JOINT MEETING OF

The Institution of Mechanical Engineers

WITH THE

Society of Chemical Industry.

(Chemical Engineering Group.)

THE CO-OPERATION OF THE ENGINEER AND CHEMIST IN THE CONTROL OF PLANTS AND PROCESSES.

BY G. M. GILL, OF LONDON, M.I.MECH.E.

A great need exists to-day for the supply of materials which have some pretence of being standardized, with quality, size and general characteristics much more uniform than is frequently the case with most manufactured commodities. With such variations in raw and other materials used for manufacturing purposes, it becomes a difficult problem to work plant and processes efficiently, and in such a way as to produce articles of standard quality and quantity. As a result, great loss is caused to the country's trade and industry generally.

It is proposed in this Paper to deal specifically with coal and refractory materials, and to outline a system which has been applied with the object of standardizing the quality of gas. The South

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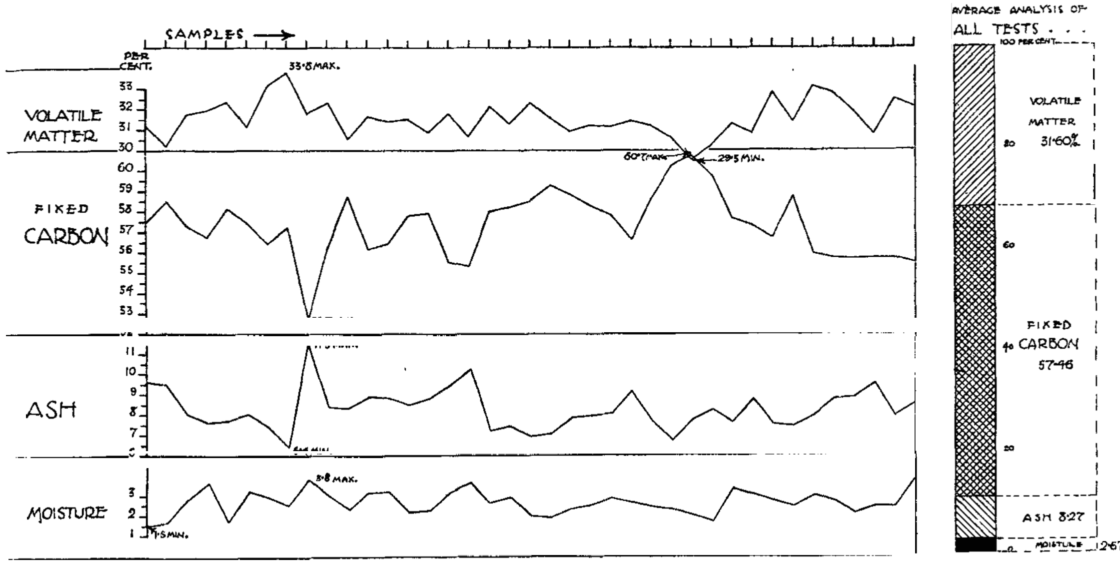
FIG. 1.—*Coal A.*



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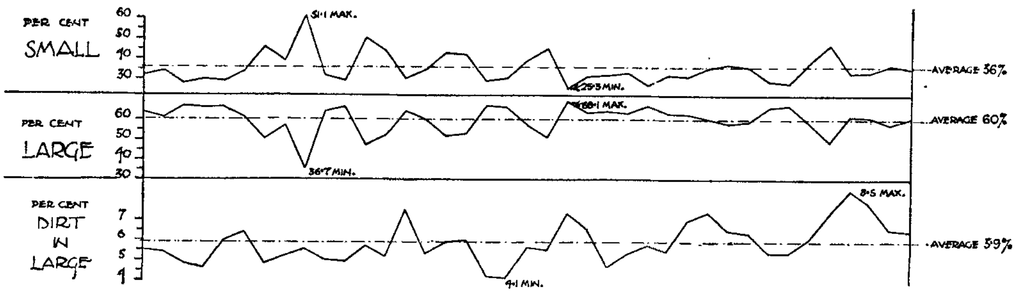
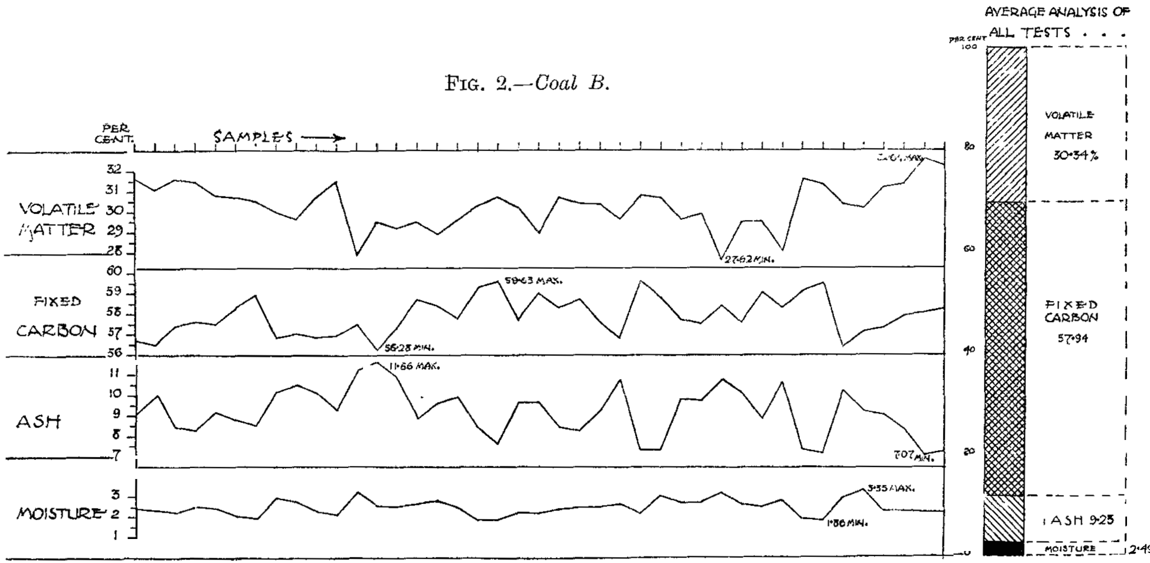


Fig. 1 shows the results of the examination of samples of Coal A, each sample being representative of a consignment of about 1,000 tons. The figures are calculated upon the wet basis, while the figures for "Fixed Carbon" are free from ash. The lower portion of the diagram shows the relative proportion of small and large in each sample, while the bottom line indicates the percentage of dirt hand-picked from the "large" portion of the sample, this latter giving a good indication of the efficiency with which the particular coal was hand-picked on the picking belts at the colliery. It will be noticed that in the case of six samples the percentage of dirt in the "large" portion of the coal amounted to over 7 per cent, which indicates very bad work on the part of those responsible for picking out this dirt.

FIG. 2.—*Coal B.*



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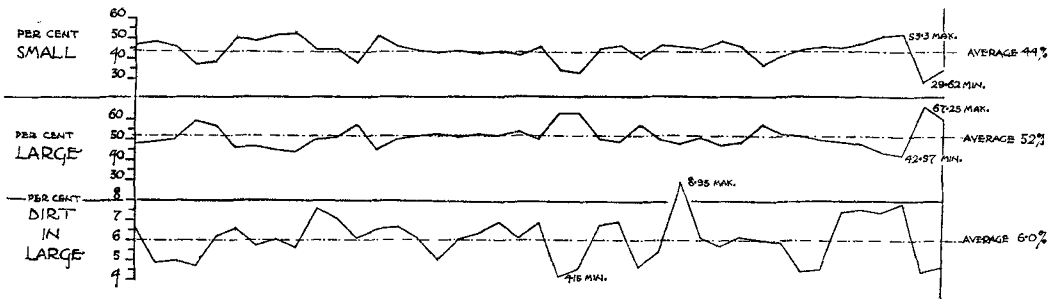

Fig. 2.—As in the case of Coal A, seven of the samples of Coal B contained over 7 per cent. of dirt in the "large" portion of the coal, which again emphasizes the possibility of improvement in the quality of coal as a result of more careful picking. It will be noticed that the consignments with the lowest percentages of ash had generally the lowest percentages of dirt in the "large" portion of the coal, showing the extent to which this removable impurity affects the ash content.

Metropolitan Gas Company being a user of coal to the extent of $1\frac{1}{4}$ million tons per annum, has found it desirable to establish a fully equipped laboratory and inspecting staff at Newcastle-on-Tyne for the purpose of examining coals supplied to the Company. The coal is sampled as it is loaded into the Company's ships, after which the samples are analysed, and all coal above a definite size is hand-picked free from dirt, the results being telegraphed to London in time to give those responsible for the operation of the works an opportunity of regulating the carbonizing plant to suit the varying grades of coal before its arrival. This system is still in its infancy, but excellent results are anticipated not only from the point of view of better informed buying, but also of improvement in the cleaning of coals, and in the working of plant to suit each consignment of coal. One of this Company's stations has already instituted a system of carbonizing by which automatic adjustments are made varying with the volatile content in each consignment of coal. It should here be explained that in good carbonizing from 90–95 per cent of the volatile content in the coal is converted into gas and liquid products, and as the percentage of volatile matter in the coals used varies from, say, 24 to 34, it will be realized that the one class of coal needs very different treatment to the other, though it is a factor which has hitherto been neglected in gas-works practice owing to lack of information.

