

that the whole question would then be discussed by the Standardisation Committee, and that mutual good would result to manufacturers and users alike. He did not think nearly sufficient well-burnt grog was got into fire-clay goods. The difficulty was that the clays would not carry it. It was usually not possible to get more than 25 per cent. or 30 per cent. into Stourbridge clay. If they were going to improve the suitability of Stourbridge clay for retorts and other goods which were subjected to variations of temperature the clay would need to carry more grog. In Germany it was a common thing for such material to contain 50 per cent. and 55 per cent. of grog. The small particles were taken out and only the large were added; but the Germans had clay which would carry the grog, and they imported what they needed. Instead of getting the clay from the ground and using it unmixed, they bought large quantities of suitable material from all parts of the world, and then combined them as desired. What they had not got they bought; and they had in consequence obtained very successful results.

Mr. F. R. O'SHAUGHNESSY asked for information as to the influence of lime and magnesia in clays, and their influence on the life of tiles and agricultural drain pipes made therefrom. His experience was that such goods varied in their weathering properties. He had examined samples of agricultural drain pipes containing 7 per cent. and 8 per cent. and even more of lime and magnesia. What should be the safe maximum of those constituents?

Mr. H. T. PINNOCK enquired as to the comparative refractoriness of bricks in relation to the fire brick. His firm had been using silica bricks for a high temperature furnace, and when they contracted the crown of the furnace fell in almost immediately. He thought it was necessary to protect the Seger cones. He had found that cones which should have melted at about 1100° melted at about 950° C.

Mr. F. H. ALCOCK, discussing the types of furnaces to which reference had been made, said it appeared to him in one of the examples (that mentioned by Prof. Turner) in which graphite was used they would find that a considerable amount of alkali would be forced by the blast against the cone. Being largely potash or soda, possibly more potash than soda, it would greatly affect the fusion point of the cone, if his surmise was correct. He thought himself that such an apparatus would not be conducive to accuracy. It appeared to him that very much was to be said in favour of the electrical furnace. He was surprised to know that weak acids, such as nitric acid and hydrochloric acid, disintegrated the felspathic products, and would like to know whether, in the elutriation of clays any hydrolysis took place, and whether the quantity was affected other than the more uniform gradation of the size of the clay particles. He was interested in the suggestion with regard to sedimentation. Mr. Tucker suggested that if a little alum be introduced it expedited precipitation. There was considerable difficulty in filtering many precipitates, and amongst them he named antimonious acid, but the addition of diluted acids, such as nitric acid, was remarkably effectual in causing rapid precipitation and clear filtration. Ammonium chloride was also as effective in this direction as in the case of barium sulphate. What was the explanation of this use of alum seeing that many of the minerals were themselves aluminous?

Dr. DAVIDSON said in the furnace to which he alluded a liner was always used, and the gas did not impinge on the objects under test. His references to grog were to bad grog, which might contain a large percentage of iron oxide.

The CHAIRMAN said, with regard to the elimination of alkalis by heat, under the conditions of the small experiment described, it was possible that a slight percentage of alkalis originally present in the clay would be volatilised; but he did not think that loss would occur when dealing with fire-clay goods in the mass, as would be the case under ordinary working conditions. He had analysed firebricks and retorts, and also the clays used in their manufacture, but had been unable to detect any diminution in the percentage of alkalis originally present in the raw material as a result of the firing.

Mr. TUCKER, in replying to the discussion, pointed out, in regard to the question raised by the chairman, that the temperatures at which the alkalis volatilised were very

high, and although these were the results of heating comparatively small pieces of the clay, he thought the experiments described by Seger and by himself were sufficient to illustrate an important point in practical working, i.e., the reality of volatilisation of these alkalis, etc. He did not know whether it was appreciated before Seger's paper, but it appeared to him that the bearing of it in technical work was great. As to the character of the furnace he had described as affecting the melting point of the Seger cones, he hoped they would not think he presumed he had got together something for which he claimed great advantages. The apparatus was in a simple, inexpensive form, and did its work. Retort carbon and graphite were not always available. Petroleum nearly always was, and mechanical power for obtaining the blast was not always obtainable or convenient; but his apparatus had its own self-contained blast, and on that point showed many points of practical convenience. He suggested that Mr. Alcock might be a little off the line in his reference to alkalis impinging on the test piece in the furnace, because retort carbon would not contain alkalis except as mere traces, but ordinary coke might seriously affect the results. With regard to the action of water on clays by hydrolysis he had not the slightest doubt that that was a reality. It was a point he wished emphatically to bring out in the paper. If clay, any clay practically, were treated by water and given sufficient time, one could always obtain an alkaline reaction in it. He regretted he was unable to give any information with respect to the contractions of silica goods, or to the respective melting points. But it seemed that silica would be more suitable, under certain conditions, than the fire-clay brick, where corrosive materials were in contact with them. The two bricks, he conceived, would have their respective uses. He was unable to answer Mr. O'Shaughnessy's enquiry as to what was the influence of lime and magnesia on the coarser kinds of goods. The only reason for disintegration he could suggest was the probability that they were not glazed goods. (Mr. O'Shaughnessy: They were not glazed.) They may have been destroyed by the frost. (Mr. O'Shaughnessy: No, because they were five feet underground). Mr. Page raised a question on the obscure subject of the plasticity of clays—a subject which had puzzled eminent chemists and physicists, and on which a satisfactory theory had not yet been arrived at. Therefore it would be well to define terms before discussing the matter. He was not sure he agreed that china clay was less plastic than fire clay. He agreed with Mr. Page in his suggestions as to the use of grog. Perhaps it would have been better had he pointed out that not only did it reduce the shrinkage, but must, obviously from keeping the clay much more open, give facilities for drying the goods which would not otherwise be available. He was glad to notice Professor Turner appreciated his suggestions as to the chemical character of the weathering of clays. He (Mr. Tucker) certainly could not claim any merit of novelty on the point. The novelty he did want to bring out was that it should be more generally recognised that something was done by the weather and that weathered clay was substantially more refractory and more plastic than raw clay.

