	0	9	2½	0	9	11	0	10	7½	0	11	4
18	0	4	6	0	5	3	0	6	0	0	6	9	0	7	6	0	8	3	0	9	0	0	9	9	0	10	6	0	11	3	0	12	0
19	0	4	9	0	5	6½	0	6	4	0	7	1½	0	7	11	0	8	8½	0	9	6	0	10	3½	0	11	1	0	11	10½	0	12	8
20	0	5	0	0	5	10	0	6	8	0	7	6	0	8	4	0	9	2	0	10	0	0	10	10	0	11	8	0	12	6	0	13	4
30	0	7	6	0	8	9	0	10	0	0	11	3	0	12	6	0	13	9	0	15	0	0	16	3	0	17	6	0	18	9	1	0	0
40	0	10	0	0	11	8	0	13	4	0	15	0	0	16	8	0	18	4	1	0	0	1	1	8	1	3	4	1	5	0	1	6	8
50	0	12	6	0	14	7	0	16	8	0	18	9	1	0	10	1	2	11	1	5	0	1	7	1	1	9	2	1	11	3	1	13	4
60	0	15	0	0	17	6	1	0	0	1	3	0	1	5	0	1	7	6	1	10	0	1	12	6	1	15	0	1	17	6	2	0	0
70	0	17	6	1	0	5	1	3	4	1	6	9	1	9	2	1	12	1	1	15	0	1	17	11	2	0	10	2	3	9	2	6	8
80	1	0	0	1	3	4	1	6	8	1	10	0	1	13	4	1	16	8	2	0	0	2	3	4	2	6	8	2	10	0	2	13	4
90	1	2	6	1	6	3	1	10	0	1	13	9	1	17	6	2	1	3	2	5	0	2	8	9	2	12	6	2	16	3	3	0	0
100	1	5	0	1	9	2	1	13	4	1	17	6	2	1	8	2	5	10	2	10	0	2	14	2	2	18	4	3	2	6	3	6	8

TABLE VIII.

DISCOUNTS OR INTEREST.

			1¼ Per Cent.			2½ Per Cent.			5 Per Cent.						1¼ Per Cent.			2½ Per Cent.			5 Per Cent.		
£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
0	2	6	0	0	0⅜	0	0	0¾	0	0	1½	42	0	0	0	10	6	1	1	0	2	2	0
0	5	0	0	0	0¾	0	0	1½	0	0	3	43	0	0	0	10	9	1	1	6	2	3	0
0	7	6	0	0	1⅛	0	0	2¼	0	0	4½	44	0	0	0	11	0	1	2	0	2	4	0
0	10	0	0	0	1½	0	0	3	0	0	6	45	0	0	0	11	3	1	2	6	2	5	0
0	12	6	0	0	1⅞	0	0	3¾	0	0	7½	46	0	0	0	11	6	1	3	0	2	6	0
0	15	0	0	0	2¼	0	0	4½	0	0	9	47	0	0	0	11	9	1	3	6	2	7	0
0	17	6	0	0	2⅝	0	0	5¼	0	0	10½	48	0	0	0	12	0	1	4	0	2	8	0
1	0	0	0	0	3	0	0	6	0	1	0	49	0	0	0	12	3	1	4	6	2	9	0
2	0	0	0	0	6	0	1	0	0	2	0	50	0	0	0	12	6	1	5	0	2	10	0
3	0	0	0	0	9	0	1	6	0	3	0	51	0	0	0	12	9	1	5	6	2	11	0
4	0	0	0	1	0	0	2	0	0	4	0	52	0	0	0	13	0	1	6	0	2	12	0
5	0	0	0	1	3	0	2	6	0	5	0	53	0	0	0	13	3	1	6	6	2	13	0
6	0	0	0	1	6	0	3	0	0	6	0	54	0	0	0	13	6	1	7	0	2	14	0
7	0	0	0	1	9	0	3	6	0	7	0	55	0	0	0	13	9	1	7	6	2	15	0
8	0	0	0	2	0	0	4	0	0	8	0	56	0	0	0	14	0	1	8	0	2	16	0
9	0	0	0	2	3	0	4	6	0	9	0	57	0	0	0	14	3	1	8	6	2	17	0
10	0	0	0	2	6	0	5	0	0	10	0	58	0	0	0	14	6	1	9	0	2	18	0
11	0	0	0	2	9	0	5	6	0	11	0	59	0	0	0	14	9	1	9	6	2	19	0
12	0	0	0	3	0	0	6	0	0	12	0	60	0	0	0	15	0	1	10	0	3	0	0
13	0	0	0	3	3	0	6	6	0	13	0	61	0	0	0	15	3	1	10	6	3	1	0
14	0	0	0	3	6	0	7	0	0	14	0	62	0	0	0	15	6	1	11	0	3	2	0
15	0	0	0	3	9	0	7	6	0	15	0	63	0	0	0	15	9	1	11	6	3	3	0
16	0	0	0	4	0	0	8	0	0	16	0	64	0	0	0	16	0	1	12	0	3	4	0
17	0	0	0	4	3	0	8	6	0	17	0	65	0	0	0	16	3	1	12	6	3	5	0
18	0	0	0	4	6	0	9	0	0	18	0	66	0	0	0	16	6	1	13	0	3	6	0
19	0	0	0	4	9	0	9	6	0	19	0	67	0	0	0	16	9	1	13	6	3	7	0
20	0	0	0	5	0	0	10	0	1	0	0	68	0	0	0	17	0	1	14	0	3	8	0
21	0	0	0	5	3	0	10	6	1	1	0	69	0	0	0	17	3	1	14	6	3	9	0
22	0	0	0	5	6	0	11	0	1	2	0	70	0	0	0	17	6	1	15	0	3	10	0
23	0	0	0	5	9	0	11	6	1	3	0	71	0	0	0	17	9	1	15	6	3	11	0
24	0	0	0	6	0	0	12	0	1	4	0	72	0	0	0	18	0	1	16	0	3	12	0
25	0	0	0	6	3	0	12	6	1	5	0	73	0	0	0	18	3	1	16	6	3	13	0
26	0	0	0	6	6	0	13	0	1	6	0	74	0	0	0	18	6	1	17	0	3	14	0
27	0	0	0	6	9	0	13	6	1	7	0	75	0	0	0	18	9	1	17	6	3	15	0
28	0	0	0	7	0	0	14	0	1	8	0	76	0	0	0	19	0	1	18	0	3	16	0
29	0	0	0	7	3	0	14	6	1	9	0	77	0	0	0	19	3	1	18	6	3	17	0
30	0	0	0	7	6	0	15	0	1	10	0	78	0	0	0	19	6	1	19	0	3	18	0
31	0	0	0	7	9	0	15	6	1	11	0	79	0	0	0	19	9	1	19	6	3	19	0
32	0	0	0	8	0	0	16	0	1	12	0	80	0	0	1	0	0	2	0	0	4	0	0
33	0	0	0	8	3	0	16	6	1	13	0	81	0	0	1	0	3	2	0	6	4	1	0
34	0	0	0	8	6	0	17	0	1	14	0	82	0	0	1	0	6	2	1	0	4	2	0
35	0	0	0	8	9	0	17	6	1	15	0	83	0	0	1	0	9	2	1	6	4	3	0
36	0	0	0	9	0	0	18	0	1	16	0	84	0	0	1	1	0	2	2	0	4	4	0
37	0	0	0	9	3	0	18	6	1	17	0	85	0	0	1	1	3	2	2	6	4	5	0
38	0	0	0	9	6	0	19	0	1	18	0	86	0	0	1	1	6	2	3	0	4	6	0
39	0	0	0	9	9	0	19	6	1	19	0	87	0	0	1	1	9	2	3	6	4	7	0
40	0	0	0	10	0	1	0	0	2	0	0	88	0	0	1	2	0	2	4	0	4	8	0
41	0	0	0	10	3	1	0	6	2	1	0	89	0	0	1	2	3	2	4	6	4	9	0

TABLE VIII.—(*continued*).

DISCOUNTS OR INTEREST.

			1¼ Per Cent.			2½ Per Cent.			5 Per Cent.						1¼ Per Cent.			2½ Per Cent.			5 Per Cent		
£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
90	0	0	1	2	6	2	5	0	4	10	0	96	0	0	1	4	0	2	8	0	4	16	0
91	0	0	1	2	9	2	5	6	4	11	0	97	0	0	1	4	3	2	8	6	4	17	0
92	0	0	1	3	0	2	6	0	4	12	0	98	0	0	1	4	6	2	9	0	4	18	0
93	0	0	1	3	3	2	6	6	4	13	0	99	0	0	1	4	9	2	9	6	4	19	0
94	0	0	1	3	6	2	7	0	4	14	0	100	0	0	1	5	0	2	10	0	5	0	0
95	0	0	1	3	9	2	7	6	4	15	0												

TABLE IX.

CIRCLES.

Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.
1	3·1416	0·7854	34	106·814	907·922	68	213·628	3631·68
2	6·2832	3·1416	35	109·956	962·115	69	216·770	3739·28
3	9·4248	7·0686	36	113·097	1017·87	70	219·912	3848·46
4	12·566	12·566	37	116·239	1075·21	71	223·053	3959·20
5	15·708	19·635	38	119·380	1134·11	72	226·195	4071·51
6	18·849	28·274	39	122·522	1194·59	73	229·336	4185·39
7	21·991	38·484	40	125·664	1256·64	74	232·478	4300·85
8	25·132	50·265	41	128·805	1320·25	75	235·620	4417·87
9	28·274	63·617	42	131·947	1385·44	76	238·761	4536·47
10	31·416	78·540	43	135·088	1452·20	77	241·903	4656·63
11	34·557	95·033	44	138·230	1520·53	78	245·044	4778·37
12	37·699	113·097	45	141·372	1590·43	79	248·186	4901·68
13	40·840	132·732	46	144·513	1661·90	80	251·328	5026·56
14	43·982	153·938	47	147·655	1734·94	81	254·469	5153·00
15	47·124	176·715	48	150·796	1809·56	82	257·611	5281·02
16	50·265	201·062	49	153·938	1885·74	83	260·752	5410·62
17	53·407	226·980	50	157·080	1963·50	84	263·894	5541·78
18	56·548	254·469	51	160·221	2042·82	85	267·036	5674·51
19	59·690	283·529	52	163·363	2123·72	86	270·177	5808·81
20	62·832	314·160	53	166·504	2206·18	87	273·319	5944·69
21	65·973	346·361	54	169·646	2290·22	88	276·460	6082·13
22	69·115	380·133	55	172·788	2375·83	89	279·602	6221·15
23	72·256	415·476	56	175·929	2463·01	90	282·744	6361·74
24	75·398	452·390	57	179·071	2551·76	91	285·885	6503·89
25	78·540	490·875	58	182·212	2642·08	92	289·027	6647·62
26	81·681	530·930	59	185·354	2733·97	93	292·168	6792·92
27	84·283	572·556	60	188·496	2827·44	94	295·310	6939·79
28	87·964	615·753	61	191·637	2922·47	95	298·452	7088·23
29	91·106	660·521	62	194·779	3019·07	96	301·593	7238·24
30	94·248	706·860	63	197·920	3117·25	97	304·735	7389·82
31	97·389	754·769	64	201·062	3216·99	98	307·876	7542·98
32	100·531	804·249	65	204·204	3318·31	99	311·018	7697·70
33	103·672	855·300	66	207·345	3421·20	100	314·160	7854·00
			67	210·487	3525·66			

TABLE X.

Percentage of Pure Sulphuric Acid, H_2SO_4, as represented by various Specific Gravities of the Solution. Water = 1.

Specific Gravity.	°Twaddel.	Per Cent.	Specific Gravity.	°Twaddel.	Per Cent.
1·8426	168	100	1·615	123	70
1·842	168	99	1·604	121	69
1·8406	168	98	1·592	119	68
1·840	168	97	1·580	116	67
1·8384	168	96	1·568	114	66
1·8376	167	95	1·557	111	65
1·8356	167	94	1·545	109	64
1·834	167	93	1·534	107	63
1·831	166	92	1·523	105	62
1·827	165	91	1·512	102	61
1·822	164	90	1·501	100	60
1·816	163	89	1·490	98	59
1·809	162	88	1·480	96	58
1·802	160	87	1·469	94	57
1·794	159	86	1·459	92	56
1·786	157	85	1·448	90	55
1·777	155	84	1·438	88	54
1·767	153	83	1·428	86	53
1·756	151	82	1·418	84	52
1·745	149	81	1·408	82	51
1·734	147	80	1·398	80	50
1·722	144	79	1·389	78	49
1·710	142	78	1·379	76	48
1·698	140	77	1·370	74	47
1·686	138	76	1·361	72	46
1·675	135	75	1·351	70	45
1·663	133	74	1·342	68	44
1·651	131	73	1·333	67	43
1·639	128	72	1·324	65	42
1·627	125	71	1·315	63	41

TABLE XI.

Specific Gravity of Solutions of Sulphate of Ammonia.

Per Cent.	Specific Gravity.	° Twaddel.	Per Cent.	Specific Gravity.	° Twaddel.
10	1·0575	11·15	36	1·2060	41·2
11	1·0632	12·6	37	1·2116	42·3
12	1·0690	13·8	38	1·2172	43·4
13	1·0747	15·0	39	1·2228	44·6
14	1·0805	16·0	40	1·2284	45·8
15	1·0862	17·2	41	1·2343	46·9
16	1·0920	18·4	42	1·2402	48·0
17	1·0977	19·5	43	1·2462	49·2
18	1·1035	20·7	44	1·2522	50·4
19	1·1092	22·0	45	1·2583	51·7
20	1·1149	23·0	46	1·2644	52·9
21	1·1207	24·1	47	1·2705	54·1
22	1·1265	25·3	48	1·2766	55·3
23	1·1323	26·4	49	1·2827	56·5
24	1·1381	27·6	50	1·2888	57·7
25	1·1439	28·7	51	1·2948	59·0
26	1·1496	29·9	52	1·3008	60·2
27	1·1554	31·1	53	1·3066	61·3
28	1·1612	32·2	54	1·3124	62·5
29	1·1670	33·4	55	1·3182	63·6
30	1·1724	34·5	56	1·3240	64·8
31	1·1780	35·6	57	1·32[illegible]8	65·9
32	1·1836	36·7	58	1·3356	67·0
33	1·1892	37·8	59	1·3410	68·2
34	1·1948	39·0	60	1·3464	69·3
35	1·2004	40·1			

TABLE XII.

Cubic Feet of Gas Discharged Per Hour Through Pipes of Various Diameters and Lengths at a Pressure of 4-tenths.