The Author has summarized the results of these tests in the case of four typical coals, which are fairly representative of a larger number similarly examined. These results are given in detail in Figs. 1, 2, 3, 4 (pages 44–51).

The Author claims to have no practical knowledge of coal mining, and cannot therefore give any indication of the limits of quality within which coals could be supplied. The diagrams at any rate show the variation in quality of coals actually being supplied, from the study of which it must be evident to practical users that considerable alterations in the regulation of plant are inevitable when coal so variable in quality is in daily use.

In gas-works generally the class of coal in use is varying in some cases from hour to hour, and in others from day to day, and as consignments of coal differ so largely, it is not customary to alter the regulation of plant until some time after a fresh class of coal has been in use and its effect has become apparent to those in charge. This change is generally too late for full advantage to be taken of the characteristics of the coal, but if this could be done before a commencement is made on a fresh class of coal, much benefit would

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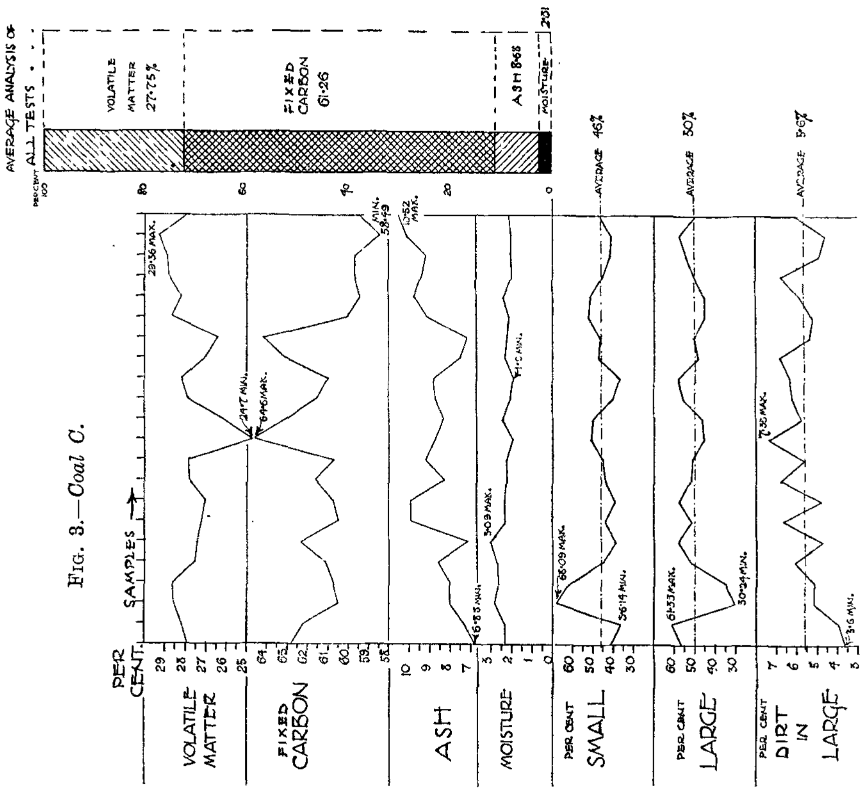
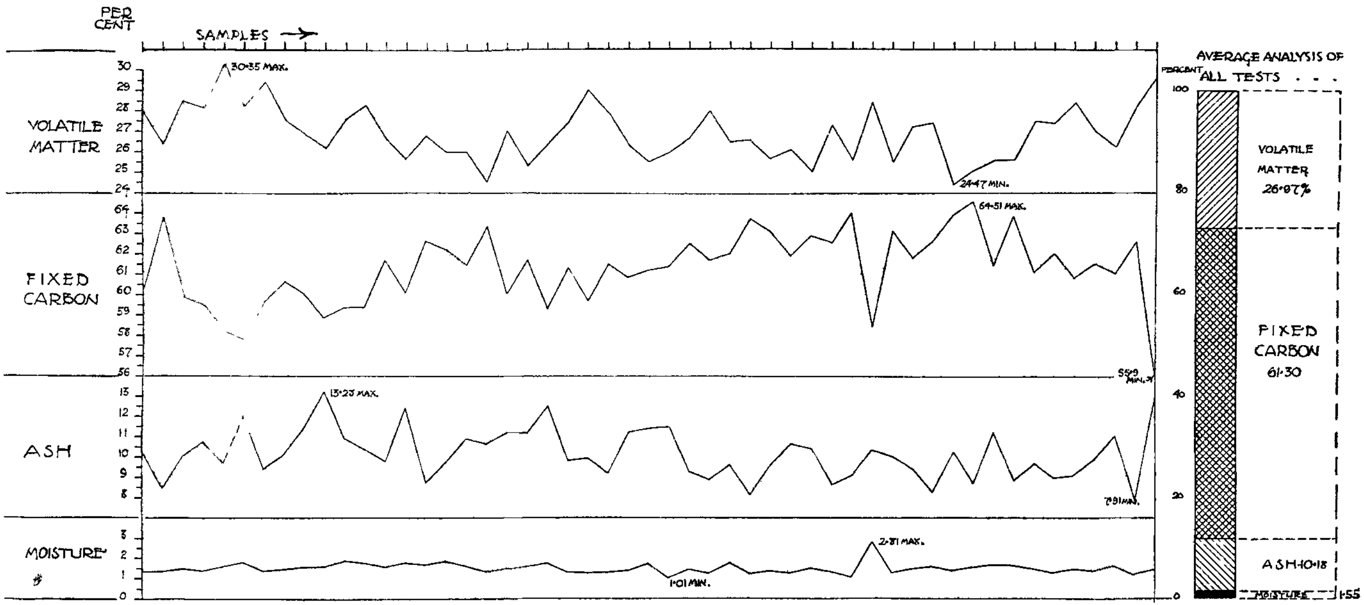


FIG. 3.—*Coal C.*

Fig. 3.—It will be noticed that Coal C contains more "Fixed Carbon" and less volatile matter than Coals A and B, rendering it more valuable for coke making and less valuable for gasmaking than Coals A and B. It will be seen that the percentage of volatile matter varies from 24·7 to 29·3, or 16·6 per cent based upon the average of 27·7 per cent, and as the amount of gas contained in the coal depends upon this portion of the coal, it will readily be appreciated that a variation of this amount will interfere very greatly with the output of a gas-making plant. In this case only one consignment contained over 7 per cent of dirt in the "large" portion of the coal.

FIG. 4.—*Coal D.*



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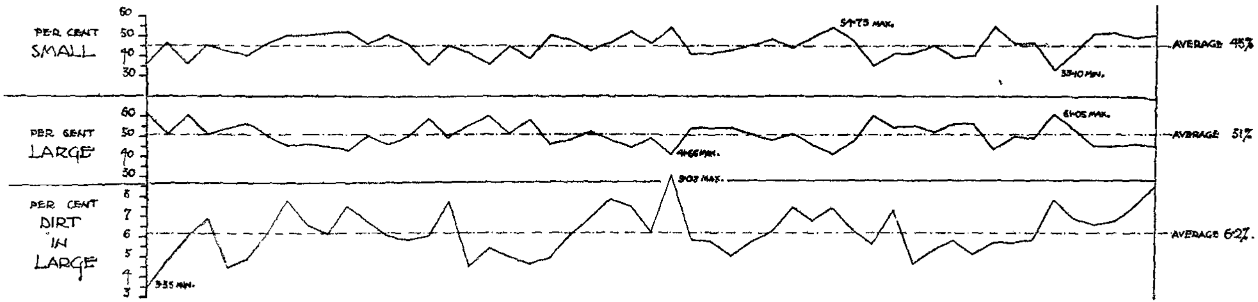


Fig. 4.—Coal D has the same general characteristics as Coal C, and might be termed a coke-making coal but for its high ash content. In this case thirteen consignments contained over 7 per cent of dirt in the "large" portion of the coal, while the variation in the percentage of volatile matter is even more marked than is the case in Coal C.

be derived. At the present time the name of a coal is the only indication of its quality and characteristics, but as will be seen from the diagrams, each coal varies so largely that the name is little indication of its quality.

Coal is everywhere bought not by quality but by name, and its price varies with the general reputation of the name in question, but these diagrams serve to show that there is so wide a variation in the quality of each coal that the worst cargoes of a so-called first-class coal are inferior to the best of a second-class coal. There is, in fact, a large element of chance in regard to the quality of any particular consignment.

The Author would suggest that the time has arrived when each colliery should grade or classify the coals from the various pits and seams, keeping each grade of the same quality within the narrowest practical limits. The advantages of such a step to the users would be very great, and this would react favourably upon the whole coal industry. To a gas undertaking it would result in higher yields of gas and products per ton of coal and per unit of plant, a higher output per man, and a smaller variation in the quality of gas made, and these would have the effect of reducing the price of gas. The desired improvement would be much nearer achievement if the coal were picked more efficiently and consistently, though, of course, this is not the whole of the problem.