He did not approve of Mr. Rees' suggestion for a change in the nomenclature from kaolinite to clayite unless some benefit was to be derived, seeing that the name was recognised by chemists generally—certainly in Germany and France. They regarded kaolinite as the acting principle of clays, and any new name for this body was evidently undesirable.

Scottish Section.

Meeting held at Glasgow, on Tuesday, February 22nd, 1910.

MR. D. J. PLAYFAIR IN THE CHAIR.

THE RETORTING OF COAL.

BY HENRY O'CONNOR, A.M.I.C.E., F.R.S.E.

The subject of the retorting of coal is a very important one, when it is considered that in Great Britain alone some 15,000,000 tons of coal are annually carbonised

for the making of gas. For many years gas engineers were justly accused of shewing little progress in the methods of applying the necessary heat to the conversion of the solid coal into the very complex matter called "gas" and the residual coke. Of recent years, however, proposals have been brought forward for improving the yield of gas as to both quantity and quality, whether illuminating or calorific, and also making a better coke.

There is no doubt that one of the greatest advances was made when Siemens introduced his gas-fired furnace, when he proposed the partial combustion in the furnace and the final conversion to carbon dioxide among the retorts. The adoption of most of the modern methods of retorting coal would be impossible without this system of firing. The next movement in the direction of improvement occurred about 25 years ago, when Coze introduced his system of sloping retorts at Rheims. He was not the inventor of sloping retorts, as these were apparently tried by Murdoch, the first inventor of gas. Coze, however, arranged a complete system of setting such retorts together with charging apparatus, which there is no doubt considerably reduced the labour and cost of gas-making. Mr. Newbigging, many years ago, laid down the axiom that "Dividends were made in the retort house" and if so it is in the retorts themselves where we must look for the making of the largest profits. It is little use saving money in the after-purification methods, if the gas has not been all evolved from the coal in the retorts, or the impurities have been increased owing to imperfect carbonization. The fundamental principle of the sloping retorts is that they are set at or about the angle of repose of the coal, which may be roughly said to be from 30° to 33° and nearly all the installations of this style are put up with the floor of the retorts lying at an angle between these two extremes. The coal then slides down, when given the slight impetus of being tipped in, but does not mass at the bottom, lying at various depths according to the rate at which it is tipped. This gives a very even layer on the floor of the retort, which is, of course a great desideratum, as any great difference in the thickness will mean that the time when the charge will be completely burnt off will vary, and sulphur, carbon dioxide and other impurities will be given off from the thinner portions, while the others will be still evolving gas. This applies equally to horizontal retorts, worked in the ordinary way.

The most recent adoption of these sloping retorts on a large scale is probably that of Mr. Herring at the Granton Gas Works, Edinburgh, where the average make per ton, throughout the year 1904 was 10,438 c. ft.; in 1905, 10,802 c. ft.; in 1906, 10,982 c. ft.; in 1907, 10,953 c. ft.; in 1908, 11,074 c. ft.; and in 1909, 10,690 c. ft. The entire costs of carbonising, including wages for foreman, discharging coal, attending to coal breakers, elevating, conveying coal to the bunkers, charging and drawing retorts, attendance to mouthpieces, cleaning and repairing retorts, greasing machinery, furnace attendants, hot coke conveyor, and engine men attending to the machinery were for 1904, 1-482d. per 1000 c. ft.; in 1905, 1-3d.; in 1906, 1-28d.; in 1907, 1-245d.; in 1908, 1-212d.; and in 1909, 1-263d., or probably little more than half the average cost of such work in the principal cities in this country. These figures are actual working results and not test results only. The retorts are D shaped, 20 ft. long by 22½ in. by 16½ in. high, set at 32° with the horizontal and the coal lies about 7 in. thick over the floor of these retorts and is completely carbonized in four hours. In this respect they follow the usual custom with Scotch coal in horizontal retorts of four hour charges, but in England the coal used there requires the longer period of six hours to complete the carbonization.

