MOND GAS.

R. D. WOOD & CO.

PHILADELPHIA.

Foundries and Works:

Millville,
Florence, } N. J.
Camden,

WOOD BUILDING, 400 CHESTNUT STREET.

Engineers,

Iron Founders,

Machinists.

CONSTRUCTORS OF

GAS PRODUCERS

AND

PRODUCER GAS POWER PLANTS.

CABLE ADDRESS:
"Tuckahoe," Philadelphia.

CODES.—A B C Code, 4th Edition,
Liebet's Code, 1896,
Premier Code,
A 1 Code,
Watkin's Code,
Postal Directory Code,
Manufacturer's Export Code—Seeger's,
Western Union Telegraphic Code,
Anglo-American Telegraphic Code.

1903.

Established 1803.

Gift

4-'03-1500.

Leading Specialties:

R. D. WOOD & CO.

PHILADELPHIA.

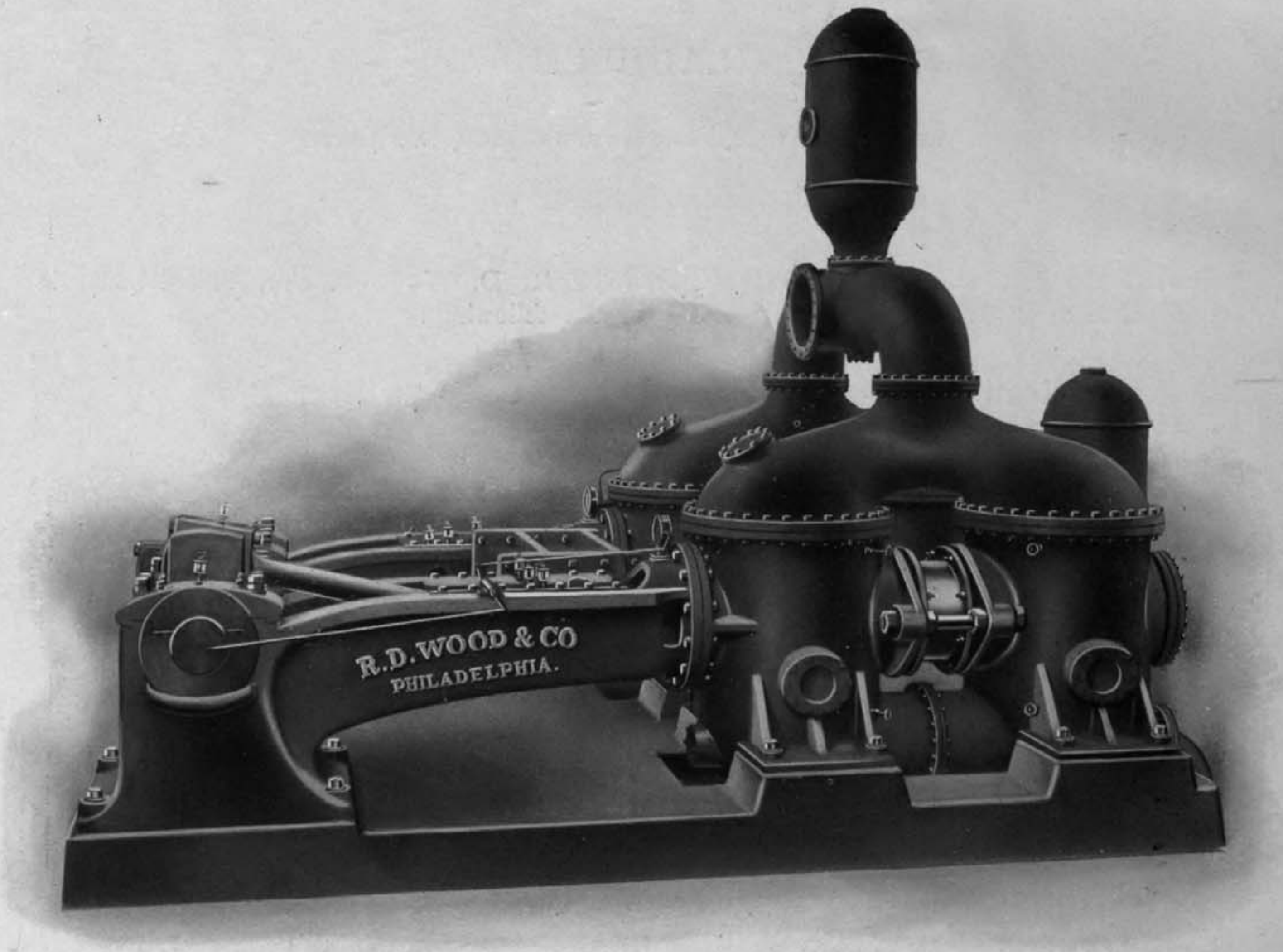
WORKS: MILLVILLE, FLORENCE AND CAMDEN, NEW JERSEY.