In examining the samples of coals, these are screened through a sieve with holes $\frac{1}{2}$ inch square, and the coarse portion not passing through is hand-picked free from dirt, the quantities of which dirt are shown in the diagrams. A study of these figures makes it quite clear that the picking process at the pits is a haphazard one, varying possibly in efficiency with the dates of the football matches in the district. The presence of this superfluous dirt in the coal causes untold loss in a gasworks. There is not only the fact that the buyer is receiving dirt instead of coal, but the dirt is transferred to the coke which is used in the furnaces for heating the retorts in which the coal is carbonized. In practice the heating of the retorts is very greatly affected by the amount of dirt in the coke, and as a consequence its presence in the original coal is most objectionable.

The Author would suggest that, in the working of a colliery, continuous sampling of the coal as it reaches the surface should be the daily and nightly duty of chemists, who would test the coal both physically and chemically, supplying the superintendent in charge with complete records of the quality of the coal, by which system the quality could readily be standardized within limits varying with the consistency of the particular seams. The working of such a system would entail the employment of chemists in the collieries to a much greater extent than is now the case, and this would lead to the production of a better and more uniform quality of coal.

The effect of such improvement would undoubtedly be far reaching, and while the Author holds no brief for chemists, he is

TABLE 1.

Showing the Maximum and Minimum Dimensions found by examining twenty-four Fire-bricks (of each of two well-known makers) chosen at random from a stack of such bricks. The Correct Dimensions should be 9 × 4·5 × 3 *inches.*

—	Length.	Breadth.	Thickness.
MAKER (A)—	Inches.	Inches.	Inches.
Maximum . .	9·30	4·56	3·16
Minimum . .	9·01	4·40	2·90
Difference . .	0·29	0·16	0·26
MAKER (B)—			
Maximum . .	9·35	4·5	3·12
Minimum . .	8·92	4·27	2·87
Difference . .	0·43	0·23	0·25

strongly of opinion that their presence at the engineer's side is essential to the proper conduct of industries generally, and here in the working of collieries is clearly fine scope for mutual co-operation between the members of the two professions.

REFRACTORIES.

The variation in size and quality of fire-bricks and blocks and retorts is one of the most unsatisfactory features with which users of refractories have to contend. All kinds of difficult problems have to be faced for want of uniformity in this respect. Table 1 shows the varying length, width, and thickness of fire-bricks supplied by two well-known makers in this country.

Fig. 5 shows three pieces of retort which were picked out from

FIG. 5.—*Showing varying Sizes of Retorts.*

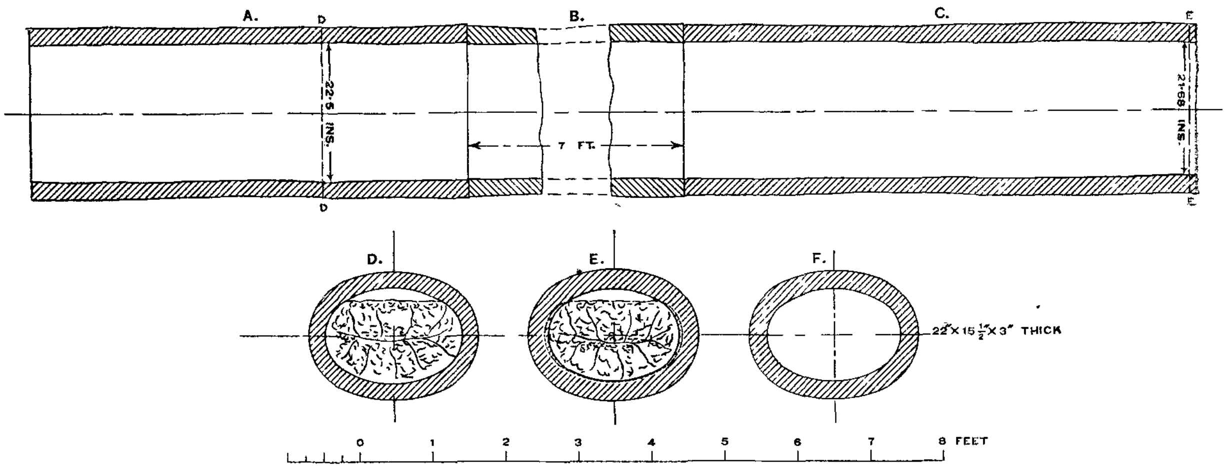


Fig. 5.—Shows three pieces of retort chosen from seven pieces picked at random from a number of retorts supplied by one maker. The largest piece is shown at A, the middle size piece at B, and the smallest at C. D shows a section through piece A where marked D.D., and E a section through piece C where marked E.E. In D is shown a typical view of a charge of coke ready to be discharged, and in E is shown the same portion of the charge and its relative size to the retort at the smallest end, from which it will be seen that the charge, where laid in the largest part of the retort, is larger than the smallest part of the retort, through which it has to be pushed by a machine. F shows the correct sectional dimensions of the retorts.

seven pieces chosen at random from a quantity in stock supplied by a well-known manufacturer. These three pieces have been placed together to make up the usual length of a 20-foot retort. The internal dimensions of these pieces should have been 22 inches by 15½ inches of an oval section, as shown in Fig. 5. Actually the dimensions in the 20-foot length vary from 22·50 inches to 21·68 inches wide, and from 15·50 inches to 15·31 inches in height. As used in a gas-works these retorts are charged with coal and when coked the appearance is as shown in Fig. 5. The charge of coke has then to be pushed out at one side, and in some cases the direction in which it is pushed is varied from day to day. It is obvious that where one part of the retort is larger than another part the charge in the larger part can only with difficulty be pushed through the smaller part of the retort, and this fact undoubtedly causes practical difficulties in working.

The dimensions of the retorts should be, within practical limits, the same from end to end, both internally and externally. The internal dimensions affect the discharging operations and the external dimensions affect the building of the settings, a large amount of cutting of bricks and blocks being necessary where the retort is of a bad shape. Unfortunately where the shape of the material is bad, human nature being what it is, the workmanship is also frequently bad, the difficulties of the retort setter being so much increased by the faulty shape of the retorts.

Such variations are typical of material supplied by most of the fire-brick makers in this country, and the Author has no hesitation in asserting that it is high time that fire-brick makers started to employ rational methods in the control of the ingredients used in brickmaking, and of their mixing, drying, and burning. The variation in size is doubtless due to faults in one or other of these parts of the process, such faults being allowed to develop in the course of manufacture owing to a complete absence, in most fire-brick works, of any semblance of scientific control.

In visiting a fire-brick works, one is usually told that the important work of controlling the kilns is left in the hands of a workman upon whose judgment, without the aid of instruments, depends the degree and uniformity of the temperature and the period over which it is extended. The same is true of the choice and mixing of the raw materials from which the bricks are made. To anyone accustomed to the aid which is given by chemists and others whose duties consist of keeping a regular check upon all the factors which contribute to the maintenance of uniformity in the quality of manufactured commodities, it is of course obvious that the absence of this absolutely necessary assistance can but result in the defects of which mention has been made.

In the building of any structure of refractory materials it is highly important that the joints between bricks and blocks should be as thin as possible, the bricks being "buttered" only, and consequently it is all-important that the thickness of such bricks should be uniform, as otherwise the bricklayer must either sort over all the bricks to get those of a similar thickness to lay in one course, or he must increase the thickness of the joint wherever the thin bricks are laid. In either case the remedy is very objectionable. Here again there is scope for the chemist to work in conjunction with the engineer or manufacturer.

What appears to the Author to be necessary in the conduct of fire-brick works is the institution of methods providing for :—

(1) The continuous sampling and analyses of mixtures in use, both chemical and physical.
(2) The use of heat recorders in kilns.
(3) Definite limiting standards for size and shape.
(4) Guaranteed working to specifications.

It might be argued that the extra cost of applying such methods would not be forthcoming from the sale of the materials made, or, in other words, that the bricks would be too expensive to sell. It is suggested that the contrary result would be experienced.

The control proposed would doubtless result in the production of a higher and more consistent quality of brick; this would increase sales and consequently lower overhead charges in the works. The control would further diminish rejected bricks, save fuel costs in kilns, increase capacity of plant and effect improvements which would result from increased knowledge of the process. At present the most enlightened refractory users are searching the country for a better quality of materials, which is of far greater importance than that of price, important though that be.

Refractory users are hopeful, though not confident, that they may find what they require in this country. They do not want to go abroad for their materials, and if this course has to be taken it will be because they have been driven to it by the apathy of the British refractory manufacturer.

Control of Plant for Making Standard Gas.

The South Metropolitan Gas Company has applied scientific control both to the working of the manufacturing plant and to the maintenance of the quality of the gas supplied, which is standard in quality within narrow limits.

To start with the carbonizing of the coal, this is carried out in retort-houses where the coal is placed into retorts and there distilled into gas and the liquid products, tar and ammoniacal liquor, the residue coke being left in the retort. These retorts are heated by producer-gas from producers fired with coke.