The late Mr. Love of the Guildford Gas Works introduced a sloping retort on an angle of 45° with the horizontal, which he arranged to fill completely with coal, and at such an angle the coke would easily fall out. Owing to his death, complete figures are not available of the results from these retorts, but, by the courtesy of Messrs. Winstanley, who are erecting these retorts, I am able to give some tests made by Dr. Harold G. Colman, of the tar

and ammoniacal liquor from these retorts, which are as follows:—

1. Tar—Sp. gr. at 60° F., 1.095; water (i.e., amm. liquor), 2.2 per cent. by volume. The amount of water is fairly low, but would probably be still lower if the tar had the amount of time for settling in the wells, which it gets under normal manufacturing conditions.

Distillation test.—The following are the results of the distillation, and for comparison are added the test carried out in the same way, of a sample of coal tar from Durham coal carbonized in horizontal retorts with a yield of about 11,500 c. ft. per ton. In both cases the results are calculated for the tar freed from water.

	Tar from 45° retorts.	Tar from horizontal retorts.
	per cent.	per cent.
Boiling below 170° C.	4.4	1.1
" 170°—270°	28.5	13.1
" 270°—350°	10.2	13.2
" above 350°	47.5	72.1
So called "free carbon"	2.6	28.7

The middle oils, boiling at 170°—270°, differ not only quantitatively, but also qualitatively in the two cases. Whereas that fraction from the horizontal tar becomes almost solid from separated naphthalene on cooling, that from the 45° retorts remains completely liquid at ordinary temperatures, shewing that the proportion of naphthalene in the tar to other liquid substances having about the same boiling point, is very much smaller in the 45° tar; it is probable that under these conditions, and with the higher amount of light oils present, there will be no trouble from naphthalene in the gas.

The heavy oils from the 45° tar, deposit some crystals on cooling, but to a much smaller extent than the corresponding fraction from the horizontal tar.

Owing to the very small quantity of free carbon present, the pitch from the 45° tar, is very different from that prepared from the horizontal tar, having a bright jet like appearance.

(2) *Ammoniacal Liquor.* Sp. gr. at 60° F. 1.045—9.0° Twaddell.

Analysis.

	Grams per 100 c.c.	Ozs. strength.
Volatile ammonia	2.38	10.98
Fixed ammonia	0.66	3.07
Total ammonia	3.04	14.05
Sulphuretted hydrogen	0.10	
Carbonic acid	4.34	
Amm. sulphocyanide	0.25	

In this case the oz. strength does not agree with the usual assumption of oz. strength = 2° Twaddell on account of the percentage of carbon dioxide in the liquor, which is unusually high proportionally to the amount of ammonia present. The sulphuretted hydrogen is low, and that of ammonium sulphocyanide also.

The results seem to indicate that the amount of cyanide in the gas from the 45° retorts is low, but that the percentage of carbon monoxide is rather high.

The latter is what might be expected with a full retort as the gas does not get heated to so high a temperature, and the tendency then is to increase the amount of carbon dioxide and diminish that of the monoxide.

A more recent plan, which has been adopted in England with horizontal retorts, and which was first suggested by Mr. C. C. Carpenter, of the South Metropolitan Gas Company, is to fill the retort completely with coal, so as to utilize the whole space, and to cause the gas to pass

quickly out of the retort and to reduce the number of times the mouthpieces have to be opened, which of course causes a certain loss of gas. This plan was impossible with scoop charging and with the ordinary methods of drawing the coke, as room had to be left for the rake to pass over the top of the coal to draw it out. It is also impossible with any but through retorts. The de Brouwer charger, which by the movement of a rubber band, driven at varying speeds by electricity, projects the broken coal in a stream throughout a 20 foot retort, has enabled the complete filling of it; and the use of the various pushers for forcing the coke out at the opposite side has provided means for removing the coke when the carbonization is completed.

Mr. Bell, of Derby, with such completely filled retorts, obtained the following results with medium Derbyshire gas coals and 25 per cent. good rough Derbyshire coking slack added, with 12-hour charges and 80 retorts in use.

Gas made per ton	11,463 c. ft.
Candle power (No. 2 Met. burner)	14.77
Sperm value per ton	580 lb.
Calorific value per c. ft. of gas gross	134.6 calories.
Calorific value per c. ft. of gas net	122.6 calories.
Impurities in crude gas, carbon dioxide volume	3.25
Impurities in crude gas, hydrogen sulphide per 100 c. ft.	620 grains.
Impurities in crude gas, carbon bisulphide per 100 c. ft.	47.4 grains.
Coke for sale per ton of coal	10.34 cwt.
Breeze for sale per ton of coal	1.33 cwt.
Tar for sale per ton of coal	12.84 galls.
Ammonium sulphate for sale per ton of coal	34 lb.

There is no doubt that the idea of this system was due to the methods adopted in the coke oven plants, many of which have been in use for a long time.