Length, in Feet.	Internal Diameter, in Inches.										
	¼	5/16	⅜	½	⅝	¾	1	1¼	1½	1¾	2
20	16	28	45	92	161	254	522	913	1,440	2,118	2,957
40	11	20	32	65	114	180	369	645	1,018	1,497	2,090
60	9	16	26	53	93	147	302	527	832	1,223	1,707
80	8	14	22	46	80	127	261	456	720	1,059	1,478
100	7	12	20	41	72	114	233	408	644	947	1,322
125	6	11	18	37	64	101	209	365	576	847	1,184
150	6	10	16	33	58	93	190	334	528	773	1,080
175		9	15	31	54	86	176	308	487	716	1,000
200		9	14	29	51	80	165	288	455	669	935
250			12	26	46	72	147	258	407	599	836
300				24	41	65	135	236	374	547	762
450				19	34	53	110	192	304	446	623
600					29	46	95	160	264	386	540
900					24	38	77	136	215	315	441

ACTUAL COSTS AND CAPACITY OF RECENTLY ERECTED GASWORKS.

By J. H. BREARLEY.

ACTUAL COSTS AND CAPACITY OF RECENTLY ERECTED GASWORKS.

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IN introducing these notes on the actual costs of gasworks, the writer would pay a tribute to the excellent articles contributed to THE GAS WORLD by Mr. Norton H. Humphrys, and now reproduced, together with much additional matter, for which Mr. Humphrys is responsible. Only close observation and practice extending over a large number of years could have resulted in bringing together so much extremely useful advice. The figures and other particulars which the writer gives in the subsequent pages relate to small works which were erected between 1907 and 1910. They may form an acceptable supplement to what Mr. Humphrys has written upon the construction and management of small works, though the notes refer to works larger than those which he had chiefly in mind, and were designed and erected to supply rapidly growing communities in the neighbourhood of new colliery shafts.

The problem of what the capacity of the works should be was difficult of solution, especially as dame rumour was busy asserting that other pit shafts within the contemplated area of supply were about to be sunk. It was deemed prudent to look at least ten years ahead, but the data to work upon was only such as to lead, at best, to conclusions that did not carry a strong sense of conviction that the forecasting would be quite correct.

Works No. 1.

The contracts for these works were let on 2nd May, and the undertaking commenced to supply gas on 12th October.

Site.—The site is close to the railway, and although the works are designed with a view to constructing a siding in the near future, supplies inwards and outwards are at

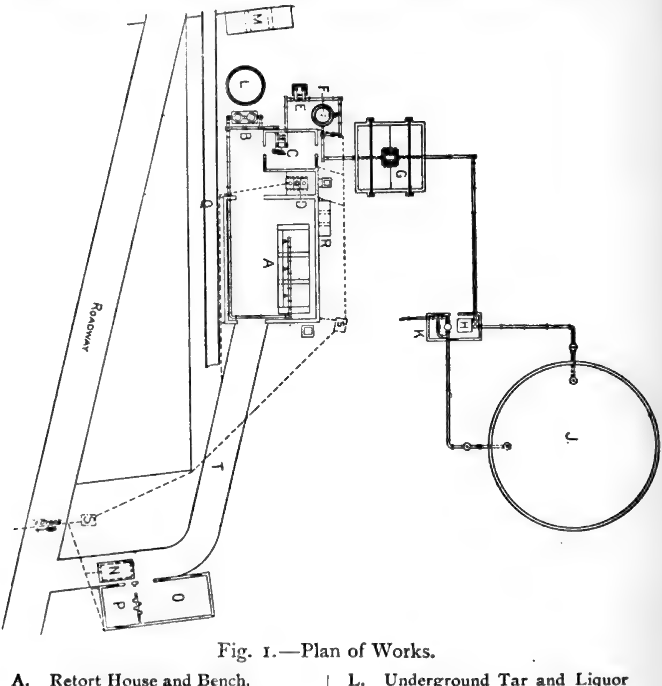


Fig. 1.—Plan of Works.

A. Retort House and Bench.
B. Condensers.
C. Exhauster House and Exhauster.
D. Boiler and Seating.
E. Livesey Washer.
F. Tower Scrubber.
G. Purifiers.
H. Station Meter.
J. Gasholder.
K. Governor.
L. Underground Tar and Liquor Tank.
M. Overhead Tar and Liquor Tank.
N. Weighbridge.
O. Showroom and Fitting Shop.
P. Office.
Q. Railway Siding.
R. Water Storage Tank.
S. Drainage Inspection Chambers.
T. Cart Road.

- - - - - - - Drainage.

present dealt with at a private siding close by, which was utilized, also, during the course of erection. The area of the site is 1 acre, and it is about midway between the two villages which form the principal supply area. Cost, £500.

Retort house.—Dimensions :—Length, 45 feet; width, 32 feet; height to eaves, 18 feet, and to apex, 29 feet. One side and half of each gable is carried 8 feet below the present floor level. Under the whole of the four walls

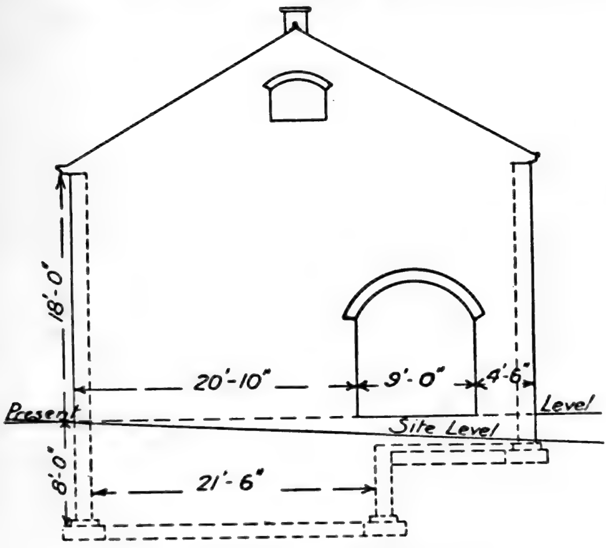


Fig. 2.—Retort House: End Elevation.

is provided a concrete foundation, 2 feet wide, and 12 inches thick, upon which is built two courses of footings, each 18 inches wide, and walls 14 inches thick. The walls are formed of good quality red bricks. In the four walls, twelve openings are left, 4 feet by 2 feet, with arch of two courses, three upper ones on each side, four lower ones on one side, to facilitate unloading of coal waggons in future, and one in each gable. In addition, there is an opening at each end for cart traffic, each 9 feet wide by 6 feet, to spring of semi-circular arch. These openings are finished off with bull-nosed bricks.

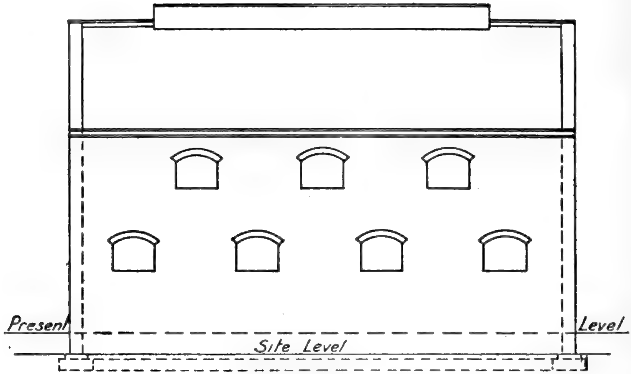


Fig. 3.—Retort House: Longitudinal Elevation.

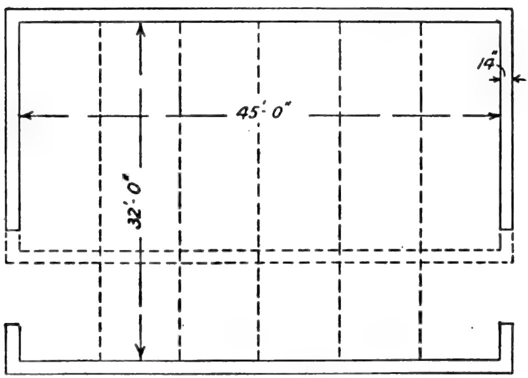


Fig. 4.—Retort House: Plan.

Retort house roof.—The roof consists of five steel principals, each set at 7 feet 6-inch centres. At the apex of the roof, an opening is left, and a ventilator, of steel plate,

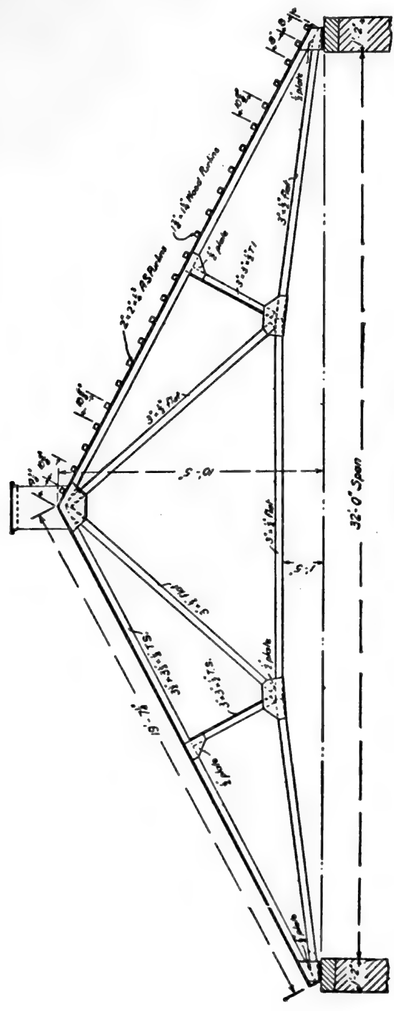


Fig. 5.—Retort House Roof.

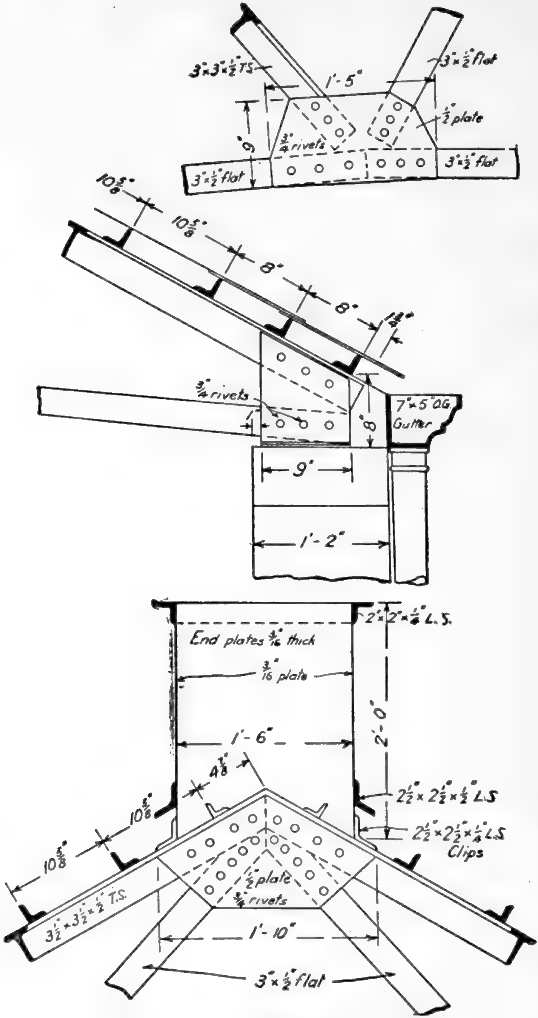


Fig. 6.—Retort House Roof: Details.

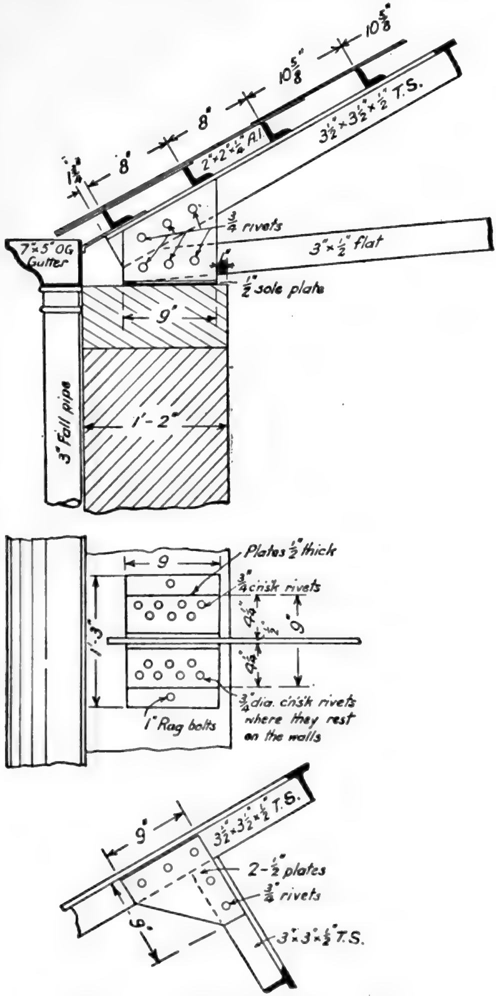


Fig 7.—Retort House Roof: Details.

constructed 2 feet wide by 30 feet long, as shown. The principals are formed of 3½-inch by 3½-inch by ½-inch T-steel, with tie rods and diagonals, 3-inch by ½-inch flat, and 3-inch by 3-inch by ½-inch T-steel, respectively. To the 2-inch by 2-inch by ¼-inch angle steel purlins of the roof are secured 1⅞-inch by 1¼-inch wood purlins, with ⅜-inch bolts. To these are fastened, with copper nails, Welsh seconds slates, laid with 4-inch lap. Along the ridge at each end of ventilator blue Staffordshire tiles are laid. Upon each gable a course of 14-inch by 3-inch tabling is firmly laid. Inclusive cost of retort house and roof, £400.

Retort bench.—The retort bench consists of three arches, but only two are completed, each having six retorts, and regenerative settings. Over the whole of the area, and projecting 12 inches beyond, a foundation of 12 inches of concrete was provided. The regenerative portion extends for a distance of 8 feet from the retort house floor level to the top of concrete foundation. The two filled arches are 7 feet 9 inches and the empty one 8 feet 6 inches wide, and 11 feet 7 inches from front to back. The inside pier walls are 1 foot 6 inches, and the end walls 2 feet 3 inches thick. Only fire-bricks of approved quality were used, except above the two 4½-inch rings which form the arches. The twelve retorts are 22-inch by 16-inch by 10-feet, ◠-shaped.

Upon a concrete foundation, 3 feet thick, and projecting 12 inches on each side, a chimney is erected, outside the retort house, being connected to the main flue through an arch left in the retort house wall for that purpose. There is a cleaning-out door in the base of the chimney. The barrel of the chimney is 2 feet 3 inches square, the walls being 14 inches thick, of which 4½ inches on the inside is composed of fire-bricks, the remainder being good quality red bricks. The inside headers are of fire-bricks. The fire-bricks and red bricks were selected so as to be as nearly as possible of the same size. The height of chimney, from top of foundation, is 45 feet 6 inches.