The Company has seventeen retort-houses, the average size of which contains 246 retorts, each of which carbonizes 25 cwts. of coal per 24 hours. Sixteen retorts are heated by one producer consuming 3·7 tons coke per 24 hours. If coal and coke are priced at 30*s*. per ton, it will be seen that the average retort-house is dealing per 24 hours with raw material valued at £546. If the other expenditure entailed in working a retort-house is added, such as labour, upkeep, and power, a further £168 must be added to this figure, making a total of £714 a day. A fairly complete system of control by means of chemists and testers can be provided at an additional cost of £3 8*s*. per 24 hours. Does it not appear obvious that this expenditure—0·5 per cent of the whole amount involved—is likely to be recouped many times over as a result of the more intelligent working of the plant ?

Fig. 6 gives the results of all tests made during one complete 7-day week in three retort-houses at one of the Company's stations, these being typical of the whole. In these tests the quality of the producer-gas is indicated by the percentage of carbon monoxide (CO) contained in the gas, the quality of the waste gases leaving the retort settings by the percentage of carbon dioxide (CO_2), while the degree of heat to which the retorts are being subjected is shown by the temperature in the combustion chamber of the settings, in which the producer-gas meets a hot supply of air and is there burnt. Considerable variations are shown in all these figures, thus emphasizing the importance of carrying out such tests, which enables faults to be remedied as soon as disclosed. It is quite certain that were rule-of-thumb methods allowed to replace the control system, the variations would be much wider.

As explained above, the South Metropolitan Gas Company has adopted a policy of supplying a standard quality of gas, this being 550 B.Th.U. per cu. ft. With a view to maintaining the standard and to reducing variations in quality to a minimum, a typical system in use at one of the manufacturing stations may here be described. The gas being made is collected at a uniform rate in a small test gas-holder for each hour throughout the day and night. It is then tested every hour for calorific power, the result being immediately

(*Continued on page* 60.)

Fig. 6.—This shows the tests in the retort-houses made by the shift chemists or testers at one of the Company's works, during one complete week.

A. shows the percentage of carbon dioxide (CO_2) in the waste gases leaving one or other of the retort-settings. 18 per cent CO_2 is the Company's standard.

B. shows the percentage of carbon monoxide (CO) in the producer gas leaving the producers heating the retort-settings. 25 per cent CO is the Company's standard.

FIG. 6.

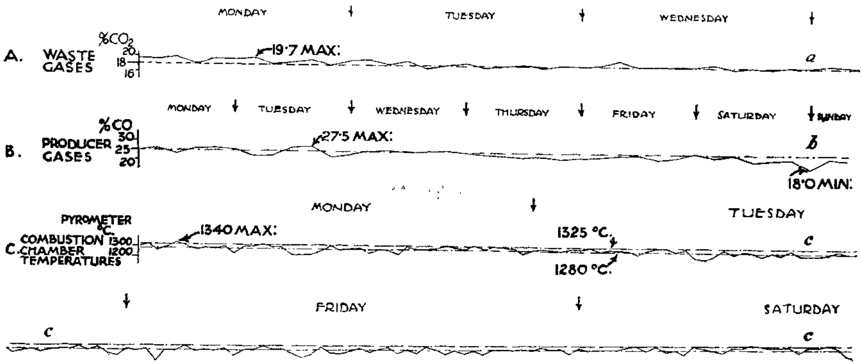


FIG. 7.—This shows percentage variation of the calorific power of the coal gas being made each half-hour throughout the same week. The required

FIG. 7.

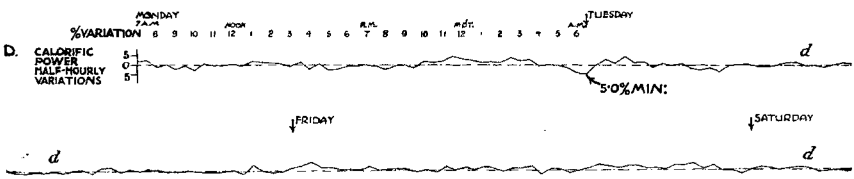
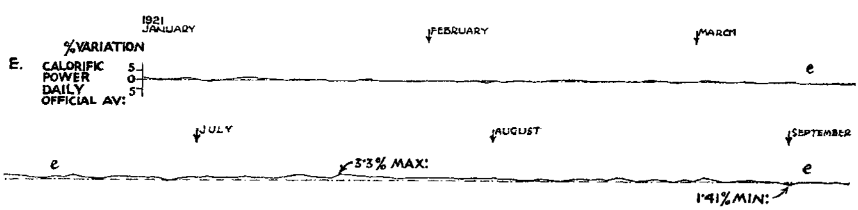


FIG. 8.—This shows the daily percentage variation from the standard calorific power of the gas supplied by the Company, as certified by independent examiners working under the instructions of the London County Council.

FIG. 8.

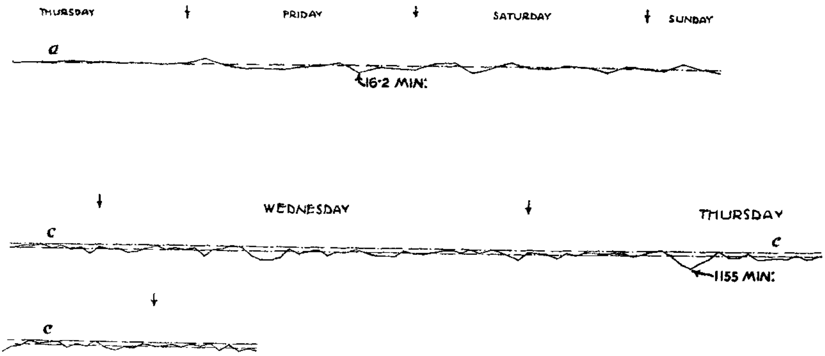


C. shows the temperature in the combustion chambers of the retort-settings. 1,280 to 1,325° C. is the Company's standard.

The standards are indicated by dot and dash lines.

It should be mentioned that these figures do not quite represent the average conditions, as the tester's work is upon occasions concentrated upon the retort-settings which are not working so well as the others. The results, therefore, tend to record the worst rather than the best.

FIG. 6.



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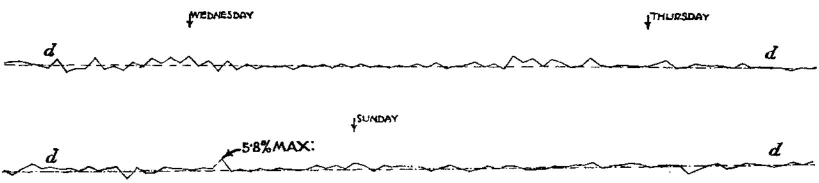
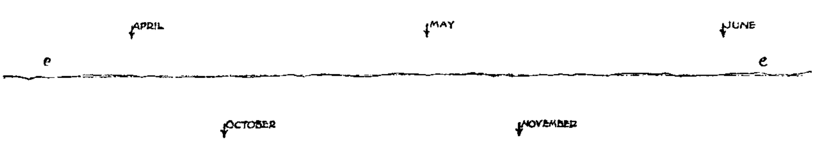
quality being 550 gross B.Th.U's. per cubic foot. Fig. 7 indicates the extent to which the gas being made is over or under the requisite quality.

FIG. 7.



These are based upon the average results of the tests made at the six official testing-stations in the Company's district of gas supply.

FIG. 8.



telephoned to the official in charge of the manufacturing operations. In addition to this, the gas being made is tested midway between the commencement and completion of each hourly sample. This is a check on the other test, the two figures giving the official at intervals of ½ hour the quality of the gas being made. A typical record of the half-hourly tests is shown in the diagram, Fig. 7, these being shown as a percentage above or below the standard quality of 550 B.Th.U. per cu. ft. The gas as made passes into a storage holder which acts as an efficient mixing vessel, thus levelling up the hourly variations.

Finally, the holder in which the gas made over a period has been mixed is used to supply the Company's district, situated at six different points upon which are London County Council Testing Stations, where independent examiners test the gas several times daily. The average of all such daily tests constitutes the official figure of the quality of gas supplied each day, and those reported since the beginning of 1921 are shown in Fig. 8 as a percentage above or below the standard quality of 550 B.Th.U. per cu. ft.

The Author having had experience of the day-to-day collaboration with a well constituted chemical department under the control of the Chief Chemist, Mr. E. V. Evans, F.I.C., has no hesitation in recommending others concerned with the manufacture of any commodity, to do all in their power to obtain similar assistance. These standardizing methods were originated a number of years ago, and there is not the slightest doubt in the Author's opinion that by the adoption of similar methods the stability and prosperity of any manufacturing business can be greatly improved.

The Paper is illustrated by 8 Figs.

Discussion.

The PRESIDENT, in proposing a vote of thanks to the Author for his most interesting Paper, said it was the third of Joint Papers between The Institution of Mechanical Engineers and the Society of Chemical Industry, and he hoped there would be more as time went on.

It was clear from the Paper that the South Metropolitan Gas Co. had found the necessity of establishing a laboratory both for analysis and control, in order to improve the quality of the product and to reduce the cost. Many would agree with Mr. Gill that other industries should do likewise.

Dr. S. MIALL (Member of Council, Society of Chemical Industry) said that it gave him great pleasure to be present to hear Mr. Gill's Paper and to have the opportunity of expressing the thanks of the Society of Chemical Industry for the invitation to take part in the discussion.