The coke ovens are usually set in batteries of 50; each retort being about 35 ft. long by 6 ft. high and 18 in. average width and these hold some 6 tons. Like the ordinary horizontal through retorts these are open at each end and have luted doors. The coal is charged through three or more charging holes in the roof of the oven and then it is levelled and the luted doors closed. The hydraulic main, as in a gas works, is not always used, but a rising pipe and ordinary main serves the purpose, valves being provided. The gas is rich at first but poorer later. With coke ovens for the making of foundry coke from slack coal the latter half of the gas made is used for heating the furnaces through tuyères with hot air, but in the gas coke ovens the heat is obtained by regenerative coke furnaces. The charge usually works off in 24 to 30 hours and is then mechanically pushed out from one end and quenched as it leaves the oven. Coke ovens reduce labour to a minimum by larger charges and long periods of carbonization. Recent practice requires that the coals should be broken and compressed in moulds the same size as the oven and then, while so compressed, run into the oven and not put in through the top. It is said that an increased output of 10 per cent. is obtained of a denser coke, with less breeze and wear on the oven lining and a saving of labour.

Mr. Thos. Glover, of Norwich, has devised chamber retorts which follow somewhat the same ideas as the coke ovens, but are smaller, holding only about one-sixth the coal. With them, however, the number of operations is greatly reduced, as compared with the ordinary horizontal retort practice, and the losses through opening and closing the mouthpieces are lower. The ammonia is considerably increased, by some 15 per cent. to 17 per cent.; the tar is distinctly thinner with much less "free carbon" and some 20 per cent. increase in quantity, of greater value, it is easier distilled and contains more benzenes and other hydro-carbons; the naphthalene, however, is not reduced. The carbon in the retorts is found at the top only, showing that the gas passes along the top of the retort, but owing to the small space through which the gas has to pass, the sulphur is not long in contact with the carbon and therefore less is combined with it, in the form of carbon bisulphide, and more of it is found in the form of hydrogen sulphide.

The first installation of these retorts at Norwich consists of a single bed containing six chamber retorts each 21 ft. in length, 3 ft. in depth, and increasing from 12 in.

in width at the charging end to 13 in. at the discharging end. The vertical sides of the chambers are slightly cambered in order to allow of their straightening out under the internal pressure set up by the expansion of the brickwork when heated. The six chambers are set horizontally in an arch of the same dimensions as those containing 10 ordinary retorts set in five rows, each containing two retorts. These retorts should not sag owing to their deep vertical sides. In ordinary retorts the heat is required at the bottom, but in these narrow filled up retorts it is required at the sides and is so supplied in these Norwich settings. Mr. Glover found that with ovens 12 in. wide the rate of carbonization equalled 0.5 in. per hour from each side, with ovens 16 in. wide, 0.47 in., and 17 in. ovens, 0.425 in., and 20 in. ovens, 0.305 in. From these figures he was able to easily decide the proper length of carbonization.

The charging of the coal is effected by a de Brouwer projector, the retort being filled as full as possible, except at each end, where the coal is allowed to slope at its natural angle of rest. The coke discharge is effected by a de Brouwer ram discharger.

Owing to the fact that the bed of chamber retorts is working in conjunction with the ordinary beds of retorts in the same house, the gas mixing in the foul main, Dr. Colman was only able to make a test at such times as the ordinary retorts were shut down for the usual Sunday stop from 10 a.m. to 10 p.m., and the period of the test was therefore limited to 12 hours.

The gas made during the test period passed through the ordinary works condensers, scrubbers and purifiers, but although as many of these were shut out as possible, the plant actually in use was very large for the volume of gas being made, which had the disadvantage that any small quantities of air getting into the gas, on the vacuum side of the exhausters, would represent a large percentage of the actual volume of the gas passing; it appeared, therefore, not unlikely that from this cause the gas made would contain more nitrogen than is normally present, which would somewhat increase the make of gas per ton and simultaneously reduce the illuminating and calorific power.

The test was carried out between 10 a.m. and 10 p.m. on Sunday, October 4th, only the bed of the chamber retorts being at work during this period, precautions being taken to ensure that no gas from the other beds could possibly mix with the gas from the chamber retorts. The temperatures of carbonization was judged to be 2,000° to 2,100° F. and during the test, except while charging was in progress, the retorts were worked without seal, the pressure in them being maintained as nearly as possible about 1/10th of an inch by means of the retort house governor.

The coal employed consisted of washed nuts, from the South Yorkshire district, a sample of which gave the following analysis:—

	per cent.
Free moisture	2.14
Volatile matter, not including free moisture	31.14
Ash	4.43

Three chambers were charged at 10 a.m. and the remaining three at 4 p.m., the period of carbonization being 12 hours, 6 tons 6 cwt. was used, or an average of 21 cwt. per chamber. The gas made was 84,300 c. ft. at 64° F. and 30 in. bar, or 83,457 c. ft. at 60° F. and 30 in. bar, equal to 13,247 c. ft. per ton.

The coke was of good character, bright and lustrous, and of a size and hardness intermediate between that of ordinary coke and metallurgical oven coke. On analysis it gave the following figures:—

	per cent.
Free moisture	0.56
Volatile matter, not including free moisture	0.58
Ash	7.70

There was a marked decrease in the free carbon in the chamber tar as compared to the ordinary retort tar and an increase in the proportion of heavy oils, showing that the volatile products from the coal were not subjected to the action of so high a temperature before escaping from the chamber as is the case with the ordinary retorts.

