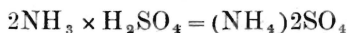


a coking coal containing 30 per cent. volatile matter yielded in the non-recovery plant 56 per cent. coke and nothing else, and when dealt with in a recovery plant gave 70 per cent. of better-class coke, together with 4 to 4.5 tar, 1 per cent. crude benzol, and 1 to 1.2 per cent. of ammonia as sulphate "waste" heat, equal to the evaporation of one ton of water for each ton of coal, and 5000 cub. feet of surplus gas (when using regeneratives). On pre-war prices the value of these products yielded a net value of 35/- per ton of coal, together with a higher value for the extra coke obtained, and also for the surplus gas at 5s. per 1000 cubic feet.

These figures are of average practice results, but the author puts the case as coming from the greatest practical authority on the subject probably in the whole of our Empire.

### **The Elimination of Ammonia.**

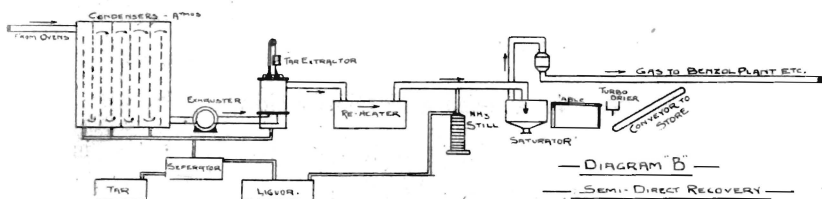
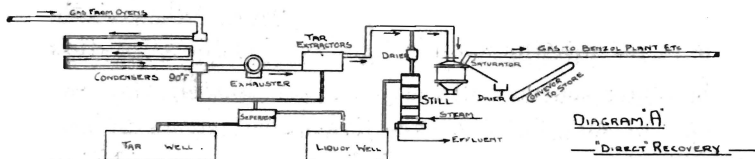
In all gases, for combustion  $\text{NH}_3$  is treated as an inert. As a gas it does not burn, nor does it support combustion. Under these conditions it is found better to abstract and turn it either into sulphate or nitrate of ammonia. The latter practice is only just feeling its way on a commercial scale, and the sudden cessation in the use of explosives may have the effect of quietening its market value; but the great market for the sulphate has the effect of causing its manufacture in most modern plants. The operation consists essentially in driving off from the condensed liquors the contained ammonia, and neutralising it with sulphuric acid, the following reaction taking place:—



The old idea of ammonia abstraction, usually termed "indirect," as still carried out by most gasworks, consists of the condensation of all aqueous vapours, and through frictional and water washing, the resultant

liquors, termed ammonical liquors, are then treated in stills, and the  $NH_3$  gas given off converted into sulphate by the neutralisation, as shown by the above reaction.

№ 16 AMMONIA PLANTS



On Fig. 16 shews on diagram "A" what is known in the coking world as the "direct recovery system." The gases issuing from the oven are led through a cooling system or condenser, and thus bringing the temperature of the gases down to about 90deg. (In the "indirect" these gases are cooled to atmospheric temperature.) From the coolers the exhausters withdraw the gases, then force them through the tar extractors. Many forms are adopted by the English constructors, but from the frequency of its use the author thinks that the Pelouze and Audoin type must be the most efficient. The main now conducts the whole of the products through the saturator, as shewn, and the ammonium salts thus recovered.

Any depositions of ammonical liquor due to the slight cooling and the tar extraction are drained into the liquor well, and from here are treated in a still, as in the indirect, the vapours being admitted to the general stream before saturation.

The diagram "B," on 16, shews at a glance that it is as a system half-way between the direct and indirect. There is the condensation to atmospheric temperature, usual exhaustion and tar extraction; then the gases are re-heated, as shewn, prior to saturation. Here again the resultant liquors are treated in a steam still, and the vapours put into the main before reaching the saturation.

The above schemes all recover approximately the same amount of salt, but the excessive use of steam to heat the stills is a most uneconomical procedure, considering, as in the 'Indirect' and "Semi-direct" cases, where the gases have been forced to unload their valuable heat units much below the dew point.

### Tar Treatment and Distillation.

The value of by-products obtained from coal tar is shewn by Table 4, under the heading of Tar. By efficient distillation of tar we may obtain the following intermediate products in the approximate quantities of:—

12	galls.	of	Light	Oils.
20	"	"	Carbolic	Oils.
17	"	"	Creosote	Oils.
17	"	"	Creosate	Oils.
38	"	"	Anthracene	Oils.
11	cwt.	"	Pitch.	