At the front of the bench a subway is formed, 7 feet wide, and extends the full length of the retort house. The space between the bench and the gable wall was excavated, and covered with steel girders, 8 inches by 6 inches, and concrete floor. In the empty arch, a 9-inch wall is built of fire-brick for a height of 12 feet from the concrete, to act as a stiffener, when the two complete settings are at work. The subway wall is formed of red brick, 14 inches thick The eight bearers for subway roof are 6-inch by 5-inch steel joists, covered in with $\frac{3}{8}$-inch steel chequer plates, the outside plates being fastened with countersunk bolts, and the centre plate in front of each setting left movable, for clinkering purposes. The contractor provided a rail in the subway floor and a corve, 3 feet by 2 feet by 1 foot 6 inches, for the purpose of elevating clinkers from the subway to the retort house floor level. For elevating these, Morris and Bastard's patent blocks, to carry 10 cwts., and a steel joist, 6 inches by 5 inches, fixed into the retort house wall, and projecting 11 feet 6 inches into the retort house, were supplied. A ladder, for access to the subway, is also provided.

The four front and four back buckstays are 8 inches by 6 inches, carried to the bottom of the bench, and fixed in cast-iron shoes, firmly bolted to the concrete. The six end buckstays are 10 inches by 6 inches, and secured in a similar manner. Flat eyes are riveted at the top ends, to receive the three $1\frac{1}{2}$-inch diameter tie rods, which are fitted with coupling boxes. The four cross girders are 6 inches by 5 inches, of H-steel section, drilled at each end, and secured to the buckstays with angle-iron brackets. The mouthpieces are self-sealing. The ascension pipes, bends, arch and dip pipes are 6 inches diameter and $\frac{1}{2}$ inch thick. The hydraulic main is formed of mild steel plates and angles, 22 inches by 22 inches, U-shaped, the bottom being $\frac{1}{4}$ inch thick, the top and end plates $\frac{3}{8}$ inch thick, the top angles 3 inches by 3 inches by $\frac{3}{8}$ inches, and the end angles 3 inches by 3 inches by $\frac{1}{2}$-inch, with butt straps of $4\frac{1}{2}$ inches by $\frac{3}{8}$-inch flat, all riveted up with $\frac{3}{8}$-inch diameter rivets, 2-inch pitch. In each section, two handholes are provided, for cleaning. Cast-iron stands support the hydraulic main from the cross joists. The foul main is 9 inches diameter, and fitted with separate valves

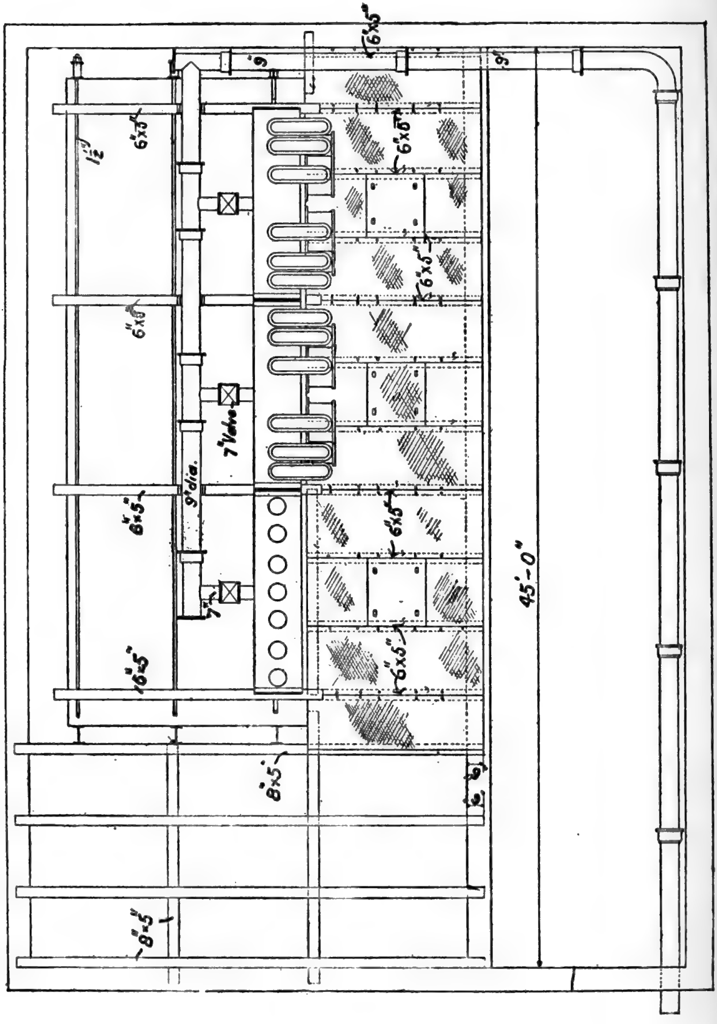


Fig. 8. —Retort Bench : Plan.

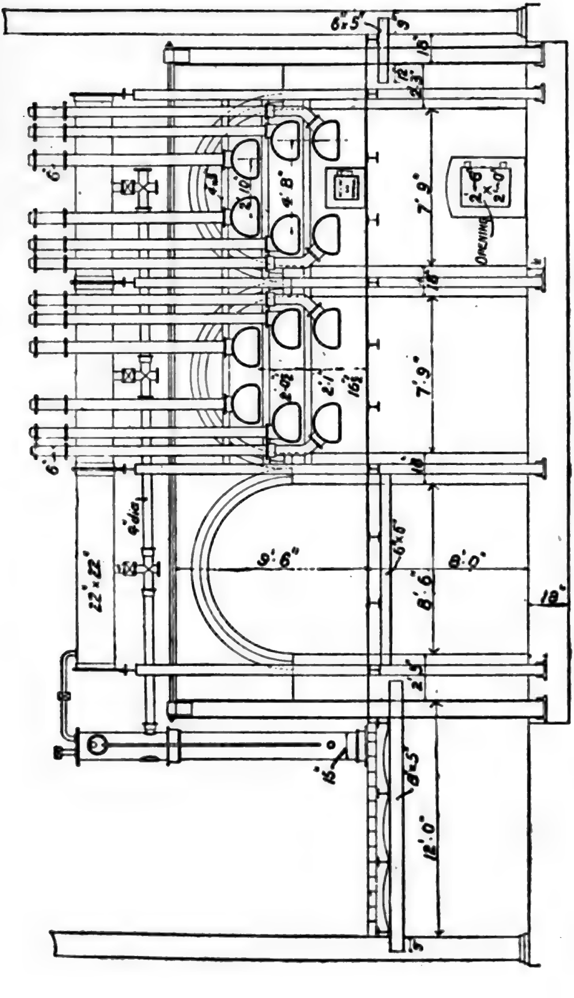


Fig. 9.—Retort Bench: Elevation.

for each bed. It is supported on the cross girders with cast-iron stands and carried round the retort house wall on suitable brackets. 4-inch tar pipes are supplied, and fixed to the underside of each hydraulic, and continued to a 15-inch tar tower. The latter is fitted up complete with ½-inch liquor feed pipe and valve, 2-inch

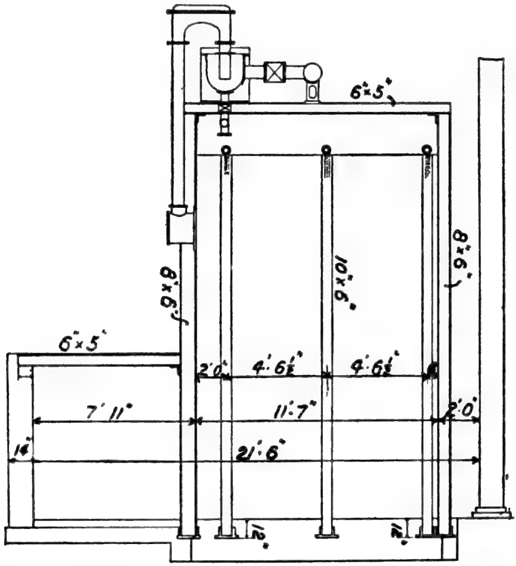


Fig. 10.—Retort Bench: End Elevation.

vacuum pipe and valve, 2-inch sealed overflow pipe, run off pipe, valve and handhole.

The two regenerative settings are capable of making 96,000 cubic feet of gas per day, or the equivalent of 19,200,000 cubic feet per annum, on the basis of 200 times the full producing capacity. Conceding that a 10 per cent. margin is needed, the capacity is still equal to 17,500,000 cubic feet per annum. With a setting placed in the empty arch, the capacity of the existing bench will be over 26,000,000 cubic feet. There is room for another setting of, say, eight retorts, and the capacity

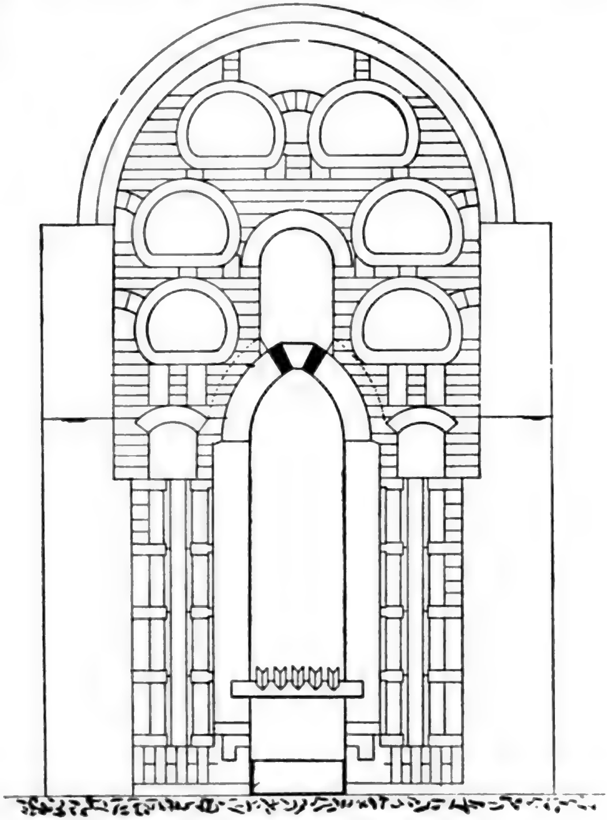


Fig. 11.—Regenerator: Elevation.

of the whole retort house may then be taken at approximately 40,000,000 cubic feet. The space which is now left at the end of the present bench is used for coal storage, for which purpose much provision is unnecessary,

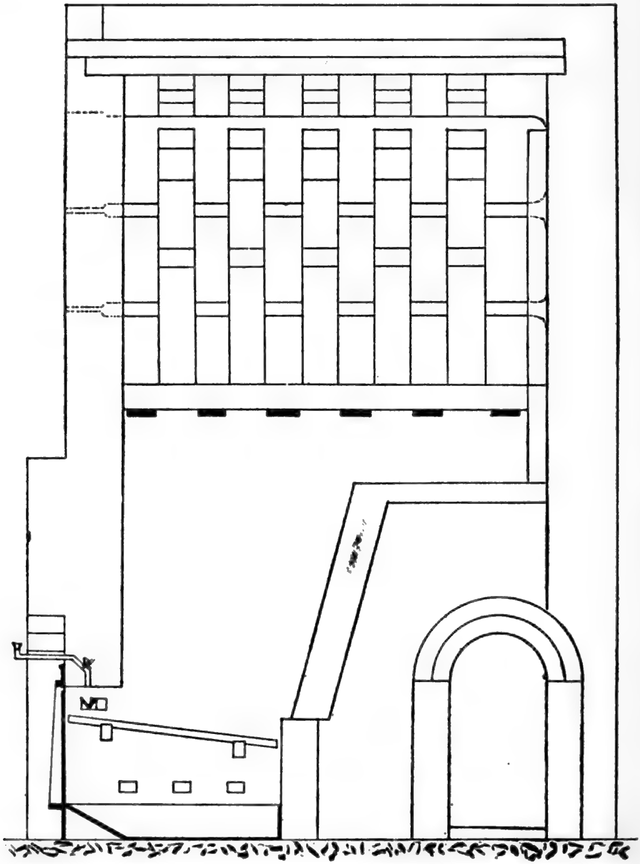
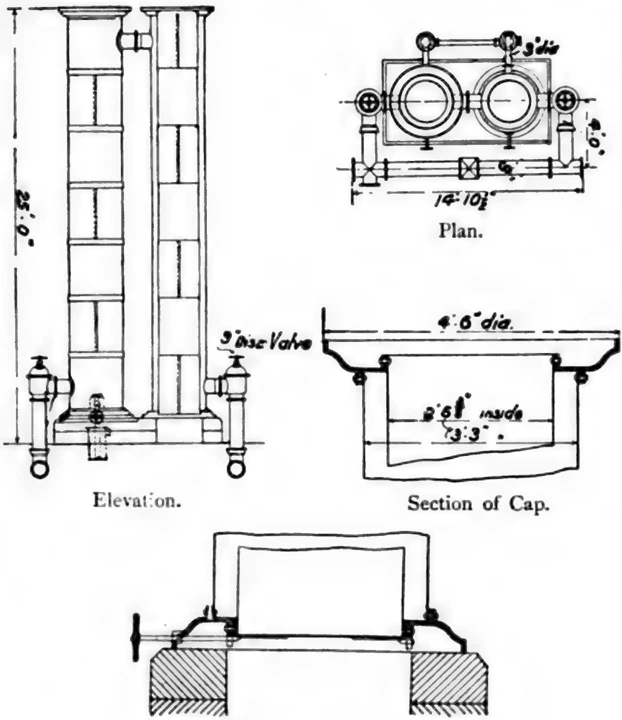


Fig. 12.—Regenerator: Section.

owing to the works being in the heart of a gas coal area. Should the space be used in future for carbonizing purposes, it will be necessary to provide storage accommodation elsewhere.

Cost of retort bench, including all ironwork, foul main running the full length of one side and one gable of retort house, chimney, covering 12 feet excavated space between bench and gable wall and subway, £770.

Condensers.—These are two in number, of the annular type, each 25 feet high, outer tubes 3 feet 3 inches diameter and inner tubes 2 feet 6 inches diameter. They



Elevation.

Plan.

Section of Cap.

Section of Base.

Fig. 13.—Condensers.

are complete with 9-inch connections, two 9-inch disc valves, one 9-inch rack valve, and by-pass. The tubes are of $\frac{3}{16}$-inch steel plates, the outer tubes having vertical lap joints and horizontal butt joints, with cover straps, $4\frac{1}{2}$ inches by $\frac{1}{4}$ inch. All the joints of the inner tubes are lapped. Cast-iron mouldings of heavy design connect the inner and outer tubes at the top and bottom, respectively. Each condenser is provided with saddle branches, 9 inches diameter, 5 inches by 3 inches rectangular opening tapering to 3 inches diameter for tar outlet, and cleaning-out doors fitted with cross-bar, screw and lug. Each tar pipe or outlet is bolted to a drop pipe, 3 inches diameter, sealing in a pot, 12 inches diameter by 18 inches deep, the pots being coupled to each other, and one provided with overflow socket for connecting up with tar well in the usual manner. A wing valve, mounted on a spindle, and fitted with hand wheel in front, is fitted at the bottom of each inner tube, for the purpose of regulating the quantity of air passing up. Two dial thermometers are fixed, one in the inlet and another in the outlet pipe.