The results obtained in the analysis of the gas from the chambers show that, as was expected, the nitrogen content was high, namely 9·7 per cent. as against 5·0 per cent. obtained in the coal gas working under normal conditions, this excess being due to the infiltration of the air. Had the percentage of nitrogen been only the same as in the coal gas the make per ton would have been reduced to 12,024 c. ft. per ton, whilst the illuminating power in the No. 2 met. argand would have been from 16 to 16·5 candles, the gross calorific power 576·1 B.Th.U., and the net 518·2 B.Th.U.

	Chambers.	Ordinary.
Gas made per ton.....	13,247 c. ft.	
Ill. power in No. 2. met.....	14·94 candle.	15·84 candle.
Calorific power gross by Junker	549·48 B.Th.U.	565·0
do net.....	493·9	512·6 candle.
Sulphur in purified gas.....	45·7 grs.	per 100 c. ft.
Free carbon in tar.....	11·1 per cent.	
Sp. gr. at 60° of tar.....	1·18	1·22 per cent.
Water, per cent. in tar, by volume	10·1	6·0

Analysis of dry tar.

	Per cent.	Per cent.
Light oils up to 170°.....	0·4	1·4
Middle oils, 170° to 270°.....	10·2	10·5
Heavy oils, 270° to 350°.....	30·1	16·14
Pitch above 350°.....	53·9	71·8
Naphthalene.....	4·7	4·7
Free carbon.....	11·1	23·2

Dr. Lessing has summed up the advantages of the carbonization in chambers generally as follows:—

Long period charges permit a great saving in labour and consequent reduction in carbonizing cost, particularly in the case of 24-hour charges, where no night work is required, except for tending the producer fires and watching the process. High make of gas, due to limited secondary decomposition therefore good calorific value. Little carbon deposit; scurfing to be done easily and conveniently. Ascension pipes kept clear. Small consumption of fuel and little loss through radiation. Coke of very good quality and size. Tar thin and containing little free carbon. Smaller heated surface per ton of coal carbonized than in retorts, and less chance for decomposition and infiltration of flue gases. Large yield of gas on small area covered, manipulation is simple and comfortable for the men. The life of the plant should be considerably longer than that of ordinary retort plant.

The disadvantages being:—Low illuminating power. This, of course, is in this country, and in view of parliamentary obligations, an all important factor. High cost of installation, which, however, can soon be made good by greater economy in working and smaller capital charges on account of higher durability.

The Dessau vertical retorts patent thus describes the invention:—The manufacture of gas by subjecting coal to distillation in a vertical retort heated to a higher temperature than is usually employed in gas manufacture so that the coke is formed from the internal walls of the retort inwards and the gas generated passes inwards and upwards through the central portion of the charge, the retort being charged with coal up to the same level as that up to which the external heat is applied so that no space is left in which the tar can quickly separate, it being compelled to pass upwards through the uncooked portion of the charge, before leaving the retorts. This gives a good idea of the points of interest about this system, though whether all the claims can be substantiated in law is doubtful. These vertical retorts which are some 4 metres long (say 13 ft.) diminish in cross section towards the top to ensure the easy removal of the coke past any inequalities on the face of the retort. Chambered vertical retorts or large units have been tried, but were not successful. It is claimed that the gas from these vertical retorts requires only half the purification of that from inclined retorts, while the sulphur is reduced and there is little or no formation of pitch or thick tar in the take-off

or dip-pipes. Designs have been made for the installation in small units which will make only some 100,000 c. ft. per day.

In these retorts the coal is inserted periodically and the whole mass carbonized, as in coke ovens or completely filled horizontal retorts, and when the process is finished, they are emptied and a new charge again inserted. In this way the gas given off must pass through various depths of completely or partially carbonized coal and the products must vary from hour to hour.

The most recent installation of this system has been at the Sunderland Gas Works where the guarantee tests of the four metre retorts was as follows:—

Duration of test (10 a.m. Jan. 6 to 10 a.m. Jan. 7)	48 hours.
No. of retorts at work.....	60
Duration of charge (no steaming).....	11 hours.
Coal carbonized (Holmside Durham).....	124·11 tons.
Gas made corrected to 30-in. bar and 60° F.....	1,492,900 c. ft.
Gas made corrected per retort.....	12,441 c. ft.
Gas made corrected per ton of coal carbonized.....	12,028 c. ft.
Illuminating power (No. 2 Met. burner).....	17·55 candle.
Calorific power (gross).....	635·4 B.Th.U.
Calorific power (net).....	568·9 B.Th.U.
Coke used for fuel dry.....	17·33 tons.
Coke used for fuel per ton of coal carbonized.....	13·96 per cent.
No. of retorts at work (12-hour charges including one hour's steaming).....	60
Weight of average charge of coal (12-hour charges including one hour's steaming).....	9½ cwt.
Gas made per ton corrected (12-hour charges including one hour's steaming).....	12,405 c. ft.
Ill. power (No. 2 Met. burner), (12-hour charges including one hour's steaming).....	16·84 candle.
Calorific power net (12-hour charges including one hour's steaming).....	550·2 B.Th.U.
Sulphur (carbon bisulphide) in purified gas (oxide only).....	20 grs. per 100 c. ft.