These may be obtained from 1 ton of tar. Each of these classes may be further divided out by fuller rectification, and the "light oils" caused to yield benzene, toluene and xylene. "The middle" or carbolic oils with the additional treatment will give off phenol, naphthalene. "The heavy" oils yield creosote, which to us in Australia is so well known as a wood preservative. The Imperial Navy also have recognised its great power as a fuel oil, and during the war period commandeered all the Empire's supplies for Diesel engine purposes.

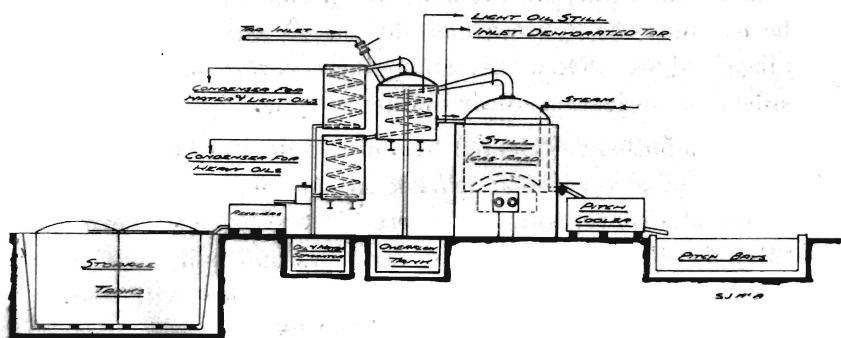
The fourth group of "Anthracenes" also have great commercial value, for from it, by special treatment, can be obtained the hydrocarbon anthracene, the base of the alizarin dyes. From this group there is also obtained a splendid lubrication oil of the heavy type.

The naphthalene yielded by the middle and heavy oils has found a very solid market in the Old World as a powerful disinfectant. Commerce has also made use of pitch for the manufacture of varnishes and paints. The French put it to a splendid use for mixing with the "slack" from their mines, and making coal briquettes for locomotive firing.

The use of tar for roadmaking has in the last decade made wonderful strides in the United Kingdom, and today her roads are really wonderful, owing probably to the skilled use of tar. Only recently has Australia made any definite steps towards specifying the quality of tars for this purpose. At present there is no absolute standard here, but the Road Board of England have set out the following specification for general use:—

- (1) The tar shall be free from water.
- (2) On distillation shall yield no distillate below 140 deg. Cen.
- (3) Nor more than 5 per cent. distillate up to 220 deg. Cen., and that distillate shall remain clear and free of solid matter when maintained at a temperature of 30 deg. Cen. for half an hour.
- (4) Between 140 deg. and 300 deg. Cen. it shall not be less than 15 per cent. or more than 21 per cent. of the weight of the tar.

A diagram shewing the form of the tar distillation plant is to be found in Fig. 17. The tar for distillation is brought up from the tar-wells by the inlet pipe, as shewn, and led into the light oil still, where, through the ex-

1917. TAR DISTILLATION PLANT

change of heat from the down-coming coil of the main still, the lighter oils and water are thrown off in the form of vapours, and ascend through the gooseneck and into the condensing coil for water and light oils. These runnings gravitate to the separating tank, where, on settlement, are drawn off—the light oil to its storage tank and the water to drains. The dehydrated tar is permitted to flow into the main still, which is heated by the underfired furnace, preferably gas fired, and by steam pipes running through its charge. The vapours given off by this distillation pass up through the large gooseneck, then to the coils of the light still, and further to the condensing still for heavy oils, from where the various oils are drafted to their respective receivers, then on to the storage tanks.

The pitch cannot be run directly out to the atmosphere from the still, owing to the risk of spontaneous combustion, and noxious vapours given off, so the pitch cooler is used to gain this result, it being purely a light steel cylinder well exposed to the air, and the outlets are strong gate valves, which are opened at such a time when the pitch is of a running consistency, and the lowest possible temperature; then it is conducted to the pitch bags, and permitted to set under atmospheric conditions.

### Recovery of Benzol.

The term benzol is really a commercial one, but its use is adopted by both the English and American markets. Table 4 shews the series of hydrocarbons obtainable from the crude benzol, which passes through the earlier recovery plant, and, owing to the high vapour tension of these gases, do not permit them being thrown down. The only means of recovery is by washing or scrubbing in the well-known tower scrubbers, using a creosote wash oil as an absorbent or solvent.