These condensers provide 900 square feet of condensing surface. The 9-inch foul main from hydraulic to condensers gives a further 230 square feet. Taking as the required capacity the generous factor of 7 square feet per thousand cubic feet of gas made per diem, the total condensing area is equal to a daily make of 160,000 cubic feet, or 32,000,000 cubic feet per annum. Cost, including excavation and foundations, £122.

Exhauster house.—The dimensions of this building are 14 feet by 18 feet 6 inches by 8 feet to eaves. A foundation of concrete, 9 inches thick and 1 foot 6 inches wide, is formed under the four walls, with one footing course of bricks, 14 inches wide. The walls are 9 inches thick. The roof is of wood, and covered with Welsh slates (seconds), surmounted with Staffordshire blue ridge tiles. The floor is boarded, and provision made for ready access to all the connections, gas, steam, tar, etc. Sketches of the building are given in Figs. 14 to 18. Cost of house complete, £54.

Exhauster.—The exhauster is of the rotary type, steam driven, and is capable of passing 7,500 cubic feet per hour, at a speed of 90 revolutions per minute, against a gas pressure of 20 inches water column. The capacity is, therefore, equal to a daily make of 180,000 cubic feet, or 36,000,000

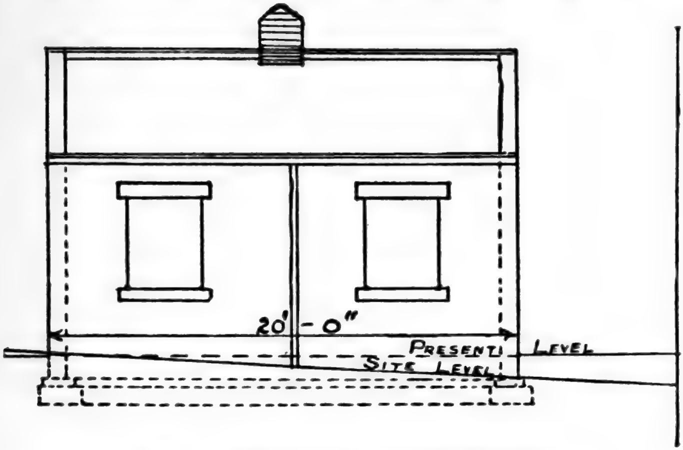


Fig. 14.—Exhauster House: Side Elevation.

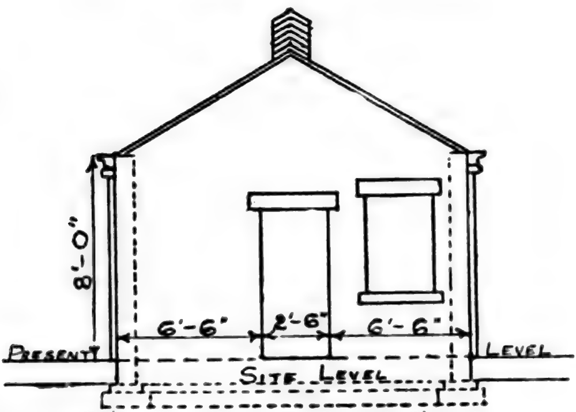


Fig. 15.—Exhauster House: End Elevation.

cubic feet per annum. Including the accessories—horizontal steam engine, base plate, two screw-down disc

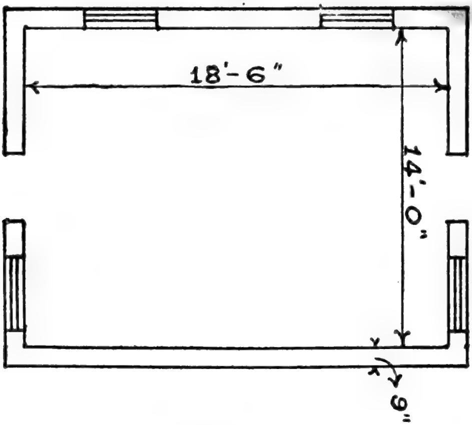


Fig. 16.—Exhauster House: Plan.

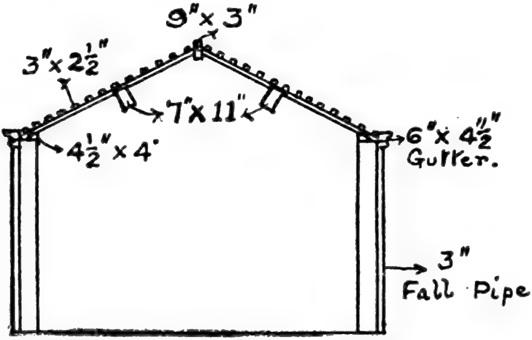


Fig. 17.—Exhauster House: Roof Cross Section.

valves, hydraulic regulator, gas governor, self-acting by-pass valve, and all usual fittings and foundations complete—the cost was £142.

Pumps.—There are two pumps. The largest has a steam cylinder diameter of 5½ inches, ram 3½ inches, and 8-inch stroke. It is used for pumping from underground to overhead tar tank, and for pumping to tar tower. The small pump has a cylinder diameter of 4½ inches, ram 3 inches, and length of stroke 6 inches. This is used for pumping water from stream to overhead storage tank, water

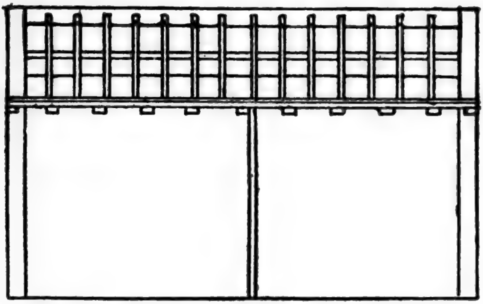


Fig. 18.—Exhauster House: Roof Elevation.

to top of scrubber, and liquor to a distributor fixed half-way up scrubber.

Gauges.—A set of aluminium gauges, in mahogany case, is fixed in the exhauster house, and connected to the inlets of condensers, exhauster, scrubber, purifiers and station meter. A jet photometer is also fixed. Cost of pump, gauges, photometer and connections, £102.

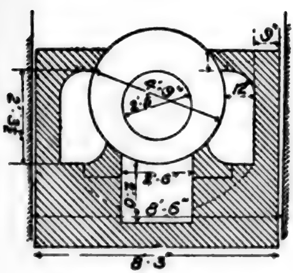


Fig. 19.—Boiler Seating. Cross Section.

Steam boiler.—Between the retort house and the exhauster house is erected a Cornish boiler, measuring 12 feet by 4 feet 9 inches with a 2 feet 5-inch firebox and giving about 14 nominal horse-power at 60 lbs. working pressure. The dimensions of seating and other particulars are shown on sketches. Cost of boiler (not quite new), seating and chimney, £113.

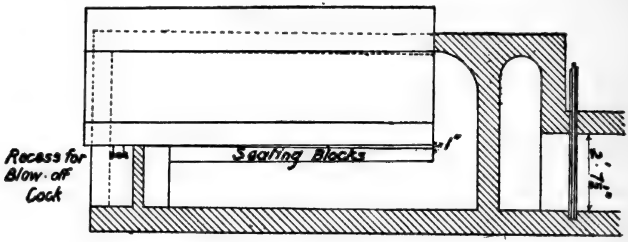


Fig. 20.—Boiler Seating: Longitudinal Section.

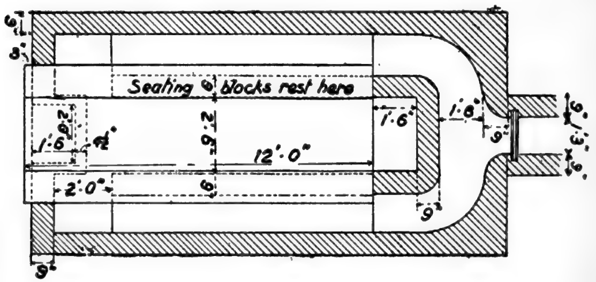
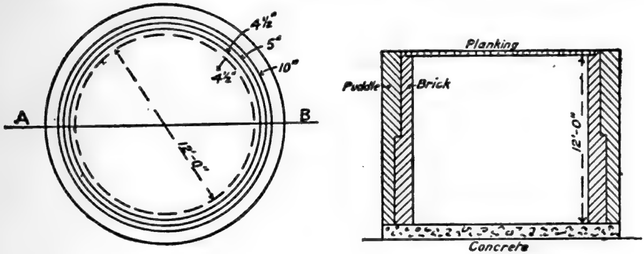


Fig. 21.—Boiler Seating: Plan.

Storage tanks.—For the purpose of collecting the tar and liquor from the various syphons and run-offs, a circular underground brick tank was built, the inside measurements being 12 feet by 12 feet. For 6 feet in height, the tank wall is 14 inches thick, and the remainder 9 inches thick. An area 16 feet diameter was first excavated, and over the whole area concrete to the depth of 12 inches was laid. A backing of puddle not less than 12 inches thick is well worked in behind the tank wall. Capacity, 8,400 gallons.

An overhead tar and liquor storage tank to the dimensions given on sketch is provided. It was fixed at this height in order to be able to load tank waggons outwards by gravitation, pending the formation of a siding. A 3-inch cast-iron pipe is carried from this tank for a distance of



Plan. Section.

Fig. 22.—Underground Tar and Liquor Tank.

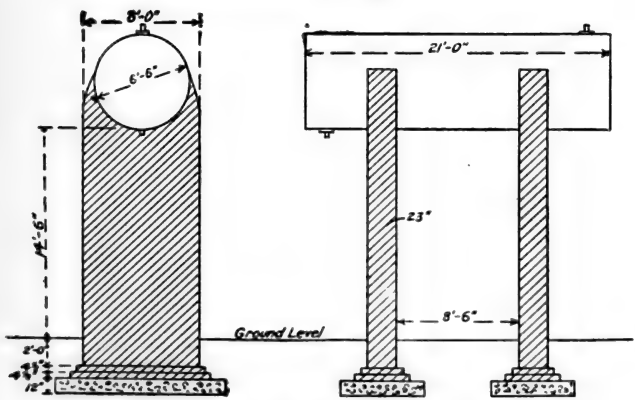


Fig. 23.—Overhead Tar and Liquor Tank.

318 feet, to fill tanks at a neighbouring siding. Capacity, 4,300 gallons.

An overhead tank (Fig. 24) is provided for water storage, and is fixed close to the boiler and the retort house, where the principal water supply is needed. The water is pumped into this tank through a $1\frac{1}{2}$-inch wrought-iron pipe, from a brook 280 feet away. Capacity, 1,200 gallons. Cost of above tanks and foundations, £156.

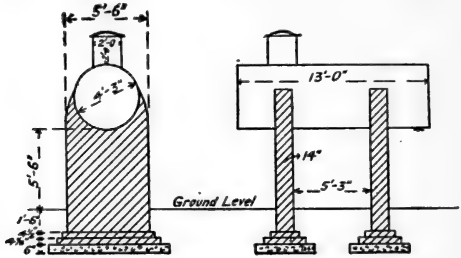
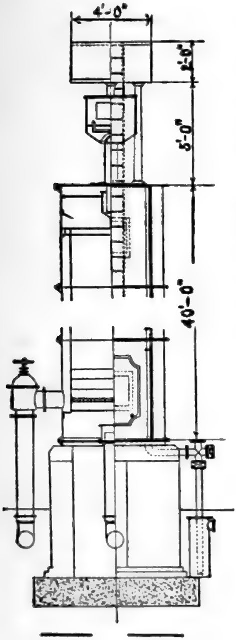


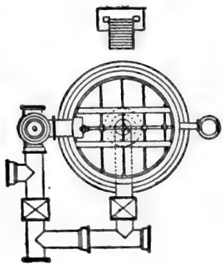
Fig. 24.—Overhead Water Tank.

Livesey washer.—Upon a concrete foundation, 9 inches thick, is fixed a Livesey washer, with 9-inch connections, valves, and by-pass main. The inside dimensions are 2 feet 6 inches by 4 feet by 2 feet 11 inches. It is so placed that the liquor can be run from the base of the scrubber by gravitation, the flow being regulated to suit the strength of liquor required. Cost, including foundations, £53.

Tower scrubber.—The scrubber is of cast-iron, 40 feet high by 5 feet diameter. It is provided with 9-inch connections, valves and by-pass. It was specified that the side plates should be not less than $\frac{3}{4}$ inch thick, with faced flanges $3\frac{1}{2}$ inches wide, bracketed between the bolt holes, bolted together with $\frac{5}{8}$-inch bolts at 6-inch centres. Manholes are provided in the first, third, fifth and eighth tiers of the scrubber, each 1 foot 6 inches square. Each plate has a neat ornamental moulding. A self-acting water distributor is fixed at the top, with revolving spreader, and tippler balanced to tipple two gallons of water at a time. Above this is a wrought-iron tank, 4 feet diameter by 2 feet deep, supported on three cast-iron columns, and fitted with quadrant cock for delivering water to the tippler. Midway up the scrubber is fixed an intermediate liquor distributor. A wrought-iron ladder of strong design is attached for access to the top. The interior of the scrubber is fitted with boards, each $\frac{3}{8}$ inch thick, at $\frac{1}{2}$ inch spaces. All castings were specified to be of the best close grey iron, and free from flaws of any description. Two coats of paint were specified, one at the contractor's works, after inspection by the engineer, and the other after erection.

Clean water is pumped to the small storage tank at the top, and weak liquor from the underground storage tank to the intermediate distributor. The gas, therefore, first passes through the strong liquor in the Livesey washer, then through the weak liquor in the lower portion of the scrubber, and finally through the clean water portion at the top.





Section. Elevation. Plan.

Fig. 25.—Tower Scrubber.

Opinion varies greatly as to what is the proper capacity of scrubbing plant, and, doubtless, it greatly depends upon the arrangement at work. As arranged here, the writer has no doubt that a time contact of ten minutes from entering Livesey washer to leaving scrubber at period of maximum make would be sufficient to thoroughly cleanse the gas from ammonia, and also extract a considerable proportion of the carbonic acid and sulphuretted hydrogen. On this basis, the scrubbing plant is equivalent to a daily capacity of 120,000 cubic feet, or 24,000,000 cubic feet per annum. Cost of scrubber, including foundations and all accessories, £265.

Foundations.—Sketches are given of the foundations provided for condensers, scrubber and purifiers (Fig. 26).