Dr. W. R. ORMANDY said he had listened with great pleasure to the very interesting presentation of an old story put forward by the Author. He did not know whether the Author's faith in humanity was not the thing which had struck him most. Mr. Gill complained that the colliery owner did not employ chemists. Was it likely that the colliery owner was going to employ a chemist so long as he could continue selling roofing shale at pounds a ton ? The idea that coal, which was one of the great sources of energy for all our industries, should be bought on a rational basis of the heat units contained in it, had been urged for the last thirty years, as far as his memory went. Twenty or thirty years ago boiler slack, small coal used for steam raising, could be bought in the North of England at anything from 3*s.* to 7*s.* a ton, and really at that time the question arose whether it was worth troubling about when fuel was such a small item in the output costs, as a rule, of most manufacturers. The gas-works was in quite a different category. Coal was its principal raw material, but, with regard to the coal that was used for power purposes in the country, in only a comparatively small proportion of cases was the coal the chief raw material; it was a subsidiary material. Nevertheless, now that such enhanced prices had to be paid for fuel, it was eminently desirable that some system should be realized whereby fuel could be bought on the heat units contained in it. Whether the colliery owners, who were a powerful organization, would agree to that or not he did not know, but several of the great industrial combines, like the fine cotton spinners, the bleachers, and firms like Lever Brothers, had been able to make contracts with various collieries on a system of payment under which there were drawbacks for excess amounts of water or ash.

He thought very few people realized what was involved in the question of a high percentage of ash. He would take the simple household case. At the present time people in the City of London were privileged to buy anthracite for anthracite stoves by paying about 25 to 30 per cent more than the same anthracite could be bought delivered in Barcelona, and when they got it, it was supposed to be sized. Certainly it was sized in the direction that it had not any pieces larger than a given size, but downwards there was no limit. The Author had referred to the 9 or 10 per cent as the maximum that could be hand-picked out of the large coal that was sent to the colliery. He could take the Author to a small anthracite heap in his own back-yard where he could pick out double that from material which had cost him nearly £5 a ton. It was an extraordinary thing that the colliery owners were allowed to obtain money from the public under false pretences, because that was what it came to. They apparently could sell stuff containing anything up to 25 per cent of ash and shale. It was remarkable that in so many of the industries of the country the public at large had no protection. He had examined so-called "all wool tweeds" from reputable tailors, containing from 15 to 65 per cent of cotton. Such things were not permitted in Australia. Some action needed to be taken in these matters. There were enough Government officials already, some of whom might possibly be better utilized than they were at present by having their energies directed into the useful channel of protecting the public in such cases. The public could not be expected to analyse samples of coal.

With regard to the question of fire-bricks, there was no necessity for uneven size. The necessity arose from the fact that many English makers of fire-bricks dug their raw material out of the earth as their fathers and grandfathers did; they put it through a machine, pugged it, and made it into bricks; put it into a down-draught kiln, which was hot on one side and only comparatively hot on the other, and said: "There is our brick, buy it or leave it." In France they had realized that it was poor economy to pay 80*s*. a thousand for fire-bricks which were crooked and irregular, when they could get a regular and proper-sized fire-brick by paying 50 per cent more, or even double. He had once gone into the question of whether it would pay, in a certain metallurgical operation, to use such fire-bricks that the furnace would have twice the life. He had suggested to the owners of that works that they should buy a certain brick which was 25 per cent dearer than the bricks they were employing, and accurate figures, got out by their own staff, showed that, instead of paying £4 a thousand for bricks, if they could have doubled the length of life of their furnace it would have paid them to have paid £40 a thousand and they would have saved money. The cost of the brick was a very small item. One got 1,000 bricks for, say, £4. Those bricks weighed a little over 3 tons, on which carriage had to be paid. Then there was the by-no-means cheap labour of the bricklayer, who slowly and solemnly put the bricks into their places. Then there was the question of the life of the furnace, and the money that was lost while the furnace was out and the capital that was lying idle. There were the growing losses during the continuation of the process while the bricks were going wrong; one was losing draught, and so on. In France they had discovered, as was perfectly well known in this country, that bricks could be made which had no appreciable contraction after they left the maker's furnace. The bricks that were made in this country were burned in the furnace until they had contracted perhaps 6 or 7 per cent. They then went into use in a still hotter place and contracted another 1, 2, 3 or 4 per cent. It was possible to make bricks which, when burned at a reasonable temperature such as could be obtained in a manufacturing kiln, had lost practically all their contraction, and at the same time, owing to the fact that they had not got much contraction to start with and had lost it at a lower temperature, it was possible to make them so that the variation in length of a standard brick should not exceed $\frac{1}{16}$ inch. But that necessitated that a very large proportion of the clay that was used to make the brick should have been burned to grog in the first place, and then ground and sieved and mixed in the right proportions as concrete was mixed, in order that the voids might be filled, and then that it should be solidified, as it were, with some of the plastic clay—about 20 per cent. If that method were followed, a brick could be made which was incapable of contraction, because it was really, so to speak, a concrete mass which was bound together with the clay; and if that clay was adequately purified and it was used as a binder, it was possible to get bricks which would not contract more than $\frac{1}{4}$ inch in the foot, instead of $1\frac{1}{4}$ inch to $1\frac{1}{2}$ inch as was quite usual at the present time, and to make a brick which had finished its contraction at a temperature of 1,200° F.—a temperature which was easily obtainable in any industrial furnace.

He was pleased to have had the opportunity of supporting the point of view which had been taken by the Author; but he would point out that he did not think it was the fault of the chemist. The chemist had long enough been pointing out that such things ought to be done and could be done, but the colliery owner and the middleman had no real desire that those things should be done.

The PRESIDENT, referring to Dr. Ormandy's remarks, pointed out that the mechanical engineer was the proper person to insist on the supply of suitable materials.

Mr. CHRISTOPHER W. JAMES (Member of Council) said a good deal had been heard that evening about the sins of the colliery owner and of the woollen manufacturer. Why the colliery owner should be particularly picked out he did not quite know, because there was a well-known maxim often heard in the Courts in this country of *Caveat emptor*. When a man bought something, he had to look out for himself, and if he did not like a certain coal he must buy some other coal. It was not compulsory on him to buy anthracite with 25 per cent of ash in it. It was possible to get it with a lower percentage of ash and comparatively well screened. The difficulty of cleaning coal was one, he thought, which, under the present methods, would very slowly be solved, because it depended on the human factor to such a great extent; but comparatively clean coal could be obtained by washing, only it must be crushed to a sufficient fineness. If small coal was washed, it could be got to a very high degree of purity indeed, practically the whole of the dirt being eliminated.

Referring to the earlier remarks of the Author, he had been hoping to hear something more about the products of distillation. Mr. Gill had referred to gas and tar and solid matter. He had been hoping to learn something as to whether more valuable products were obtained by distilling the coal at different temperatures to those usually adopted in gas-works. Every now and then something was seen in the Press about low-temperature carbonization. He would like to know whether such processes resulted in more valuable products, and whether the resulting coke had a higher heating value than that resulting from the ordinary gas processes.

Mr. E. R. DOLBY said he proposed to confine his remarks to two points—namely, carbon dioxide and fire-bricks. He could not claim any intimate specialized knowledge of gas-works, but as a consulting engineer he had been engaged upon work in connexion with institutions, factories, and so on, and it had always been his endeavour to improve the efficiency of fuel consumption. For that purpose he had sometimes installed CO_2 recorders. He did not propose to mention the types, because that might be invidious, but he wished to say that, in his opinion, most of them were more suited for use in a laboratory under an expert than to be placed in the hands of the engineer-in-charge, usually found at such institutions. Under those circumstances he had been greatly interested in the curve shown on page 58, in which was shown the CO_2 percentage taken over a week, the desired standard being 18 per cent. If that curve were examined, it would be seen that it was practically on that standard line. There were only two or three little peaks above the line, and in only one case was 19·7 per cent reached. There were only two or three little depressions below, and the lowest was 16·2. He greatly envied Mr. Gill those results, and ventured to hope that in his reply the Author would state what type of instrument he used—whether it was a recording type and whether any special precautions had to be taken in the observations.

With regard to fire-bricks he endorsed the views of the Author entirely. His experience was chiefly in the setting of boilers—Lancashire, Yorkshire, and Babcock and Wilcox types. If a single make only, say Stourbridge, were used, one had merely one set of irregularities, but when one came to the setting of a Babcock and Wilcox boiler, it might be found desirable to use Stourbridge fire-bricks for the moderate temperatures and another type, such as Glenboig, for a position more exposed to excessive heat. That complicated the matter, because there were then two sets of variables, and this was very annoying if one required to use those two different qualities in courses which corresponded with one another.

Professor J. W. HINCHLEY said that the title of the Paper was a somewhat provocative one, and he had been agreeably surprised to find that that provocation had not happened. The suggestion to him as a chemical engineer had been that the co-operation of the chemist and the engineer would take the place of the chemical engineer. The Paper had gone to prove the necessity of the existence of the chemical engineer, not only in the gas industry, but also in the fire-brick industry and in other industries, and Mr. Gill had evidently adopted the position that the gas engineer needed some consideration, and he needed consideration from chemical engineers in other industries, namely, those who made fire-bricks and retorts. After all, science was only organized common-sense based upon experimental determinations of natural facts. The

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human element to which Dr. Ormandy had referred was a point which would need far more consideration in the future than it had received in the past. It was all part of the same problem, which was to get everybody to work together to produce the maximum efficiency in our industries.