The wash oil used in America is a petroleum product of about .88 specific gravity. English and Continental practice call for a tar oil, out of either the carbolic or creosote group distillates from the tar distillery. Rough specification calls for an oil in which 90 per cent. distils between 200 deg. and 300 deg. C., and the naphthalene content then must not be over 7 per cent.

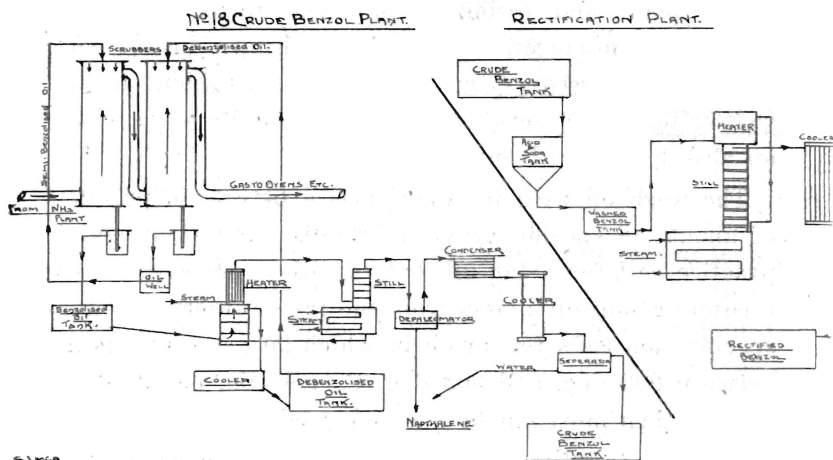
In districts where there is no legal illuminating standard, but a stated calorific value, all carbonizing plants can strip their gases of the benzols, which, even as a crude product, has a great value, and upon fractionation to benzene, toluol, xylol, solvent naphtha. No difficulty is to be found in obtaining markets, each intermediate having its own essential value.

The trade terms, 90 per cent. and 50 per cent. benzols, mean that 90 or 50 volumes respectively out of a total of 100 submitted to fractional distillation, boil over below 100 deg. C.

### Crude Benzol.

Benzol recovery almost invariably takes place after the removal of tar and  $\text{NH}_3$ . The gas issuing from these plants generally has a temperature of about 70 deg. C., and for the efficient abstraction of the benzol must be brought down to at least 25 deg. C.

Assuming we have the gas at a suitable temperature, the plant, as shewn on diagram (Fig. 18), comes into use. The gases are led in and through the tower scrubbers in an upward direction, each tower being thoroughly sprayed from the top and intermediate spaces with wash



oil: No. 1 tower with the semi-benzolised oil from No. 2, and the second tower with pure debenzolised product.

These oils are now containing the previous benzol vapours held by the gases (with efficient scrubbing 99 per cent. of the original content can be eliminated), and are conducted from the final seal pot into the benzolised oil tanks. The oils run from this tank through a debenzolising still, where sufficient heat is provided to drive the vapours off from the solvent oil, which is now led through a water cooler and back to the debenzolised tank for further use as an absorbent in the scrubbers.

The vapours carry on through the pre-heater, then to the steam still, where all traces of the remaining solvent and waters are removed; the sudden chill then thrown by the dephlegmator causes the deposition of the naphtha-

lene. It is now necessary to bring the vapours back to a liquid state, so they are passed through a water-cooled serpentine and special cooler into a separator, where any traces of water are drawn off the product, which passes into the crude benzol tank.

TABLE No. 5.  
GENERAL TAR DISTILLATION TEMPERATURES, ETC.

Distillate.	Tempr. Cent.	Yield.	Specific Gravity.
Light Oils ...	Up to 170°c.	2-8%	9-95
Middle Oils ...	170°-230°	8-10%	1.01
Heavy Oils ...	230°-270°	8-10%	1.04
Anthracene ...	270°-400°	16-20%	1.10

#### Benzol Rectification Plant.

The further plant necessary for rectification of benzol is shewn in Fig. No. 18 also. The crude benzol obtained by the initial distillation is stored in the special tank; from here it is drawn, and successively treated with strong sulphuric acid and caustic soda in the acid and soda washing tank, then being considered free from impurities, assumes the name of washed benzol, and finds a great market in England as a motor fuel.

The product in its new form is forced through the heat exchanger and fractionating still, and yields 90 per cent. benzol and solvent naphtha.