Purifiers.—These are of the luteless type, four in number, 5 feet deep, and are arranged with a series of eight valves, 9-inch, fixed in one box above the centre (Figs. 27 to 30). Each valve is fitted with a wheel and suitable indicator. After the site had been excavated to the necessary depth, a concrete foundation, 9 inches thick, was made. Each plate is $\frac{3}{4}$ inch thick, with flanges $3\frac{1}{2}$ inches wide, $\frac{7}{8}$-inch thick, and bolted together with $\frac{5}{8}$ inch bolts at 6-inch centres. A strengthening bracket is also cast between each bolt, $\frac{1}{2}$ inch thick. The flanges are all planed, and stand $2\frac{3}{4}$ inches clear of the plates. On the inside, two tiers of snugs are prepared to receive the tee steel bearers, and upon the end plates two rows of continuous ribs, $1\frac{1}{2}$ inches broad and $\frac{5}{8}$ inch thick, to carry the wood grids, these being bracketed underneath at 12-inch centres. On the outside of each plate is cast a suitable moulding. Each purifier is fitted complete with two tiers of tee bars, of 3-inch by 4-inch by $\frac{1}{2}$-inch steel, and two tiers of grids, of well-seasoned timber, with taper deal bars and oak sides, and securely bolted with $\frac{3}{4}$-inch bolts.

The covers are formed of an angle steel frame, 5 inches by 3 inches by $\frac{3}{8}$ inch, stiffened with two lines of 5-inch by 4-inch 13-lb. bulb tee, securely riveted to the plating with $\frac{1}{2}$-inch rivets, 6-inch pitch. The plates are $\frac{1}{4}$ inch thick, lap-jointed and single-riveted, with $\frac{1}{2}$-inch rivets, $1\frac{1}{2}$-inch pitch, $1\frac{1}{2}$-inch lap. Eyes are bolted to bulb tees, for lifting the covers. A 3-inch diameter taper plug and seating, with test tap, is fixed into each lid, as air valves.

The lifting arrangement is formed of two 10-inch by 5-inch steel joists, fixed on four cast-iron columns, and fitted with two sets of travelling carriages and pulley

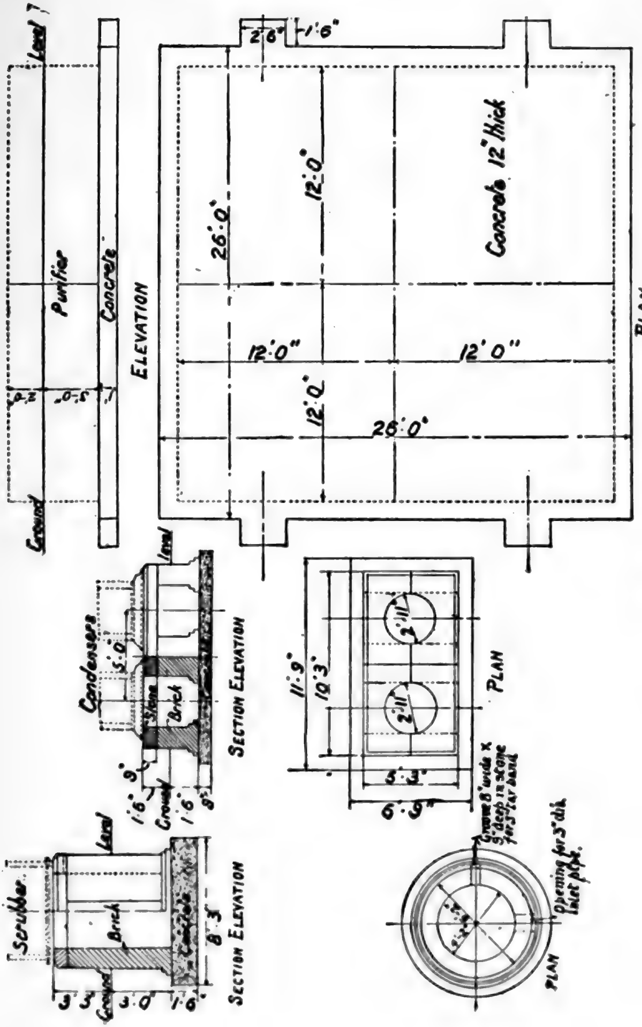


Fig. 26.—Foundations

blocks. All the joints of the purifiers are machine-faced, and jointed with cement when erected. Where exposed to sight, all bolts have hexagon heads and nuts, the latter

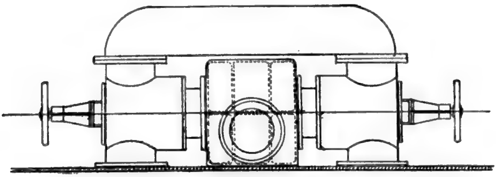


Fig. 27.—Purifier Valves: Elevation.

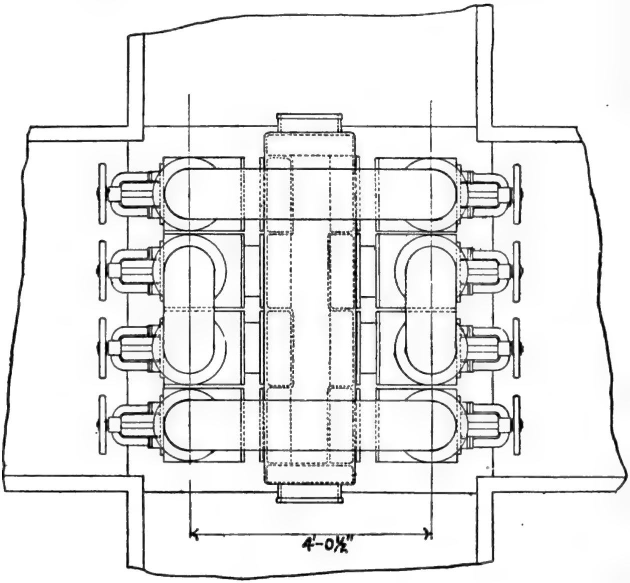


Fig. 28.—Purifier Valves: Plan.

of full thread, with an iron washer underneath. The wrought-iron used in the work was specified to be equal to the best Staffordshire, and to be capable of bearing a

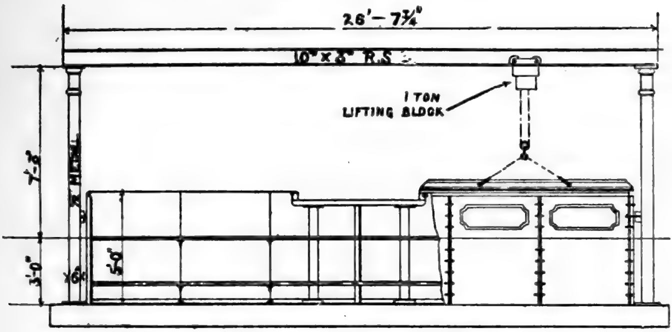


Fig. 29.—Purifiers: Sectional Elevation.

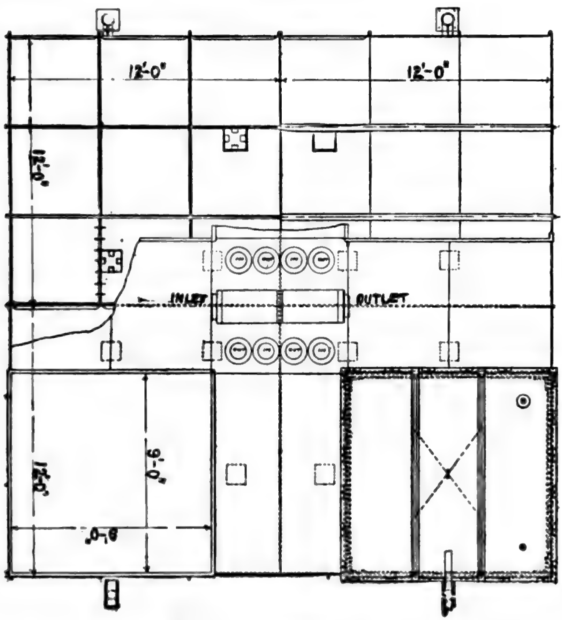


Fig. 30.—Purifiers: Plan.

tensile strain of 20 tons to the square inch of section without fracture. The steel work was required to stand a similar test at 28 tons. All iron castings were to be of good close grey metal, to be examined by the engineer before painting, after which they received one coat of paint before delivery and another after erection.

The old factors for purifying area are becoming somewhat antiquated, in view of the modern practice of hurdle grids and working by means of the rotation method of changing without opening. Although the writer is a thorough advocate of both these modern devices, it was decided that ordinary grids would be quite sufficient for some years, *i.e.*, until the boxes approach the maximum capacity so fitted. With the present method of working, they will be quite capable of purifying a maximum daily make of 240,000 cubic feet, or, say, 1,000 cubic feet for each 2·4 square feet of area. This is the equivalent of 48,000,000 cubic feet per annum, and doubtless it can be considerably increased by subsequently adopting hurdle grids.

The proportionately large purifiers were adopted because excess of purifying area always conduces to economy in labour costs. Cost of purifiers and foundations, complete, £473.

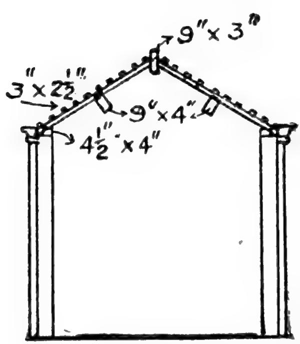


Fig. 31.—Meter and Governor House: Roof, Cross Section.

Meter and governor house.—This building is erected in the most suitable position for intercepting the inlet and outlet pipes to the holder, which enter the latter at right angles. Its dimensions are 18 feet 6 inches by 9 feet inside, 8 feet to eaves, and 12 feet to apex. The walls are of brick, 9 inches thick, with foundations as specified for exhauster house. The floor is boarded so as to give access to connections. Cost, £41.

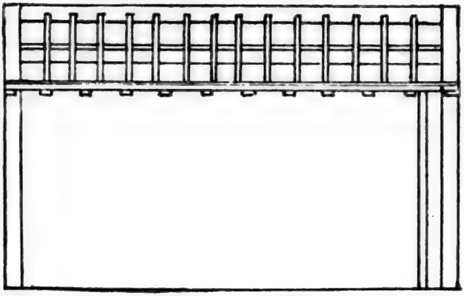


Fig. 32.—Meter and Governor House: Roof Elevation.

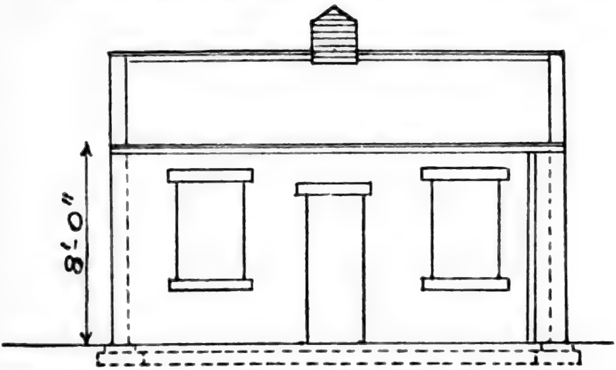


Fig. 33.—Meter and Governor House · Side Elevation.

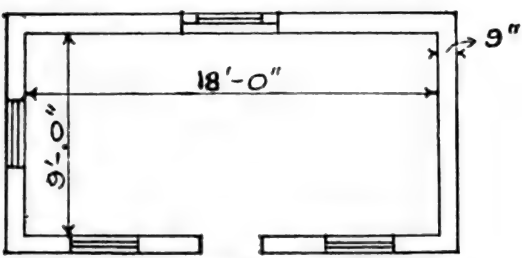


Fig. 34.—Meter and Governor House: Plan.

Station meter.—The station meter is fixed on a concrete foundation, 6 inches thick. It is fitted with by-pass, valves, and other accessories. The capacity is 180,000 cubic feet per day, or 36,000,000 cubic feet per annum. Cost, second-hand, including foundations, £80.

Gasholder foundations.—Although it is best to err on the side of safety when providing foundations, it is not an uncommon thing to exaggerate greatly the thickness of concrete necessary to support such a structure as a gasholder fixed in a steel tank. Naturally, a good deal depends upon the site selected. In this instance, trial holes showed that the subsoil was of such a character that the thickness of concrete over a greater part of the area could safely be fixed at 12 inches, and the remainder was made 1 foot 6 inches thick. The gasholder is of the Gadd and Mason type, in a steel tank, two lifts, each 20 feet deep, the top lift being 60 feet and the outer lift 62 feet diameter. The steel tank is 63 feet 6 inches diameter by 20 feet 4 inches deep.