The Woodall and Duckham system of vertical retorts uses the continuous carbonizing process and the retorts are made up in about 3 ft. lengths to 25 ft. long, with cast iron mouthpieces. Their dimensions are 20 in. by 29 in. at bottom tapering to 9 in. by 21 in. at top, where a rotary feeding device is attached and a gas off-take pipe at side of same. This device consists of a faced cylindrical drum rotated by power. The coke extractor can be set to remove the coke at any desired speed and the coal feeder is worked in proportion. The retort is always kept full of coal so that the gas as soon as it is made has to pass constantly through the same thickness of uncarbonized coal. The hottest part of the retort is near the top, as the combustion chamber, which is built entirely of silica brick, is there, and the heating gases descend to the bottom of the retorts before entering the regenerator chambers.

Tests made with these vertical retorts at Nine Elms Gas Works with coal which had been stored in the open, and was wet; but in which no allowance had been made for moisture shew the following results:—

Coal used (Birley Silkstone).....	80·3 tons.
Gas made.....	1,072,204 c. ft.
Gas made per ton.....	12,423 c. ft.
Ill. power (No. 2 Met.).....	15·82 candle.
Spent value.....	674
Calorific value (gross).....	596·6 B.Th.U.
Calorific value (net).....	530·7 B.Th.U.

Composition:—Carbon dioxide, 2·22 per cent.; hydrocarbons, 2·88 per cent.; oxygen, 0·27 per cent.; carbon monoxide, 7·41 per cent.; methane, 35·05 per cent.; hydrogen, 45·85 per cent.; nitrogen, 0·32 per cent. It will be noticed that the proportion of carbon monoxide is not high and therefore the gas does not partake of the nature of water-gas. There is an increase of gas and ammonia, better coke and tar, less cost for land and buildings, less nitrogen, less fixed sulphur and less naphthalene. Improved working conditions and less wear and tear of retorts.

It was at first thought that the introduction of steam to make some water-gas would be advantageous, but up to now this has not been found so. This would, of course, utilize some of the heat in the coke after carbonization which unless it can be fed directly into the furnace while hot, is lost. If a lower candle power and calorific value would satisfy the people of this country as it does on the

continent, then no doubt the steaming could be carried out and full advantage of this heat be obtained.

The Glover-West vertical retorts at St. Helens have 20 ft. retorts 24 in. by 12 in. at top expanding to 30 in. by 18 in. at bottom. Each carbonizes about $2\frac{1}{2}$ tons a day, and each charge is 12½ hours passing through the retort. The producer is at one side and is fed with cold coke. The secondary air is heated by the coke before discharge, and the highest heat is at the top rather than at the bottom. The coke in the retort rests on a plate at bottom which is swept by an arm at any desired speed and the coke falls into a chamber below, from which it is periodically removed, this chamber is luted with water. There is no steam admitted for the purpose of making water gas. The lower portion of the charge for 2 or 3 ft. is coke then the uncarbonized portion takes a V shape, gas passes through uncarbonized coal, and issues at 160° C. (320° F).

The average results per ton from three coals, one from Durham (Thornley) and two from Yorkshire (Barrow Colliery and Wigan Arley Mine) are given below.

Gas made per ton.....	12,561 c. ft.
Quality by No. 2 Met. burner.....	15.66 candle power.
Calorific power, gross 578.2 net.....	517.6 B.Th.U.
Coke, dry.....	13.8 cwt. per ton
Fuel per cent. of dry coke.....	12.6 per cent.
Tar.....	11.81 galls.
Ammoniacal liquor galls. of 10 oz. per ton.....	28.1=23.7 lb. of sulphate.
Cyanide ($\text{Na}_4\text{FeCy}_6, 10\text{H}_2\text{O}$) lbs. per ton.....	5.54.
Naphthalene.....	31.1 grains per 100 c. ft.

The tar is not reduced in quantity and is much freer from carbonaceous matter, it may amount to 12.9 galls. per ton of coal.

The production is 60 per cent. greater for the same ground space. The system of regeneration by absorption of heat from the coke at bottom of retort is only applicable to verticals. The coke is decidedly improved, there are no stopped pipes or pitched hydraulics. The same coals used in the ordinary horizontal retorts would only make some 10,250 c. ft. per ton. From such continuous carbonization there is no smoke.

E. Körting states the disadvantages of continuous carbonization as follows, but I think I am right in stating that he is interested in the intermittent system:—

1. Separate charging and discharging machinery is required for each retort. 2. Continuous movement of the whole contents of the retort cannot possibly be advantageous to the coke. The economy of the system would be very dubious if the reduced durability of the coke increased the quantity of breeze by only a small percentage of the weight of the coal carbonised. 3. It is impossible to inspect the inside of the retorts, because they are always full, and to ascertain whether they need repair and whether the coal is properly disposed in them.