He was not quite sure whether Mr. Gill's method of plotting his analyses in order to show a series of curves was quite the best plan, but still it did illustrate how variations occurred continually, and it would be quite easy to use the Author's curves—if his abscissæ were quantities or times—to give a more definite scientific relation. The position of the chemical engineer in industry was an extremely difficult one to-day, but if such men as Mr. Gill would say that they were going to have fire-bricks which did not vary more than $\frac{1}{16}$ inch in length or breadth or depth they would get them if they insisted upon them; but if they were content to accept a second class thing, there would be no improvement. That was one of the positions which had to be realized. The definite gospel of discontent in industry was a most important one in this country at the present time. The chemical industry of this country owed a great deal of its progress before the War to the manufacturer of chemical plant in such a country, say, as Germany, simply because that manufacturer devoted himself to those chemical engineering problems and turned out stoneware and plant which did their work properly; whereas in this country there was found to-day the same dearth of chemical engineering as was found before the War.

The manufacturers were going back to their old deplorable methods. In his opinion the commercial man was a great deal to blame. He would engage a man to buy his fire-bricks, for instance, who had no knowledge of fire-bricks. There were many persons in this country to-day in factories who were buying materials without any knowledge whatever of them, and the result was that those who had to use the materials were despondent because they could make no advance. No doubt Mr. Gill had a voice in the purchase of his fire-bricks, but there was a large number of engineers in British works who had no voice whatever in the purchase of their fire-bricks. Someone in the office said that he could get them 5*s*. a thousand cheaper, and proceeded to buy some rubbish. The position therefore was that there had to be men who had some knowledge of science and some knowledge of the industry in which they worked. As an example, the head of one of the largest spirit distilleries, who was in charge of the works, did not know that he was distilling alcohol. He only became aware of it when he appeared in a court of law to give evidence. He (Professor Hinchley) had also been through works during the War where he pointed to a heap and asked what it was, suggesting it was sulphate of iron. "No, that is copperas," replied the manager. This kind of ignorance which was tolerated in our industries had to be got rid of. This could only be done by continual effort and by refusing to buy materials from firms who continued to encourage that kind of thing.

He was heartily with the Author in his demand for a higher standard of accomplishment. By all means more should be paid for the stuff. Ultimately the higher efficiency would completely wipe out any increased cost and they would find sooner or later, as the engineers had already found, that the more accurate a thing was made the cheaper it was, generally, to make it. The Ford car was possible at a low price, not because it was made with its dimensions anyhow, but because it was made as accurately as possible. We had to reach that standard in our industries which depended upon the application of science, or organized common-sense to all our operations, by which the highest efficiency could be attained and the possibility of the maximum of leisure for all afforded.

Mr. W. NEWTON BOOTH said he thought one of the things which the Author desired to put forward was the necessity for standardization. It was the duty of the engineer to see that if he wanted a certain product, the conditions under which that product was manufactured in his works were kept standard. If he did that, he had every right to expect that his product would maintain the same degree of standardization. Anyone who knew sufficient of the work of the South Metropolitan Gas Co. and who had studied the charts of the results of their work, which Mr. Gill had shown, would realize how very far that Company had gone in achieving that result as far as their own product was concerned.

He was particularly interested in Mr. Gill's reference to coal, partly because he had been working himself on the same problem and partly because he found that Mr. Gill was actually doing something that he (Mr. Booth) as yet was only setting out to do. Seeing that the South Metropolitan Gas Co. had an office at Newcastle, whose duty it was to control the whole of their coal buying and to sample the coal and actually test it, so that the results reached London at or before the time the coal reached there, he would like to ask the Author how that sampling was done. Anyone who had tried to take an accurate representative sample of 3,000 or 4,000 tons of coal knew that it was by no means an easy job, and unless the sample was accurately taken, the result was only worth the paper it was written on.

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With regard to the testing of coal, he would like to know whether any attempt had yet been made to arrange contracts in which the payment for the coal was governed by the actual quality of the coal received. That again was a problem which he was working at, and he found that there was a very great reluctance, as Dr. Ormandy had put it, to accept new methods of selling and buying coal. As long as 10 per cent of dirt could be put in and paid for as coal and freight paid upon it, the practice would continue.

With regard to fire-bricks, he would like to ask the Author whether they were hand-made or machine-made, because the variation was rather more than he had actually come across himself in using some considerable quantities of bricks.

The Paper was headed "Co-operation," but there was very little about it in the Paper. That co-operation was necessary and advisable he thought no one would deny, especially when one realized all the possibilities there were behind the scientific investigation of various problems that arose in ordinary works, and the possibilities that were thereby opened out for the co-operation between the chemist and the engineer.

The call in the gas industry and in quite a number of other industries was for continually increasing qualities of refractory materials. The chemist was already pointing the way to answering that call by first of all purifying the clay, and then by the introduction of other materials than the silica-alumina compounds which formed the basis of all the ordinary fire-bricks. These materials comprised carborundum, which was coming into use increasingly as a high temperature refractory, alundun, which was another similar product, and the newest one of all, zirconia, which seemed to offer possibilities, placing it in the forefront of high-temperature refractories where the call was for a sufficiently high quality to pay for the comparatively high price.

Mr. J. ARTHUR REAVELL (Chairman of the Chemical Engineering Group of the Society of Chemical Industry) remarked that any subject which concerned the co-operation of the engineer and the chemist would certainly receive his very hearty support, because he believed a great many of our industries to-day were suffering simply because the absolute necessity of that co-operation was not recognized. It was not a question of the chemist *versus* the engineer or *vice versa*. It had to be admitted that everything manufactured or produced had to come down to engineering. That was the bed-rock of civilization. But the chemist and the engineer must work together, and this co-operation must be carried out through the chemical engineer who knew the thoughts of the one, and who could translate them into the actions of the other. The question as to whether the seller should have a chemist or the buyer should have a chemist seemed to him beside the point. They had heard from Mr. Gill about the colliery owner selling poor coal, and he sympathized with one of the other speakers who had said that if the buyer was fool enough to buy dirt instead of coal, it certainly was his own fault; but he thought that what was needed was a chemist with the buyer and a chemist with the seller, and then the chemical engineer would be the man who would work out the different details and view the problem in its proper perspective.

A little while ago he had had to examine a case of some evaporation plant in which there was a great variation in figures, that was, in cost. The chemist wanted a certain plant and the buyer, who was a person such as the one who had been described, namely, without any knowledge whatever, wanted the cheapest price. The chemist knew exactly what he wanted as far as chemical work was concerned, but as far as mechanical work was concerned he knew nothing at all about it. On looking over the tenders he (Mr. Reavell) found that the buyer was going to place an order for a plant at a very low price, and he had had to point out to him that he had got a low price because the man was offering him a plant to evaporate a certain quantity of liquor, basing the heating surface upon evaporating "from and at." The other man had taken the temperature of the cold liquor—and liquor with a very high boiling point—and it had never occurred to anybody—certainly the chemist missed it and the buyer could not have understood it—that 14 tons of liquor an hour had to be heated up to its boiling point before it went to the apparatus. That accounted for the enormous difference in price. "From and at" did not convey any meaning to anybody who was dealing with these tenders. The mechanical engineer was constantly using the expression "from and at."

One had a good illustration as to the question of whether or not one should keep a chemist in both buying and selling organizations even before the War: for instance, when buying tubes for use with chemical compounds. He would mention the very common use of tubes in connexion with caustic soda. One went to any of the standard tube makers and said: "I want a solid drawn tube for use in caustic soda boiling." The maker said: "Well, here you are. Here is my tube at so much a foot." "How does it stand under boiling caustic soda of such and such a degree?" "I do not know; buy it and see. You want it. I do not want it." But manufacturers could not afford to buy £2,000 worth of tubing to find out that John Smith's tubing was of no use for caustic soda. He had been offered from the Continent the same material, and a very intelligent letter had been sent to him, saying: "For caustic soda of such and such a density you will have such and such a boiling point, and we would recommend such and such a tube." What was the result? The result was that the buyer was going to the man who could give him the goods. In his opinion, that was really where co-operation came in. Chemists were wanted on both sides, but the co-operation of the chemist with the engineer was needed so that the seller knew what he was selling, and the buyer knew what he was buying. That was what would give this country a chance. All the necessary brains and knowledge were in this country, but we were rather haphazard in how we applied them.

Mr. E. A. ALLIOTT said that in an ideal world there would be the perfect chemical engineer—a man who would know everything about engineering and everything about chemistry. Unfortunately at present he had to be divided into sub-species which ranged from the pure engineer to the pure chemist, these extremes being linked by various types of chemical engineer, either "general" or more or less specialized. One of these might be the engineer, with a very sound engineering knowledge of a particular branch of engineering and at least a sufficient knowledge of chemistry to appreciate all the chemist meant and why he meant it, and with imagination to grasp the part which chemical factors played in his own special field.