Steel tank.—The bottom plates are ¼-inch thick, riveted with ⅝-inch rivets, 2-inch pitch, 2-inch lap, joints being taped. The top and bottom curbs are 3½-inch by 3½-inch by ½-inch angle steel, the joints being covered with round backed angle steel, 1 foot 6 inches

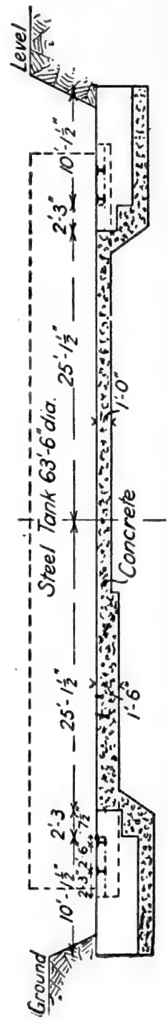


Fig. 35.—Gasholder Tank Foundation: Section on A—B.

long. The ends of the bars are machine sawn, to ensure a perfect butt. The bottom curb is riveted to the sides and bottom with $\frac{3}{4}$-inch rivets, $2\frac{1}{4}$-inch centres, and the top curb to the sides with $\frac{3}{4}$-inch rivets, 6-inch centres. There are five rows of side plates, the two bottom rows being $\frac{5}{16}$-inch and the top three rows $\frac{1}{4}$-inch plates. The horizontal and vertical seams are riveted together with $\frac{3}{4}$-inch

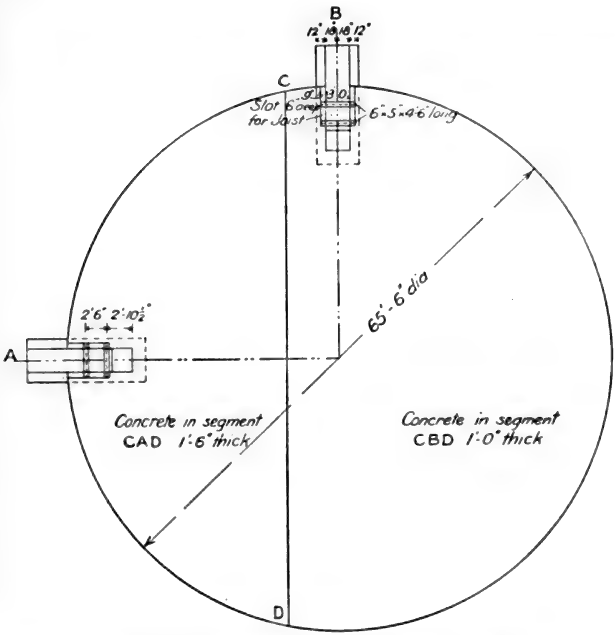


Fig. 36.—Gasholder Tank Foundation: Plan.

rivets, $2\frac{1}{4}$-inch pitch and $4\frac{1}{2}$-inch lap, the two bottom rows being double riveted and the remainder single riveted. There are six pairs of steel brackets of $\frac{3}{8}$-inch plate, and $3\frac{1}{2}$-inch by $3\frac{1}{2}$-inch by $\frac{3}{8}$-inch angles, riveted to sides of tank, to take the cast-iron base plates and carriages for guiding holder. There are six pairs of strong cast-iron carriages and rollers, working in turned steel axles. The rollers are turned, bored, grooved, and prepared with oil holes. A hand-rail, consisting of two rows of $\frac{3}{4}$-inch wrought-iron, is passed through holes in fifteen uprights of $2\frac{1}{2}$-inch by $2\frac{1}{2}$-inch by $\frac{5}{16}$-inch angle iron, the hand-railing being 1 foot 6 inches and 3 feet, respectively, from the top curb. In the bottom of the tank are provided twelve cast-iron rest blocks,

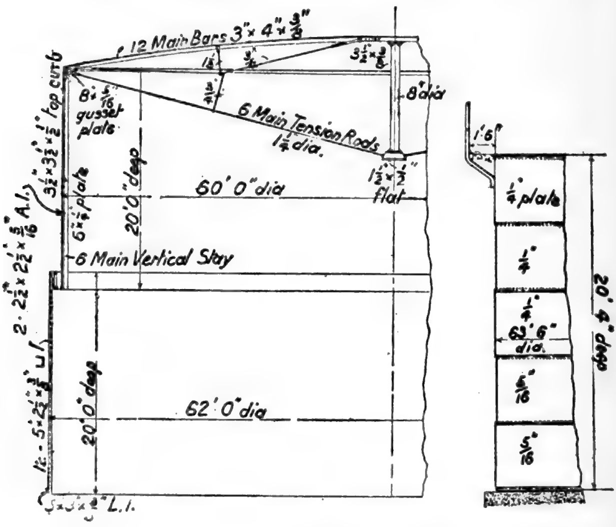


Fig. 37.—Gasholder and Tank.

6 inches deep, for the holder to rest upon when out of action. Two steel joists are placed across each of the recesses provided for inlet and outlet pipes, which are 9 inches diameter, fixed at right angle centres, so that gas passing up inlet is thoroughly diffused before passing down outlet. Syphon pots, with $\frac{3}{4}$-inch pump pipes, are provided to each pipe, and each pipe is stayed with $2\frac{1}{2}$-inch by $2\frac{1}{2}$-inch by $\frac{3}{8}$-inch angle iron, secured to the bottom with

two 3-inch by 3-inch by ⅜-inch angle irons, 9 inches long, and ¾-inch bolts.

Gasholder.—The dome-shaped crown rises 3 feet to the centre. The materials and strengths of the inner lift are as follows :—

Eight rows of sheets, top and bottom of 12 S.W.G., and intermediates of 14 S.W.G.

Top curb of angle steel, 3½ inches by 3½ inches by ½ inch, with steel joint covers, 18 inches long.

Six main vertical stays, of 8-inch by ¼-inch steel plate, and 2½-inch by 2½-inch by 5/16-inch steel angles, riveted together, and bolted to the top and bottom curbs, and in the centre to the spiral plate.

Six intermediate vertical stays, of 4-inch by 4-inch by ⅜-inch tee steel, attached to top and bottom curbs.

Six spiral plates, ¼-inch steel, 12 inches wide, riveted to sides with ⅜-inch rivets, and to which are fixed guides of steel rail, weighing 41 lbs. per yard, and surmounted with cast-iron cap.

Centre crown sheet of 3/16-inch plate, outside row of 12 S.W.G., and five intermediate rows of 14 S.W.G.

Two oval manholes, fitted with 3/16-inch flat cover stiffening ring, and set screws.

Crown plate, 5/16 inch thick, 4 feet diameter, with flat ring underneath, 3½ inches by ⅜ inch, between which and the plate the ends of the main bars are bolted.

Centre pipe, 8 inches diameter, of cast-iron, ⅝-inch metal, with strong bracketed flanges at each end. To the lower end of the pipe is bolted a cup, 8 inches deep.

Twelve main bars of 3-inch by 3-inch by ⅜-inch steel tees, trussed with ⅞-inch diameter tension rod and 1-inch diameter strut.

One ring of 3-inch by 3-inch by ⅜-inch angle steel bars, with ends turned and bolted to main bars.

Twelve 3-inch by ½-inch flat steel secondary bars, bolted to cross-bars and top curb.

Three concentric rings of 2-inch by 2-inch by ¼-inch angle steel bracket bars, with ends turned, and bolted to main and secondary bars.

Six main tension rods of 1¼-inch bar steel, bolted to gussets at the curb and to centre pipe, with enlarged screw ends and double nuts.

Six pairs of double gusset plates, 8-inch by ⅜-inch, connecting main bars and vertical stays together.

Hydraulic cup, of 7-inch by 2⅝-inch rolled steel channel, with 8 gauge skirting plate, 16 inches deep, stiffened at upper edge with 2-inch by ⅜-inch flat strip.

The materials and strengths of the outer lift are as follows :—

Hydraulic cup, similar to inner lift.

One steel angle, 5 inches by ⅜ inch section, and angle covers, 18 inches long, forming bottom curb.

Twelve vertical stays, 7 inches by 2⅜ inches, channel steel, secured to dip channel, bottom curb, and, where possible, to spiral plates.

Side sheets and spiral guides as inner lift.

Six pairs of cast-iron carriages, and rollers working in turned steel axles, fixed at equal distances around the dip channel.

To each lift is attached a ladder, consisting of 2-inch by ⅜-inch flat sides and ¾-inch diameter rungs. The whole of the sheet rivets are ¼-inch diameter, 1-inch pitch, with tape inserted in joints. The top curb rivets are ⅝-inch diameter, 2-inch pitch, and the bottom curb rivets ⅝-inch diameter, 4-inch pitch. Sheeting to dip and cup channels, ⅝-inch diameter, 2-inch pitch, and flats to skirting plate, ⅝-inch diameter, 6-inch pitch. The whole of the tank plates received one coat of oil before leaving contractor's yard, one coat of red oxide paint during erection, and another on completion. To the top curb of tank from the ground is fixed a ladder, formed of 2-inch by ½-inch flat sides, with ¾-inch rungs.

The capacity of the gasholder is about 110,000 cubic feet, or, taking the capacity required as twenty-four hours maximum output, the equivalent of 22,000,000 cubic feet per annum. With the greater regularity of load, however, which is now experienced, through the extended use of gas engines, cookers, etc., it would probably suffice for a much larger output, particularly in a district devoid of factories. With inner lift inflated, the pressure given is 31-tenths; and with outer lift inflated, 53-tenths.

	£	s.	d.
Cost of tank, gasholder and foundations . .	1,694	0	0
Cost per thousand cubic feet capacity . .	15	4	0

Governor.—The governor is of the compensating type, size, 6 inches. A by-pass main is fixed, including the necessary rack and pinion valves, three in number. Cost of governor, including connections, £32.

Office and showroom.—This building is erected at the entrance to the works. The office is 12 feet by 15 feet, and the showroom, 28 feet by 15 feet. The foundations and walls are similar to those specified for exhauster house. A 4½-inch division wall separates the two rooms, flues being

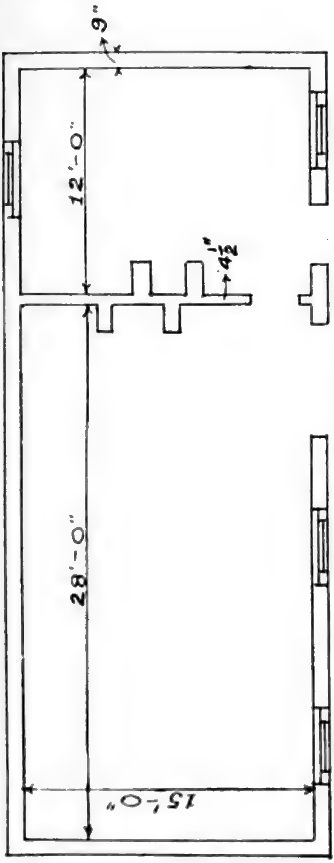


Fig. 38.—Office and Showroom : Plan.

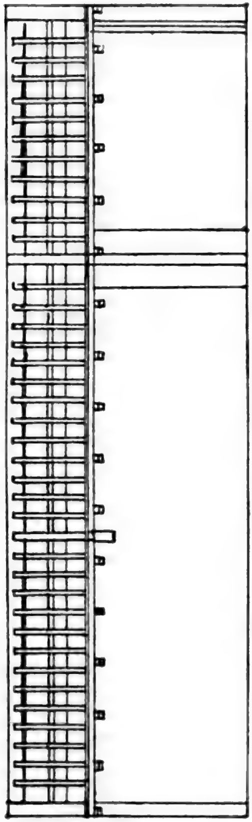


Fig. 38.—Office and Showroom : Roof Elevation.

provided at each. One side of the building forms the outer boundary wall of the site at that point. The height to eaves is 8 feet. A concrete floor is laid $4\frac{1}{2}$ inches thick, and floated with cement, $\frac{1}{2}$ inch thick, the office floor being boarded in addition, the walls plastered, and the ceiling underdrawn. Between the wood principal

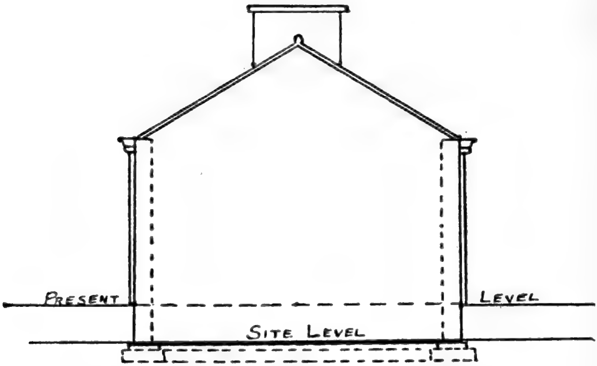


Fig. 39.—Office and Showroom: End Elevation.

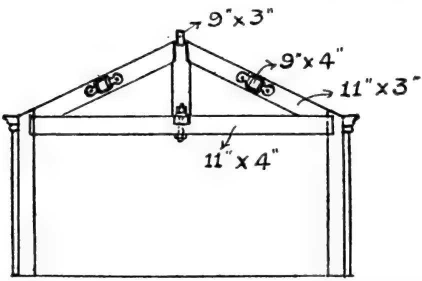


Fig. 40.—Office and Showroom: Roof Cross Section.

of the showroom and the end wall a lock-up store has been formed, of wood, with steps for gaining access thereto. An 8-ton weighbridge is erected outside the office.

Cost of office, showroom, and furnishings, including safe, weighbridge and foundations	£195

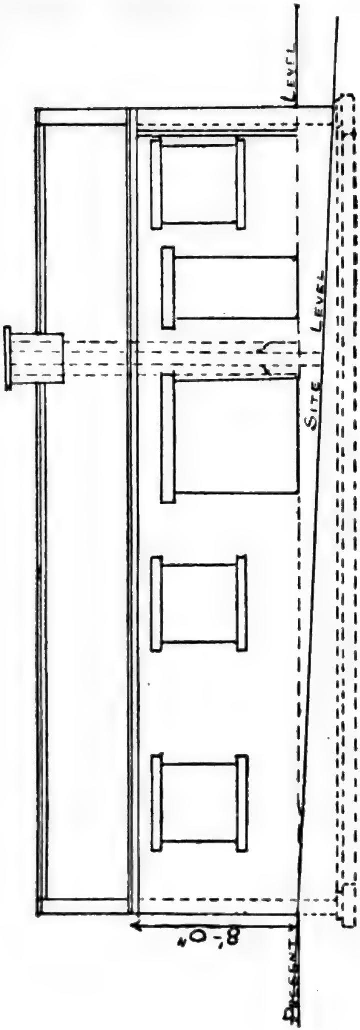


Fig. 41.—Office and Showroom : Side Elevation.

The following is a schedule of the length of 9-inch mains laid on the works to connect up the various pieces of apparatus, together with the specials used for same :—

9-inch Main Pipe.	Yards
Foul main to condensers	18
Condensers to exhauster	4
Exhauster to washer	6
Washer to scrubber	6
Scrubber to purifiers	11
Purifiers to meter	30
Meter to gasholder	16
Gasholder to governor	21
Governor to road	55
Total length of 9-inch pipe	167

9-inch Specials.

One ¼ bend, one flange T, three thimbles.
One ¼ bend.
One ¼ bend.
Three ¼ bends.
Three ¼ bends, one syphon.
Three ¼ bends, one bottle syphon.
Two ¼ bends, one syphon, one 12-inch by 9-inch reducer, three thimbles.
One ¼ bend, one syphon, one 12-inch by 9-inch reducer, one thimble.
One ¼ bend, two $\frac{1}{16}$ bends, two thimbles.

The following is a schedule of the length of cast-iron mains and specials required for tar and liquor pipes :—

3-inch Pipe.	Yards.	3-inch Specials.
Tar tower run-off pipe	16	One ¼ bend, one ⅛ bend.
Condenser run-off	2	Two ¼ bends.
Scrubber run-off	6	One ¼ bend.
	24	
Tar main to siding	106	Two ¼ bends.
Total length of 3-inch pipe	130	

4-inch Pipe.	Yards.	4-inch Specials.
Washer run-off	4	One 4-inch by 3-inch T, one ⅛ bend, one syphon.

The cost of the foregoing mains was £211.

Boundary wall.—When erected, the cost of a boundary wall 800 feet long, 6 feet high, formed of 9-inch brickwork, with 14-inch pillars every 12 feet, double-nosed bricks on top, 6-inch concrete foundations and two courses of footings, will be £196.

Water service.—In addition to the supply pipe from brook to storage tank, water pipes are laid from the storage tank to water bosh supplying producer bars, to top of scrubber, to station meter, to gasholder tank, to workshop or showroom, and to boiler injector.

Lighting.—The following are the lighting arrangements :—Office, two ceiling and two wall brackets; workshop, four wall brackets; retort house, three wall brackets above charging floor and three below; for lighting boiler, one inverted lamp is attached to retort house; exhauster house, two lights fixed to wall, one connected to purifier outlet, and the other to gasholder outlet; governor house, one wall light.