The latest proposals for vertical retorts come from Mr. Herring, of Edinburgh, who is erecting at Granton Gas Works a single setting of these retorts, upon the same area as is at present occupied by one of the ordinary sloping retort beds, a set of six vertical retorts. The arrangement allows of the heating of the retorts in almost any manner, either with the greatest heat at the top, the middle or the bottom, by means of ports for the admission of the producer gases and the secondary air at any level from top to bottom; suitable means having been provided to close off any ports not required. Mr. Herring does not suggest that these designs are in any way final, but has erected them purely as experimental retorts with every possibility of testing, so as to obtain the best arrangement for future carbonisation of the coals with which he has to deal. The retorts are built of grooved bricks, and are made square to avoid expense of special bricks, and in the hope that the corners will become filled up in time with carbon. A good taper is given to them so that the coke may not be obstructed in leaving. In most things he has followed the vertical oil retorts practice, as he points out that that industry has had a number of years experience which must have led to the survival of the fittest. The only part patented is the ground valve type of coal inlet and coke outlet.

Having described the various modern systems and the results obtained by them, we may now profitably discuss their advantages or otherwise.

With small charges the separation of the carbon occurs so energetically that the ascension pipes are constantly becoming blocked and coke must be drawn before being completely burned off; a large charge on the other hand is more evenly distributed than a thin one, and the decomposition, with filled retorts, is avoided, so that higher temperatures of carbonisation can be used. It is evident that filling the retorts has made a different tar which should be easier handled and has removed many of the gas manager's greatest troubles, namely, stopped ascension pipes and pitched hydraulic mains.

Heating surface compared to the weight of the charge is a good indication of the comparative efficiency, but this is only the case with vertical and completely filled retorts, as it is only the heat, which is acting directly on the coals, which is wanted. Tests have shown that with tiles and asbestos on the tops of horizontal ordinary retorts, where the heat is not wanted on the inside, the quality of the gas has been improved. This might be expected, as the heat would convert some of the hydro-carbons into the solid carbon which usually collects on the inside of a partially filled retort and must thereby reduce the illuminating power. The lengthy contact with the hot side of a retort which is partially filled, must injure the gas, so that an improvement may well be expected when there is little room and consequently a quick passage for the gas away from this heat.

The requirements of coal gas and the illuminating power is daily becoming of less moment, while the calorific value is of more and more moment. What this calorific value is to be fixed at depends on the coal available. On the continent they are satisfied with a much lower figure than in this country, but tests must be made, and this without delay, by all gas companies and corporations to ascertain the extent of the calorific power obtainable from the coals near at their hands. In many cases they will not have the necessary apparatus at their hands for the purpose, but they should arrange for a periodical test of each of the coals they are using when being carbonised under the usual conditions prevalent in their works. Further than this, they should aim to find out the particular method which will give the best heating result from these coals, so that they can alter their processes accordingly. The published tests by the coal owners are not of much assistance in this matter, but may be taken as a guide as to the extent to which their efforts may be aimed. The apparatus for carbonising coal varies so greatly in certain ways that similar results cannot be looked for in different gas works.

The great aim should be to obtain as much methane as possible, as such a gas has a calorific power of 1024 B.Th.U. gross and 919 net, while hydrogen has only 326 gross and 272 net and carbon monoxide 323 gross and net—all per c. ft. Consequently any process which will increase the proportion of the former in the gas made must prove the one which will be likely to succeed in the future.

DISCUSSION.

Mr. JAMES McLEOD said that Mr. O'Connor's paper was very opportune, coming at a time when the gas industry was occupied with the question of vertical versus horizontal retorts. In his opinion, the vertical retort would be generally adopted for the carbonising of coal. In the first place, it meant a great saving in ground space. It had been shown, for example, that for an output of 750,000 c. ft. of gas per 24 hours, a space of only 30 ft. by 70 ft. was required. In the second place, the machinery required for a vertical retort system is simpler and much less subject to wear and tear than horizontal charging machinery.

Mr. DAVID VASS said that vertical retorts on the continuous system might require a coal somewhat different from that hitherto used, because they were suitable only for small coal, whereas in Scotland the practice had been to break large coal into pieces of from four to six inches cube. He considered the Woodall-Duckham system one of the most perfect he had seen. Attempts

were being made to obtain the same results from horizontal retorts by heavier charging, but there was the difficulty of getting the pusher to remove that large mass of material. In coke ovens it was found advisable to stamp the coal into a solid mass before putting it into the oven to be retorted, obtaining in that way a coherent mass which was easily pushed out when carbonised.

Mr. GEORGE R. HISLOR was of opinion that some time must elapse before horizontal retorts could be displaced. It had been proved to be an advantage to push the coke out of the retort, but in Scotland difficulties were met with. The coke from English coal was of a caking character, adhering together and therefore easily pushed out, while that from Scotch coal was very soft, and in the attempt to push it out, there was the risk of bursting the retort. No doubt, this difficulty might be reduced by the adoption of vertical retorts. If space was of great value, vertical retorts might be adopted and perhaps do fairly well with Scotch coal, but where space was not of much account, the extra cost of the distillation by the vertical system would be against it.