Another sub-species might be the chemist with a thorough knowledge of his particular branch of chemistry and, at the least, sufficient engineering common-sense to realize practical conditions involved in ordinary plant. Those were people who might usefully co-operate. It was common knowledge that the extreme types could rarely meet successfully, and even the bare minimum qualifications outlined involved a chemical engineering outlook in both places requiring special study and experience.

The field of co-operation was somewhat as follows. There was first the design of the plant. One had then to settle the conditions which had got to be fulfilled in treating the particular chemical material which one was handling—temperature, pressure, questions of corrosion, and so forth. The engineer by experience would know probably within a fraction exactly what was to be done, but the chemist could help him very much by advising him what small variations in treatment and composition of that material might mean to his problem, and how corrosion difficulties might be overcome. These were very important points which were apt to be overlooked unless, as he said, the engineer had acquired such an outlook as to enable him to realize what knowledge he required in that connexion.

Finally, there was the question of the size and shape and strength of the plant. That, of course, was very largely an engineering problem, although again the chemist could show how certain factors or constituents in the material being handled might affect, say, the transmission of heat in the plant. When the plant came into operation, the importance of chemical knowledge became still more emphasized. For instance, there was the question of filtration. One might put in a filter press or a centrifugal to do a certain filtering operation. There was not much that the engineer could do to control that except vary the speeds or pressures, but the chemical engineer would understand that the best output from that plant could not possibly be obtained unless the material came to it in a right state. For instance, one and the same material might be at one time comparatively crystalline and at another time it might be very gelatinous, depending sometimes on apparently insignificant variations in conditions in the previous processes. All this would affect the output of the plant very much indeed. There was nothing which the engineer could do to help it; it was the chemist who came in there, and the engineer required to have sufficient chemical knowledge to realize where and how far that was so, and to look to the chemist to help him. Conversely, the chemist needed to understand that it was due to him to supply the plant with such a grade of material as would enable it to give its best output.

To come to the question of evaporation, the engineer could build an evaporator to do a certain job. There was the question, for instance, of handling soap-lye. The engineer could build a plant of suitable dimensions to give a certain output if it was reasonably worked, but he could not get that output with any reasonable size of plant unless the chemist came in and helped. For instance, the chemist had to watch that there was not too much organic material in the lye. If there were, it would become too thick and slow moving in the final operation ; it would not be able to circulate as it should, and capacity would be cut down. Again, there was the question of inorganic salts. If there was too much of certain constituents, the salt which came down would not filter properly and one would not be able to get the salt away sufficiently dry or sufficiently quickly from the salt boxes of the evaporator. Then if the chemist allowed traces of fat in his lye, the capacity would be very much cut down because that would affect the output of the heating surface. There was a real need for co-operation between the engineering side and the chemical side of the industry, in order to get good results and to keep the initial costs and the costs of running and maintenance down to levels which would enable British manufacturers to compete with people elsewhere.

Mr. W. A. TOOKEY said there was a need for more intense co-operation between the chemist and the engineer. One of the difficulties which he had found in that connexion was that the engineer spoke in an almost entirely different language and had a different system of units to the chemist. He thought that, if more Meetings of the present character could be arranged, they would then be able to co-operate very much more closely together. It was not every one of them—not every mechanical engineer, at any rate—who had an opportunity of getting into intimate touch with chemists. It was not every chemist who had the opportunity of getting into intimate touch with mechanical engineers. There were many points that must be elucidated by both. Elucidation sometimes meant a great amount of experimental work on both sides. Experimental work was more or less intricate research, and sometimes time and opportunity did not permit one or other to dive very closely into the research portion of the problem, but by co-operation the research sometimes could be short-circuited, so to speak, and especially if the problems were thought of in general principles rather than in points of detail. By the chemist and the engineer putting their heads together, a difficulty—practically an insurmountable one—could often be circumvented by taking another route towards the goal. Even in such a topic as had been discussed that night, Mr. Gill had shown how in the manufacture of gas the variations in the raw material made a great difference to the output of the gas which the South Metropolitan Gas Co. provided.

The South Metropolitan Gas Co. had done excellently well, as everybody who lived in the south of London area knew, in maintaining a constant quality of gas against all the difficulties which Mr. Gill had mentioned. At the same time it must be realized that those difficulties were mainly dependent upon the volatile constituents of the coal. But the coke bulked very largely indeed. Would those difficulties be less immense if, by an alteration of process, the effect of varying percentages of volatiles could be diminished by greater use of coke? Was it certain that the present processes of gas-making were incapable of improvement? Could not cheaper gas and gas of a more regular quality be obtained if gas from the volatiles and gas from the coke were bulked together more than was the practice at the present day ?

Mr. R. C. MACDONALD mentioned that recently he had had the pleasure of reading the autobiography of Andrew Carnegie, and one of the most interesting parts of that fascinating story to him was the portion dealing with the introduction of the smelting of iron in America. In his book Carnegie claimed that he had been the first to introduce chemical control into the manufacture of iron in the United States of America. His modesty evidently prevented him from saying that he had introduced it from his native country. One point which had struck him (Mr. Macdonald) very forcibly had been that, as a result of the introduction of chemical control into the manufacture of iron, Carnegie found that a great deal of the iron ore which had previously been thrown on one side because it was not suitable for the manufacture of iron, had proved to be the most valuable iron ore for that purpose.

While Mr. Gill had been speaking about the refractory materials it had struck him that, if the manufacturers of refractories adopted the same policy, they might find good results and reap the same golden harvest. He quite expected that as a result of this Meeting there would be a rush of engineers and chemists to purchase those refractories.

Mr. L. M. JOCKEL said he was not concerned with gas engineering, but only with the mechanical side. He thought it might interest the mechanical engineers present, and perhaps some of the works chemists, if he mentioned some facts with regard to the quality of coal supplies delivered in the London area. He had taken out some figures from personal tests based on approximately 50,000 tons of Midland coal delivered in the year 1921 at the works at which he was employed, and the figures bore out everything which the Author had said as to the enormous variations in the coal. During the year 1921 the total average moisture in the fuel delivered at the works was 11·3 per cent by weight. The volatile matter averaged 25·2, and the fixed carbon or carbonaceous content was 58·20 per cent, the ash being 16·5 per cent. over the year.

With regard to the question of minima and maxima, he found that the minimum total moisture on a test for the year was 2·7 per cent and the maximum was 19·6. The volatile matter minimum was 23 per cent and the maximum 32 per cent. The fixed carbon minimum was 52 and the fixed carbon maximum was 69·9. The ash minimum was 5·6 and the maximum was 32·2. He had excluded the three months of the coal strike and the deliveries which had been affected by the coal strike conditions. Speaking from a boiler-house point of view, and from the point of view of an engineer engaged in steam production, those figures showed a very poor state of affairs. High boiler efficiencies could not be maintained when the product varied over such wide limits. He was sorry that more had not been heard that night about the sampling and testing of coal, either for gas-works use or for any other purpose, such as steam manufacture. Greater co-operation was required between the chemist and the engineer with regard to methods of sampling and assaying of coal for manufacturing processes. In the United States the question seemed to have been taken up much earlier than in this country, with more or less satisfactory results.

He endorsed everything the Author had said about refractories. He had just been looking at some refractory work in a furnace, and had been struck with the variations in sizes of the bricks which the bricklayer and his mate were using. Some of the figures exceeded Mr. Gill's, but, what was worse than that was the fact that about 10 per cent of the time was spent in merely sorting out bricks.

He was rather surprised at the figures quoted by the Author with regard to carbon dioxide contents, and was afraid that steam-engineers could not do quite so well. They always had trouble with their refractories when they went up to anything beyond 14 or 15 per cent, and that was particularly the case when oil-fuel was being used. Although one had the lower carbon dioxide content, oil firing was somewhat severe on the refractories. He had noticed particularly that at times the refractory material was punished so severely that it was practically impossible to maintain it in certain spots with a very high CO_2 content.

Mr. WILLIAM H. PATCHELL (Vice-President) thought the members must congratulate themselves on this, the third Joint Meeting between the two Societies. It had been intended to be a kind of return match for the Meeting held earlier in the session, but in the meantime they had had an excellent Paper by Mr. West thrown in. Mr. E. V. Evans, Chairman of the London Section of the Society of Chemical Industry, whose name was mentioned by Mr. Gill, had telegraphed from Manchester his regrets that he could not be present at the Meeting. He (Mr. Patchell) had hoped that Mr. Evans, as the Chief Chemist of the South Metropolitan Gas Co. would have been present with Mr. Gill, the Chief Engineer of the Company. He thought the case was really proved that there was a benefit to be obtained from the collaboration of the chemist and the engineer. They had been fighting hard for that for some time, and wanted to get very much closer together than they had done. They also wanted to get other learned Societies together. Closer co-operation between them was needed, if they only saw more of each other and discussed many matters jointly he was sure it would be for the public good. Whether it was co-operation or affiliation or whatever it was called, he was not so concerned with, so long as they did get together. Mr. Tookey had suggested the chemist had a different language from that of the engineer, but he (Mr. Patchell) thought that they did have a common language as when things got very bad they could perfectly well understand each other!