NOTE.—The cost of water supply and gas lighting is added to each respective building or plant.

General.—The governor, station meter, boiler, and two overhead storage tanks were good second-hand; the rest of the plant was new.

All the concrete used in the foundations consists of 1 part best portland cement and 6 parts broken bricks or sand, with no materials of more than 2 inches cube.

The stated cost for exhauster house, governor house and office and showroom includes provision of all windows and glazing, spouting, of 7-inch by 3-inch wood, and one fall pipe on each side wall.

A suitable damp course of bitumen is built in with the wall of each building.

In consequence of the gradient from east to west falling 1 in 16, it was necessary, after the completion of the buildings and the erection of plant, to do a certain amount of levelling up. In addition to this, a substantial cart road was constructed leading from the retort house to the weighbridge, and from the weighbridge to the roadway adjoining the works. This road was formed, after levelling, of 9 inches pitching and 3 inches of macadam. A thorough system of drainage from all the spouts and the boiler blow-off was put down, consisting of 4-inch drain tiles, with traps, where required, and two inspection boxes. The drainage system is shown in Fig. 1 (p. 200). It was also necessary to compensate the former tenant for disturbance and tenant right.

The total cost of levelling up, forming roadway, drainage and other small items was £181.

General conditions.—The contracts for the various portions of the work were subject to the standard clauses approved and recommended by the Institution of Gas Engineers and the Society of British Gas Industries.

Mainlaying.—Along the branch road leading from the works to the highway a 9-inch main, 320 yards long, is laid, with 6-inch branches in the two directions. The average depth of the mains is 2 feet 6 inches. The bulk of the excavation was let by contract, but the jointing and laying of pipes was carried out by the employees of the company. The contractor was required to form handholes, to facilitate the jointing of the pipes, but, as a rule, the pipes were jointed in two lengths outside the trench, thus necessitating only one handhole each 18 feet. The contractor was required to separate the excavated material into (1) surface covering, (2) pitching, and (3) soil or other material; the last named being replaced first, then the pitching and surface covering. To comply with the requirements of the rural authority, it was necessary to provide a quantity of pitching and covering material so as to leave a depth of such material of 9 inches and 3 inches, respectively. The contractor provided, also, all picks, shovels and tools necessary for excavation, and also watchmen, when the trench was left open after working hours. It was specified that he should have his workmen insured against any claims under the Workmen's Compensation Acts and the Employers' Liability Acts.

The following is the schedule of the lengths of mains and cost of same. It should be explained that the pipes are of cast-iron, except the 2-inch, which are of wrought-iron, and laid at a shallower depth than the larger sizes:—

Size of Pipe.	Length.	Cost of Pipe per Yard.	Cost of Jointing per Yard.	Excavating per Yard.	Cost of Laying per Yard.	Total Cost per Yard.	Total Cost.
Inches.	Yards.	s. d.	d.	s. d.	d.	s. d.	£
2	1,208	1 4	0	0 3	1¼	1 8¼	102
3	730	2 1	1½	0 9	2	3 1½	114
4	2,616	2 8½	1¾	0 11	2¾	4 0	523
6	4,936	4 8	2¾	1 1	3	6 2¾	1,537
9	320	7 8	5¾	1 7	6¼	10 3	164
	9,810						2,440

Service laying.—The total number of services laid was 510, the average length being 46 feet 6 inches, the average cost per service £1, 7s. 6d., and the total cost £710. Nearly all the services are ¾-inch wrought-iron tubing, steam quality.

Summary of works costs.—The costs are now sectionized under heads (*a*) land, (*b*) buildings, (*c*) plant. With an expenditure of about £120, the producing capacity of the retort bench can be brought up to 26,000,000 cubic feet per annum, allowing 10 per cent. for contingencies, and taking 200 times the maximum day's production as the annual output. Similarly, the holder, with its 110,000 cubic feet capacity, will suffice for a 22,000,000 cubic feet output, the purifying plant is equivalent to 48,000,000, the scrubbing plant up to 24,000,000 cubic feet, and the remainder of the works more commodious still. If the works is taken to be equal to 22,000,000 cubic feet per annum, therefore, it is well within reason.

	Cost. £	Per Million £
(*a*) Land	500	22·7
(*b*) Buildings :—	——	
Retort house	400	
Exhauster house	54	
Meter and governor house	41	
Office and showroom	195	
Boundary wall	197	
Drainage, levelling, etc.	181	
	1,068	48·5

	Cost. £	Per Million. £
Brought forward:—	1,508	71·2
(*c*) Plant:—		
Retort bench and chimney	770	
Condensers	122	
Exhausting plant	142	
Pumps and gauges	102	
Washer and scrubber	318	
Purifiers.	473	
Station meter.	80	
Gasholder	1,694	
Steam boiler and seating	113	
Storage tanks.	156	
Governor	32	
Works mains	211	
	4,213	191·6
Total.	5,781	262·8

NOTES.—(1) Cost of foundations included with plant. (2) Engineering and supervision are apportioned to the various items, two-thirds of such cost being allocated to works and plant and one-third to mains and services.

The cost on a similar basis of annual capacity cannot be worked out for the expenditure incurred on the system of canalization and supply. The present line of mains will probably prove efficient feeders for a greater output than the estimated producing capacity, but as new streets are opened, fresh subsidiary mains will need to be laid, though, on the other hand, mains are already laid in streets where a large amount of property is expected to be erected within the next twelve months. The expenditure on mains, as per schedule given, is £121 per million, on a 22,000,000 plant. As regards the services, meters and fittings, the cost of these will increase *pro rata* with the erection of buildings, or thereabouts. The cost, per consumer, of service, meter and fittings averages £4, 12s. This is made up as follows:—

	£	s.	d.
Meter, including cock, compo. and labour	1	17	8
Service, materials and labour	1	5	11
Fittings, material and labour	1	8	5
Total	4	12	0

This is based upon the recent experience of fitting up over 500 houses. The average number of lights fixed free was 5·5, and the average cost per light 5s. 2d. Where brackets were fixed, the cost of same was 11d., and the average price paid for pendants was, 2 feet 6 inches, 2s.; 2 feet 9 inches, 2s. 1d.; and 3 feet, 2s. 1½d.

With an average consumption per consumer of 10,000 cubic feet, it would be necessary to connect up 2,200 residences, etc., and on the basis of present costs it would entail a capital expenditure of £10,120. Having regard to the manner in which the present mains link the district, there can be little additional expenditure on this head, but allowing £500, the total capital of the undertaking will then be £19,341, including £500 for a Provisional Order, thus:—

	Total Cost.	Cost per 1,000 Sold.	
	£	s.	d.
Present cost of works, including land, etc.	5,781	5	3·06
,, ,, mains, £2,440			
Future ,, ,, £500 . . .	2,940	2	8·07
2,200 houses, fitted with service, meter and lighting installation . . .	10,120	9	2·40
Provisional Order	500	0	5·45
Total	19,341	17	6·98

The cost per thousand cubic feet sold is based on the assumption of an annual sale of 22,000,000 cubic feet. It may be urged that no allowance is made for leakage or gas used on the works. Although the average leakage of a concern may be from 5 to 10 per cent., it is well known that the average leakage at the period of maximum production is much less than the average for the whole year. Whatever leakage there may be, therefore, is ignored, as the capacity of the works is under rather than over estimated.

This summary reveals in a convincing way the fact that free fittings cannot be indulged in in country districts without adding enormously to the capital costs of the undertaking. The meter and fittings have cost, per consumer, £3, 6s. 1d. Based upon a sale of 10,000 cubic feet, this means a capital expenditure of 6s. 7¼d. per thousand, and unless provision is made for depreciation, it means a permanent addition to the cost of gas of 8d., on a 10 per cent. basis. The most rational way of treating such expenditure is, obviously, to apply the extra amount charged for slot installations to the liquidation of the capital expenditure.

Notwithstanding the cost imposed by fitting up consumers' residences free, the above summary shows that, even for small works, the capital must be considered inflated if it exceeds £1,000 per million cubic feet of gas sold. Generally speaking, that figure should be the crucial test of works valuation. No one would think of taking coal stocks at 15s. per ton, even if they were stored at that figure, if the value had declined to 10s. There are many companies, some of them fairly large, that have capital accounts which are too large as compared with modern costs of erection, but statutory undertakings are not allowed to reduce the amount, except by doing it out of divisible profits. Although the consumers may have got the benefit of past inflation, gas being sold cheaper than it should have been, no allocation can be made to writing off capital unless for works actually dismantled. Some legislative provision is necessary to enable companies to legitimately wipe out over-capitalization without being taxed, since such a procedure means gas at a more reasonable price in the future.

The tenders.—A word or two may be added on the tenders received for the works which have been described. The distance of a contractor's works from the site of a gasworks has, naturally, a bearing upon the price at which work can be executed. Even so, the tenders for gasworks plant almost always vary to an extent out of all proportion to the consideration of distance. In the case of the works under notice, the highest tender was higher than the lowest by the following percentages:—

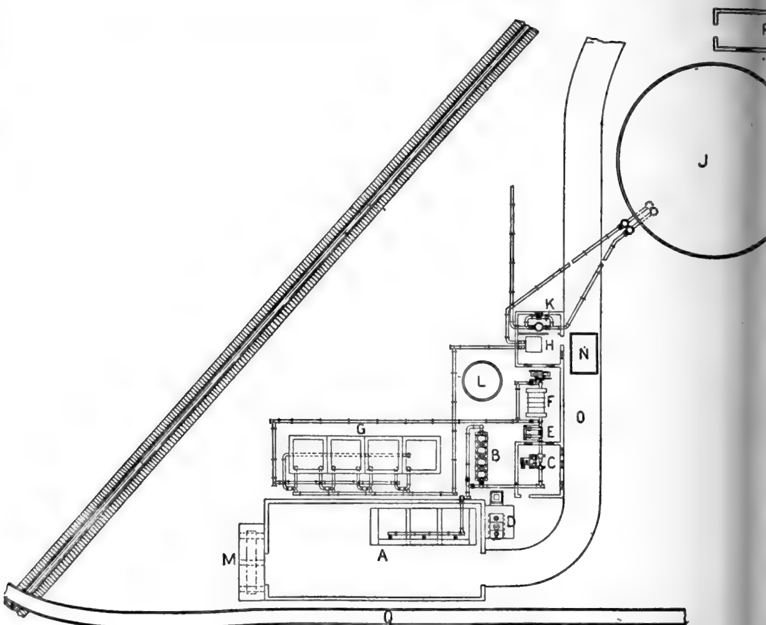
No. of Tenders.	Description of Plant.	Percentage Highest Above Lowest.
6	Retort house roof	29·4
4	Retort bench	21·9
5	Condensers	35·0
6	Livesey washer	38·3
5	Tower scrubber	14·4
6	Purifiers	63·7
6	Gasholder	11·0
2	Exhauster	8·0
2	Buildings	2·5

For obvious reasons, the actual amount of tenders is not given. It is not difficult to locate a works of this character, and tenders are here treated as confidential documents, concerning only those who send them and those who receive them. For that reason, the cost of foundations, engineering and supervision has been included with the structures. The above summary shows that with regard to gasholders, at all events, the pricing out of quantities is done with great uniformity.

Works No. 2.

In the case of this works, the general constructional details are similar to No. 1, so that it is not proposed to refer to them at length, except to point out important differences. The land is 3 acres, 2 roods and 23 perches in extent, near the railway, from which a siding has been laid, and carried a little beyond the retort house. No doubt some of this land will ultimately be disposed of, as it is not likely to be required for gasworks purposes, even after making a generous allowance for future possibilities. The site is practically level, and of a clayey stratum. Included in the site purchase is a stable, for which a rental of £10 per annum is received.

The retort house is 68 feet by 30 feet wide. The roof is formed of nine principals, at 6 feet 9 inch centres. The retort bench consists of three arches, two being completed with regenerative settings, seven and five retorts, respectively. There are four condensers, each 20 feet high, with outer tubes 2 feet 6 inches and inner tubes 1 foot 10 inches diameter. The foul main is not carried



A. Retort House and Bench.
B. Condensers.
C. Exhauster House and Exhauster.
D. Boiler and Setting.
E. Livesey Washer.
F. Washer Scrubber.
G. Purifiers.
H. Station Meter.
J. Gasholder.
K. Governor.
L. Underground Tar and Liquor Tank.
M. Overhead Tar and Liquor Tank.
N. Weighbridge.
O. Cart Road.
P. Fitting Shop.
Q. Railway Siding.

Fig. 42.—Plan of Works No. 2.

round the retort house, so that although the condensing plant alone gives 20 per cent. more cooling surface, it is

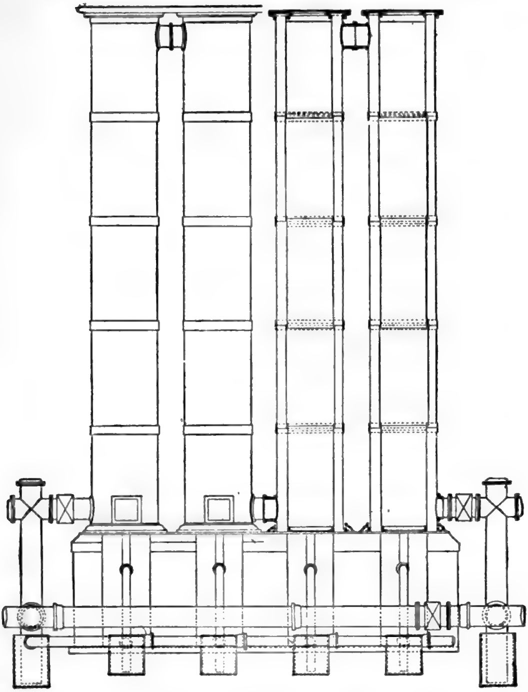


Fig. 43.—Annular Condensers: Sectional Elevation.

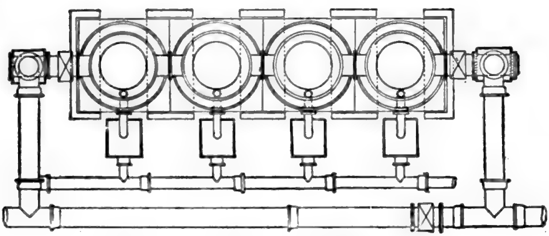


Fig. 44.—Annular Condensers: Plan.

little more than that of works No. 1, when foul main capacity is also included.