Dr. THOMAS GRAY said that the best results might be expected from some method of continuous distillation, since the conditions of working remained practically uniform, and that he had been surprised to find the coal gas industry so slow to adopt a system of this kind. Retorts working continuously, very similar in construction to some of the vertical retorts illustrated by the lecturer, had been employed successfully in distilling shale for about 30 years, and there was no reason to suppose that these would not be equally successful in dealing with coals of a non-caking character. While discussing the working of a chamber retort Mr. O'Connor had stated the yield of gas to be 13,247 c. ft. per ton of coal. That was a very high yield of gas even when allowance was made for leakage of air, and he found it difficult to explain how such a large quantity could be obtained except on the assumption that the tar had been partially decomposed, and was consequently viscous in character; whereas the author had stated that a fluid tar had been obtained. He asked if Mr. O'Connor could give any data regarding the temperatures at various parts of the vertical retort.

Mr. ROBERT HAMILTON asked if there was any difference in the yield of ammonia in the vertical and in the horizontal system.

Mr. SAMUEL GLOVER (communicated) said that at St. Helens they had adopted the vertical system by means of which they could retort successfully coal of all grades. By special heating chambers the temperature of the retorts could be controlled, and the gases which came off easily were carried away readily from the top of the

retort, while those which were evolved on the destructive distillation of the coal were not harmed by overheating, and the heat of the coke was returned to the setting as it was made to heat the secondary air going to the combustion chambers. The life time of the retorts would be a very long one and the through-put of coal very great compared with that of horizontal inclined or German retorts. The gravity charging worked well and the quality of the gas was very regular.

The CHAIRMAN said it would be interesting to know the difference in tar produced by the continuous as against the intermittent process. There was also the point of how much the gas engineer could improve the value of the by-products by varying the temperature of distillation. He would also like to know if it had ever been tried to have steam injected into very hot fuel so that a mixture of coal-gas and water-gas could be obtained.

Mr. O'CONNOR, in reply, said that no doubt there was a great advantage in vertical retorts when ground space was limited, but he believed that the extra amount of gas obtained on a certain space was manufactured at a somewhat heavy cost. In one case recently the system of vertical retorts cost four or five times that of horizontal retorts. One of the difficulties in the setting up of vertical retorts was that they must be tapered from top to bottom to prevent the coke sticking in the retort. Consequently it must be built up in rings, each ring being made of the proper taper, or must be built with special bricks, or as in the retort set up by Mr. Herring at Granton, built square with grooved bricks. Until a definite size was decided on and a definite taper accepted, so long would the expense in building vertical retorts be considerable, because each piece of the retort would have to be made of exact taper to fit the one above and the one below. A considerable increase in the yield of ammonia was claimed for the vertical system. So far as he knew, no tests had been made regarding the temperature at different parts of the retort, but it was intended to make these with the experimental plant at Granton.

In reply to the questions of the Chairman, the tar from the vertical system appeared to be heavier, and regarding the use of steam it was impossible to use a large quantity of this because the candle power was bound to be reduced. In Germany, where they were satisfied with a candle power of 11 or 12 steaming was used on practically every occasion. In lowering the candle power, care should be taken not to lower the calorific value. The aim should be not to manufacture hydrogen but methane. If water-gas was made, that meant carbon monoxide, which was not so valuable for heating purposes as hydrogen.

Journal and Patent Literature.

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I.—GENERAL PLANT ; MACHINERY.

Refrigeration for analytical and industrial investigations at low temperatures (—75° C.); Convenient method of —.

J. O. Handy. J. Ind. Eng. Chem., 1910, 2, 92—94.

THE author discusses various methods of refrigeration, and gives the preference to the use of carbon dioxide snow with acetone or with petroleum ether. Of these, the acetone mixture has some advantages. The "snow" is prepared by the usual method of allowing the liquid carbon dioxide to blow off through canvas or flannel bags. The temperatures resulting from various quantities of the "snow" with 150 grms. of acetone (at 23° C.) are given as follows:—6 grms. of carbon dioxide, —5° C.; 11 grms., —20° C.; 24 grms., —38° C.; 45 grms., —54° C.; 77 grms., —61° C.;

excess of carbon dioxide, —78° C. With 114 grms. of petroleum ether of 86° B. at 22° C., the temperatures obtained with different weights of carbon dioxide were as follows:—5 grms. of carbon dioxide, —22° C.; 10 grms., —36° C.; 15 grms., —55° C.; 30 grms., —69° C. If absolute freedom from risk of fire is desired, carbon dioxide and carbon tetrachloride or chloroform can be used for a limited range.—R. C. P.

PATENTS.

Separating fluids having different densities; Method and means for —. C. S. Brown, Nashville, Tenn., U.S.A. Eng. Pat. 4962, Mar. 1, 1909. Under Int. Conv., March 23, 1908.

THE invention consists of a valve which allows fluid to pass but prevents vapour or gas from doing so. It is said