The relation of the iron and steel industries to the chemical industries had been dealt with lately in a Paper by Mr. Cramp, read before the Iron and Steel Institute of America. The figures which Mr. Cramp gave as showing how the chemist affected, and worked in with, the American iron and steel industry were astonishing. Ten per cent of the sulphuric acid made in America was absorbed by one steel company alone, namely, the Standard Company—no less than 600,000 tons of sulphuric acid went to the American steel industries—10,000 tons of hydrochloric, 22,000 tons of sulphur, 3,700 tons of sal ammoniac, and so on. If the iron and steel people used such amounts, was not there an absolute need for close co-operation and collaboration between the chemist and the engineer?

Mr. Gill's analyses A, B, and C of coal interested him very much. Mr. Gill pointed out that in the B and C analyses the ash was in the large dirt. In analysis A it was to be noticed that it was not in the large dirt, but in the bulk. In the collieries with which he (the speaker) had most to do, the coal went over a 2-inch screen. The "large" then went over a picking band. "The small," in some cases, went to a washery. It generally paid to wash coal, and it always paid to buy washed coal if heavy carriage was included in the cost. Lately the extraordinary experiences found with the froth flotation by the P.D. Company had been published. They had what they now called supercoke for metallurgical purposes. An extraordinary amount of dirt had by that system been taken out of the very fine dust coal before it was put into the coke ovens, and had produced supercoke for which qualities were claimed which no coke had previously been found to have. Thus from coal picked on the belts to treatment by froth flotation, there was no limit now to the cleanliness with which coal could be delivered; it was purely a question of paying for it—would it pay?

Mr. James had said that if they did not like their coal they should not take it. Mr. James had only lately come to London from off the coalfield, where one could have what one liked; but in London one had to take what one could get. He had had to take anthracite at £5 a ton and then had to buy other coal to burn it.

As to the question of how much ash could be carried, Mr. Fedden had lately quoted in that room that he had been getting 20 to 30 per cent. Twenty per cent was a good old standard in South Wales "small" if it was used on the job. Mr. Bennis had said that in Lancashire he had burned stuff with 50 to 60 per cent of ash. Of course, one could burn bricks, but it depended how far it paid! If one had a train of 100 trucks only 50 of which contained combustible coal, the other 50 containing ash, one could see what the transport people were in for, and the buyer paid carriage for the lot.

The question of fire-bricks was very important for another reason than that mentioned by the Author. The bricks must match up. One speaker had mentioned that he had to match best with other fire-bricks. Those of the members who were familiar with the old B.W. drawings would recollect that they showed ordinary bricks for the outer part of the setting and fire-bricks for the fire side of the setting. He had never believed in that. He had sometimes used glazed bricks on the outside of a boiler so as to stop air leakage. With a glazed brick, a good square brick and a good clean joint were obtained, but he had never yet found a glazed brick which would match up with a fire-brick. When not using glazed bricks, he had always used a lower grade fire-brick for the outside and a high-grade fire-brick for the inside, and there was a very real difficulty. There should be no difficulty whatever, as Dr. Ormandy had pointed out, in so mixing the clay and in getting the right proportions when one knew what the shrinkage was. The cost of brick-setting was almost more important than the cost of bricks, and the cost of repairs was worse still. One speaker had mentioned that it was profitable to pay a higher price. Some people were using carborundum bricks, for which one did not pay so much per thousand, but so much per brick, and they had found that it paid to do so.

Then there was the question of what temperature the fire-brick would stand, and not only that but what would be the reaction of the ash in the coal at those temperatures. Engineers did not know that; they wanted the chemist to help them. The chemist could not tell them by the light of nature, but had to go into the works in order to see the difficulties with which the engineer was contending.

He sympathized with Professor Hinchley about the buyer. But there was also the seller to take into account, and he was not quite sure when Professor Hinchley said the buyer and when he meant the seller. There were some sellers on the road who ought to be pensioned, but there were others with whom it was a pleasure to deal. It was a very bad business for a man to send out representatives to sell his materials who did not really know what they were selling.

As to the question of coal standards the first coal standards he had seen published were those arranged for the Greenwich Power Station of the London County Council Tramways, about 1909. Mr. J. H. Rider, in introducing them,* stated that the coal merchants were very dubious about it to start with, but when they found that they could really work to them and get benefit from them, as also the buyers, they worked well. No doubt during the War those standards had been dropped, and how they managed to-day he did not know. He had tried himself before that time to do the same thing, but he had failed, as he was not such a large buyer as the London County Council, but he had got something approaching it, with beneficial results to the seller and to his company.

With regard to the last part of the Paper, dealing with gas, Mr. Gill had said nothing about pressure. If it was strong enough to give a 1½-inch or 2-inch pressure at the outlet of the pipe, the gas could be burned.

The PRESIDENT said, arising out of the discussion, he would like to know whether the British Engineering Standards Association had appointed a Committee to standardize the dimensions of fire-bricks and the errors permissible in those dimensions.

Professor HINCHLEY said that a Committee on that subject, of which he was Chairman, had just been appointed by the British Engineering Standards Association.

Mr. GILL, replying to the discussion, expressed his thanks for the manner in which the Paper had been received. Dr. Ormandy had given much useful information, which however needed no reply. Both Mr. James and Mr. Patchell had spoken about the washing of coal. Not many gas-works used washed coal—in fact, he did not know that there was much available for gas-making purposes. At the same time, it must not be overlooked that a good deal of

* Journal, I.E.E., vol. xliii.

water was left in coal that had been washed; and this had to be got out before they could start gas-making. They lost a lot of ash by washing, but gained a good deal of water.

As to low-temperature carbonization, about which Mr. James spoke, gas engineers generally were not greatly enamoured with this. There were many difficulties with it, and the gas engineer generally could see more money in what he was doing than in what he was not doing. Low-temperature carbonization would possibly succeed in the future; but from the carbonization point of view it was not much of a process. Mr. Dolby spoke of the CO_2 figures. All the Author's producers were deep ones. He did not regard the figures he had given in the Paper as being very special ones. There was no great difficulty, with ordinary control, in gas-works, to get figures within those limits of 16·2 and 19·7 per cent. The ordinary Orsat apparatus was used to make the tests referred to in the Paper. Mr. Dolby had also spoken of different makes of brick, which contracted and behaved differently under high temperatures. His Company in the past had used certain bricks which expanded in one part of the setting, and bricks which contracted in another part; and to a large extent, these counteracted each other. It would, of course, be better still to use bricks of a material which neither expanded nor contracted; and this was gradually becoming possible. Brickmakers were gradually giving more attention to this point, though they were in a small minority at present. Before the War, his Company went to Germany for all their retorts, because they could not get those of the necessary quality in this country. When he told them his Company had eighteen miles of retorts in use, they would realize what a big thing it was. As to insisting upon having what they wanted, as mentioned by Professor Hinchley, he dared say this would come about in time; but it took a very long time. In the meantime, they had to take what they could get, because they could not get what they wanted. Professor Hinchley also made the point of the advisability of paying more for a better article—that quality was the great thing, and price of secondary importance. He absolutely agreed, especially in the case of refractories, because it was all-important to use the right material, provided the cost was within reasonable limits. As to sampling, mentioned by Mr. Booth, the coal was tipped down shoots into the ships, and as it came down, something like a bucket at the end of a stick was immersed into the coal at fairly frequent and regular intervals right through the time the cargo was being loaded. About 10 lb. of coal was collected in the bucket at each immersion. The sampler could not see what was coming down,—and this was always important when sampling—because it fell much too fast for that. The quantity taken for the sample was quite a large one consisting of roughly $\frac{1}{1000}$th part of the whole cargo. The sample, when completed, was divided by screening into two parts, under $\frac{1}{2}$ inch and over $\frac{1}{2}$ inch. Further, the coal over 1 inch in size was picked clean of impurities. All the large coal was then broken down and thoroughly mixed with the small. The heap was then reduced by the well-known long pile method to obtain the laboratory sample. He believed the system was one which had commended itself to the colliery owners, to whom the results were supplied. Indeed, in many cases he believed that this was the only way they knew what coal they were producing. His company had not made a contract for coal by which payment was made on the basis of quality, upon which subject, however, a great deal of information had been collected. Mr. Reavell had also said that it was the buyer's fault that he did not get the right stuff. But, again, he could only say that if no one was making what they wanted, they had to put up with what they could get. Mr. Tookey suggested that variations in the quality of gas might be reduced by making more or less gas from coke for admixture with coal gas. In reply he would say that such admixture tended to increase rather than to reduce the variations in the character of the gas supplied. In making standard gas he would prefer to make coal gas only, however much the volatile content in the coal might vary, rather than to attempt to improve matters by introducing water-gas. He was interested in Mr. Jockel's figures, because they were worse than his own.

Mr. Patchell enlarged upon the practical difficulties of using bricks which did not match up. Not only did bricks of different grades and qualities, of the same nominal size, not match up, but bricks of the same grade and nominal size from the same maker sometimes varied just as greatly. He agreed entirely with Mr. Patchell with all he said on this subject, and would further suggest that the formation of a Refractory Users Association might be worthy of consideration. Such a body could, with a united voice, put before refractory makers the requirements of industry to-day.