The exhausting set and Livesey washer are similar to works No. 1, but a rotary washer of 250,000 cubic feet capacity is used in place of a tower scrubber. The capacity of the scrubbing plant, therefore, is considerably greater. The purifiers are luteless, and in one way, with separate inlet and outlet to each box. The boiler, storage tanks, station meter, governor and gasholder are similar in size and capacity. The bottom row of tank plates are

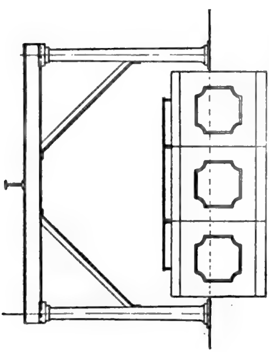


Fig. 45.—Purifiers: End Elevation.

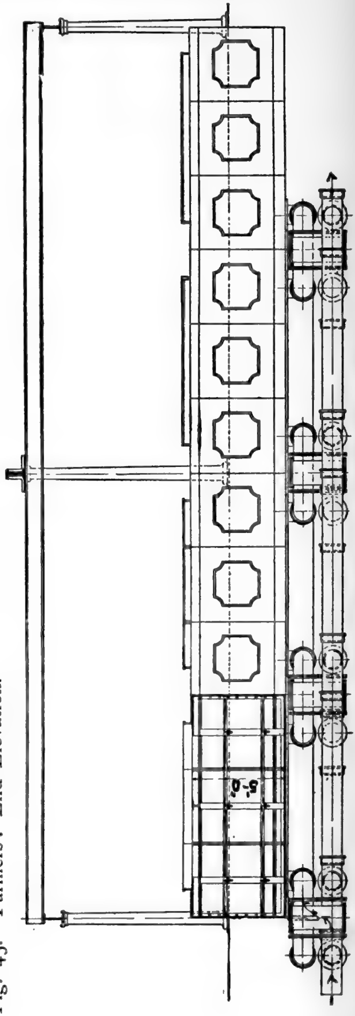


Fig. 46.—Purifiers: Side Elevation.

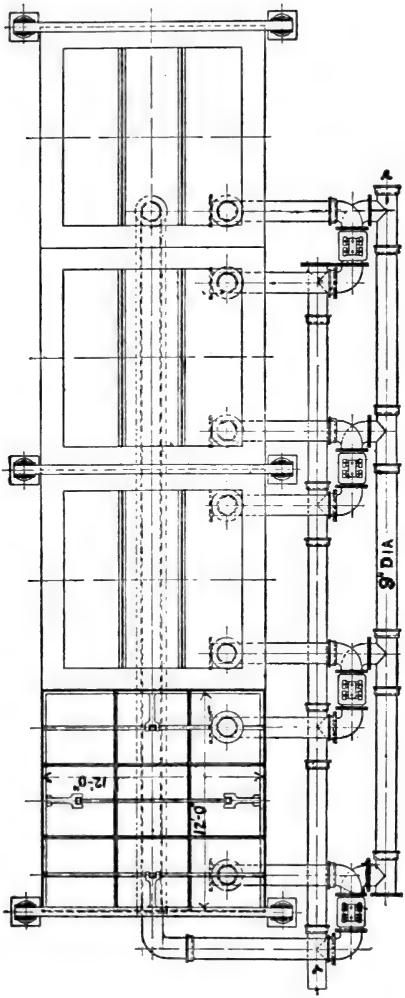


Fig. 47.—Purifiers: Plan.

$\frac{1}{16}$-inch thicker, and there are other slight modifications in details, but they do not make much difference to cost.

The works may be taken to be of the same capacity as No. 1, though the retort house is larger and the scrubbing power greater.

The costs were as follows:—

	Cost. £	Per Million. £
(*a*) Land (less £150 for rented property)	650	29·5
(*b*) Buildings:—		
Retort house	410	
Exhauster house	55	
Meter and governor house	55	
Washer-scrubber shed	22	
Workshop and weighbridge	96	
Drainage, roadway, etc.	48	
Railway siding	85	
Fencing	50	
	821	37·3
(*c*) Plant:—		
Retort bench and chimney	835	
Condensers	158	
Exhausting plant	120	
Livesey washer	53	
Washer-scrubber	234	
Pumps and gauges	70	
Purifiers	566	
Station meter	153	
Gasholder	1,651	
Steam boiler and seating	82	
Storage tanks	117	
Governor	46	
Works mains	242	
	4,327	196·7
Total	5,798	263·5

NOTE.—Cost of foundations, engineering and supervision included with the respective structures.

The works being some distance from the shopping centre, an office and showroom has been rented away from the works.

The cost of works, as above, comes out remarkably close to works No. 1. The buildings cost more in the case of the latter, because of the more difficult site as regards levels, and because the provision of an office at the works was made.

The tenders.—The following summary shows the variation in prices in such portions of the plant as were tendered for:—

No. of Tenders.	Description of Plant.	Percentage Highest Above Lowest.
4	Retort house roof	40·6
4	Retort bench	23·7
4	Condensers	34·6
4	Livesey washer	72·6
3	Scrubber-washer	38·5
6	Purifiers	39·8
6	Gasholder	7·4
2	Exhauster	5·5
3	Station meter	0·0

The gasholder tenders were even closer than in the case of works No. 1. The station meter was a new one, and the fact that the tenders were all one price may be set down to the existence of a working agreement between the respective makers.

Mainlaying.—The system of mains to supply the district for which this works was designed is much more extensive than that connected with works No. 1. The excavation, too, was of a more difficult nature, several hundred yards of hard rock being encountered, the rocky stratum running in several places quite close to the road surface. The excavation in such situations costs 3s. per lineal yard. The costs, therefore, are higher, although the average depth at which the mains are laid is about the same. The following is the table of costs, the figures being inclusive of all materials and labour :—

Size of Pipe. Inches.	Length. Yards.	Cost, per Yard. s. d.	Total Cost. £
2	120	1 6	9
3	2,880	3 3	468
4	4,926	4 4	1,067
6	4,242	6 7	1,396
8	2,418	8 9	1,058
Total	14,586		3,998

Service, meter and fittings.—The cost of service, meter and fittings averaged, per consumer, £4, 5s. The meters are nearly all 3-light slot meters, as, indeed, are those used in works No. 1. The lower total cost, per consumer, is accounted for by shorter average services, and by the purchase of meters at a specially low rate. The houses, too, are in bigger blocks; consequently, there was less time wasted in passing from one job to another, and better supervision was also possible. 1,250 services, meters and fitting installations, at £4, 5s. each, £5,312.

Provisional Order.—This company have already obtained a Provisional Order. Although an agreement had been made with the rural district council, which amply protected them in the matter of upkeep of roads, and also protected the consumers with regard to gas testing, price of gas, etc., the hands of the company were, nevertheless, forced by the action of a proposed rival company, who gave notice of intention to promote a Bill for supplying this and other adjoining areas. In the end, the Bill was abandoned, but as a result of the opposition, the company's Provisional Order cost £650.

Total cost.—Summarizing the figures given, we now get the following as the total cost of this undertaking, with a total of 1,250 consumers.

	£
Works, including land, etc.	5,798
Mains	3,998
Meters and installations	5,312
Provisional Order	650
	15,758

The sale of gas for the first complete twelve months, to 30th June 1910, was over 11,000,000 cubic feet. This included that consumed by about fifty public lamps. It takes a year or two to entirely wean a community from the old-fashioned oil lamp, even when gas has been installed. In this case, all the buildings for which the works were put down were erected, or nearly so, and the tenants used oil for artificial lighting. With the exception of less than half a dozen, all adopted gas, though it is too much to expect them to discard their oil lamps entirely and unanimously, at the first flash of gas lighting. The estimate of 10,000 per consumer, reckoned upon in discussing works No. 1, may, with confidence, be looked for after, say, the second complete year of the undertaking's existence.

When another 950 consumers have been added to this undertaking on the existing line of mains, assuming they will cost an average of £4, 5s. each, the capital will be increased by £4,037, and if the consumption has then reached 10,000 per consumer, the capital, at £19,790, will work out, on a sale of 22,000,000 cubic feet, to about 18s. per thousand cubic feet, a figure which approximates very closely to that of works No. 1 forecast. It has been assumed that only future consumers will have free fittings, to make the figures comparable with No. 1 works. As a matter of fact, when the abnormal building to provide for the urgent needs of the new community was finished, the practice of free fitting was discontinued, and landlords are now required to pay for installations. In addition to this, provision will be made for depreciating the installations already in use, so that by the time the output is 22,000,000 cubic feet, the capital will be much more favourable than the comparison given.

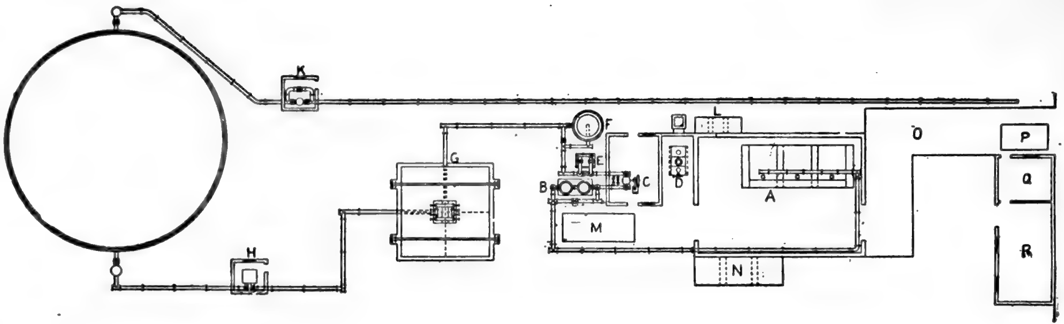
Works No. 3.

Without going into details, the costs of these works may be given. They are situated in the neighbourhood of works No. 1 and 2. The area of the land is about 1 acre.

and the capacity of the works is, approximately, the same. The cost of formation is included with the land. The engineering expenses are apportioned to the various items of expenditure, as in the case of works Nos. 1 and 2. The costs were as follows :—

	Cost. £	Per Million. £
(*a*) Land	425	19·3
(*b*) Buildings :—		
Retort house	354	
Exhauster house	54	
Meter house	45	
Office and workshop	176	
Boundary walls	44	
Governor house	26	
Drainage, levelling, etc.	50	
Total	749	34·0
(*c*) Plant :—		
Retort bench chimney	795	
Condensers	115	
Exhausting plant	142	
Pumps and gauges	102	
Livesey washer and scrubber	310	
Purifiers	544	
Station meter	153	
Gasholder	1,570	
Steam boiler and seating	114	
Storage tanks	130	
Governor	45	
Works mains	246	
Total	4,266	193·9
Total cost	5,440	247·2

NOTE.—The costs of foundations, engineering and supervision are included with plant.



A. Retort House and Bench.
B. Condensers.
C. Exhauster House and Exhauster
D. Boiler and Seating.
E. Livesey Washer.
F. Tower Scrubber.

G. Purifiers.
H. Station Meter and House.
J. Gasholder.
K Governor and House.
L Water Storage Tank.

M. Underground Tar and Liquor Tank.
N. Overhead Tar and Liquor Tank.
O. Cart Road.
P. Weighbridge.
Q. Office.
R. Showroom and Fitting Shop.

Fig 48.—Plan of Works No. 3.

The following table gives the cost of mainlaying :—

Size of Pipe.	Length of Main.	Cost per Yard.	Jointing.	Excavating.	Laying.	Total Cost per Yard.	Total Cost.
Inches.	Yards.	s. d.	s. d.	s. d.	s. d.	s. d.	
2	1,130 (w.-i.)	1 4	—	0 3	0 1½	1 8½	92
3	2,000 (c.-i.)	2 1	0 1¾	0 10	0 2½	3 3¼	327
4	8,600 (steel)	2 1½	0 0¾	1 1	0 2	3 5¼	1,478
4	3,200 (c.-i.)	2 8½	0 2	1 1	0 3	4 2½	677
5	1,190 (c.-i.)	3 5	0 2¼	1 2	0 3¾	5 1	303
6	2,000 (steel)	3 10	0 1	1 2	0 2	5 3	525
6	360 (c.-i.)	4 8	0 3¾	1 2	0 4	6 5¾	117
					Total .	. .	£3,519

The cost of 1,650 services, meters, and lighting installations amounted to £6,432, thus averaging about £3, 18s. per house. The number of lights fixed per house, however, averaged only four, and the average length of service was 28 feet 9 inches, as compared with 46 feet 6 inches in works No. 1.

The total cost of these works, with 1,650 consumers, and 18.480 yards of mains, may be summarized as follows :—

	£
Works	5,440
Mains	3,519
Services, meters and fittings	6,432
Total	15,391

INDEX.

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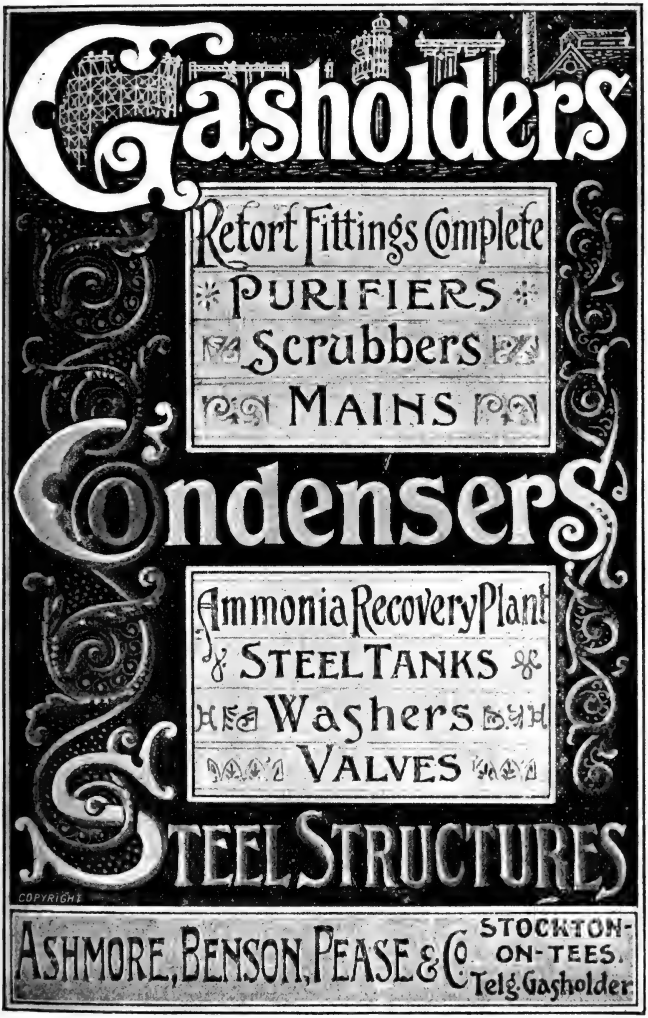
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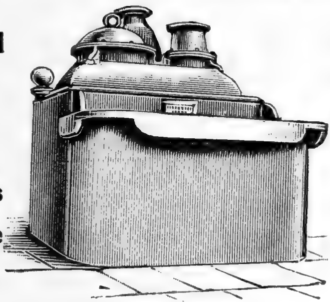

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