By a further fractionation, on similar lines, chemically pure benzol, toluol and xylol can be obtained. Table 3 of this paper shews that English plants which the author visited obtained, as an average, 2½ galls. of benzol per ton of coal carbonized.

The following table, No. 6, taken from the author's notes, may be of general interest in shewing the compositions characteristic of the commercial products:—



TABLE No. 6.

	Benzene %	Toluene %	Xylene %	Solvent Naphtha %	Nap- thalene Oil %	Specific Gravity
SO% Benzol ...	74	20	2.5	3.5	...	880
50% " ...	43	47	10	...	...	875
Solvent Naptha ...	...	...	...	...	...	...
90% a 160° Cent. ...	...	5	70	25	...	874
90% a 170° " ...	...	...	35	60	5	890
Heavy Naptha ..	...	...	5	80	15	920

### Coking in New South Wales.

This concluding section of the paper might easily have been headed "Coking in Australia," for in this State there are about 18 plants, aggregating to 1000 non-by-product ovens, and 114 by-product ovens, whereas the author cannot trace the record of any other plants outside the State.

The figures of coke production shew the growth of an enormous industry. In 1890 the production yielded 31,097 tons coke, the prevailing value then being about 26/- per ton. Twenty-five years later, 1915, shewed an increase to 417,753 tons, and an average value of the present-day market is about 20/-.

With the figures shewed in the opening lines, where England coked 75 per cent. of her coke in by-product plants, Germany 90 per cent., and America 60 per cent., it may be interesting to know what we are doing.

Of the above 114 by-product ovens, only 66 are in operation; the remainder have never really worked, and are often credited to Coppee Ltd. The system is certainly Coppee, but that firm never handled the construction, or attempted any design for this plant. The 66 ovens are coking about 2200 tons of coal per oven per annum, and producing 61 per cent. coke as against the "non-by-pro-

ducts" 56 per cent. of coke, and under the above list we might quote Australia with 7 per cent. In appearance the Australian coke equals that of other countries; but its hardness fails in comparison. The cell structure is not so definite, and against these items we are only in one instance recovering any by-products, and on pre-war prices we are losing some £400,000 per year in by-products, and also passing into the atmosphere are roughly 5 thousand million cubic feet of valuable heating gas; 50 per cent. of this could be made available for power generation purposes, thus shewing that we are also losing 125 million horse-power hours per annum, or 14,000.

Figures from the Mines Department of New South Wales shew an average ash content of our coke as 15 per cent. The English market will not accept a coke over 10 per cent. ash. Now, if the practice of the Old Country demands such a figure, it proves conclusively that our efficiencies in metal production cannot equal theirs. It isn't the fact that the coals cannot be washed. Our Southern product very much resembles the Welsh coal in that respect, and the results gained on some of the plants visited by the author are shewn on Table 3.

The prospect of legislation by the Imperial Government, as spoken of in the early part of the paper, is, according to the latest technical journals, shewing early signs of development, and it appears to the author that if the Imperial people consider the necessity of husbanding the Empire's resources as essential, then the Australian Governments will be asked to legislate commonly.

### Conclusion.

This, gentlemen, now concludes the paper. The author does not anticipate in any way its value from a technical viewpoint, but, believing it to be the first paper on the subject yet read before your Association, it has been his

effort to bring before the engineers of this country in a public way the apparent wastes going on, and the possibilities of future development, if worked on the existing English practices.

The author would like to express his indebtedness to the coking and gas engineers of the United Kingdom, especially Mr. Jos. Harrison, Middlesborough; Messrs. Chas. Hunt and P. N. Hambly, London; Messrs. S. Hunter, E. Lloyd, and A. Naylor, Manchester, through them in enabling him to gather sufficient data and experience on the subject matter of this paper.

Members of the Australian Forces have found the Engineering profession of England quite eager at all times to go to any extreme in order to comply with a request; the Australian uniform was alone sufficient guarantee, and with that one could obtain without question all data he required, and permission to visit any works.

---

### DISCUSSION.

**MR. POOLE:** I have much pleasure in moving a hearty vote of thanks to Mr. McAuliffe for his highly interesting and valuable paper. Mr. McAuliffe is to be congratulated on the thorough and able manner in which he has dealt with this subject, which is of increasing importance to this country.

The Association was to be congratulated in that a new class of subject had been added to the already wide scope of Engineering subjects which from time to time have been presented to members. It was also a pleasure to note that one of the younger members, while serving his country with the Expeditionary Forces, had taken advantage of his furlough for visiting modern coking and recovery plants in Great Britain to ascertain the most