AMONG the leading specialties manufactured by R. D. WOOD & Co., Philadelphia, in addition to "MOND GAS PLANTS" are the following:

Cast Iron Pipe—all kinds and sizes, 1" to 72".
Fire Hydrants—The "Mathews."
Valves for water, gas, etc.
Valve Indicator Posts, Patented.
Valves—Large Diameters, Geared and Power.
Valves—Foot and Check.
Sluice Gates, Intakes and Screens.
Tanks, Towers and Stand-Pipes.
Gas Holders and Gas Apparatus.
Gas Producers—"Taylor," Patented, with or without Automatic Feed.
Gas Producer Plants for Operating Gas Engines.
Sugar House Work.
Castings for Chemical Works.
Turbines and Power Pumps.
Hydraulic Tools and Machinery.
High Duty Pumping Engines.
Centrifugal Pumps.
Heavy Special Machinery—to designs of purchasers.
Loam Castings.

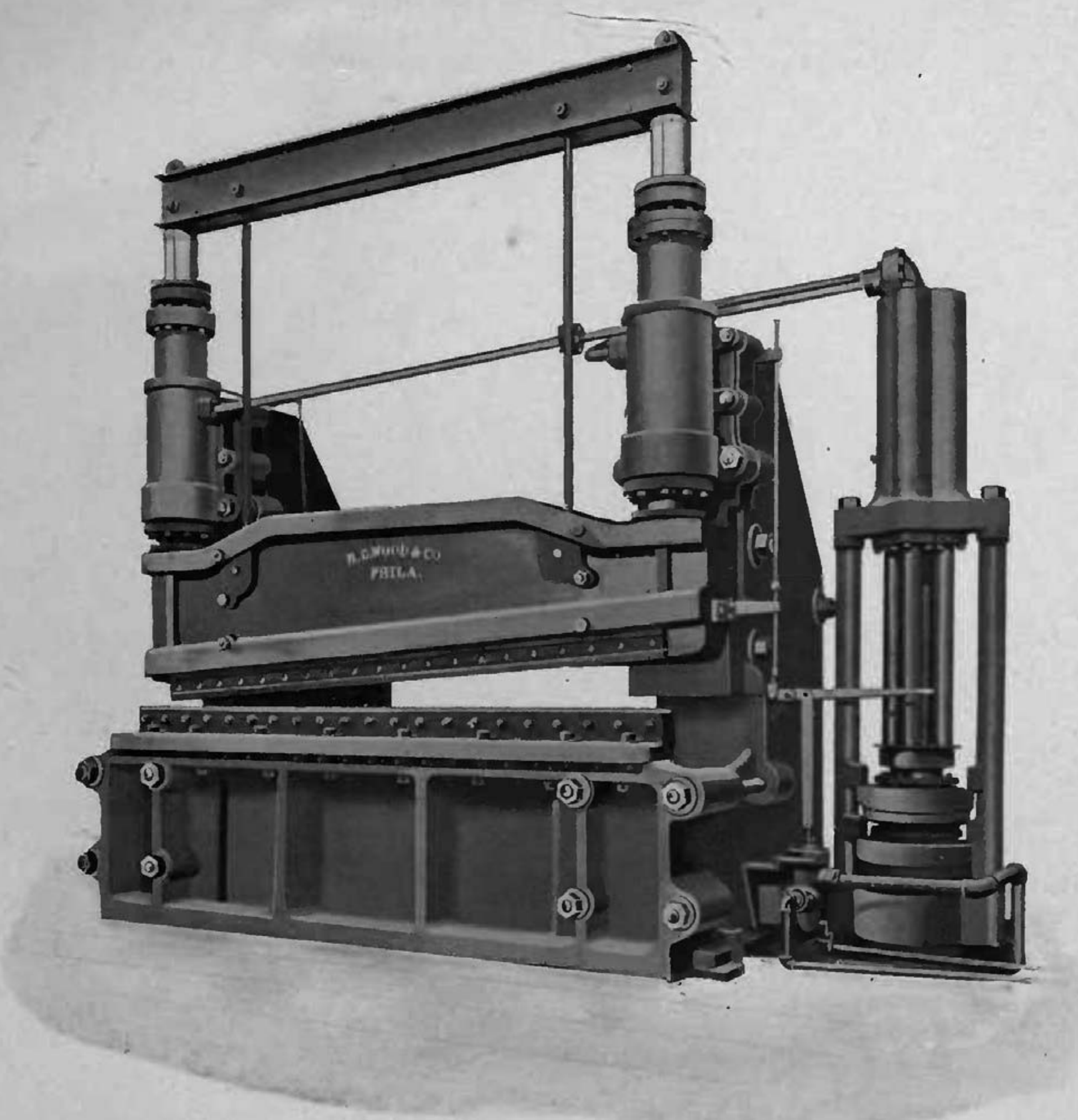
See advertisements, pages 4 to 6 and 99 to 104.

PUMPS.



Large power-driven pumps for water works and irrigation service, arranged to be operated by electric motors, turbines or other power; direct connected, geared, belted or rope driven; both duplex and triplex pattern.

Hydraulic Tools, Cranes and Machinery.



Multiple Power Hydraulic Plate Shear.

154″ between housings—knives 181″ long to cut all thicknesses of plate up to 2″.

(Send for Hydraulic Tool Catalogue.)

TAYLOR GAS PRODUCERS.

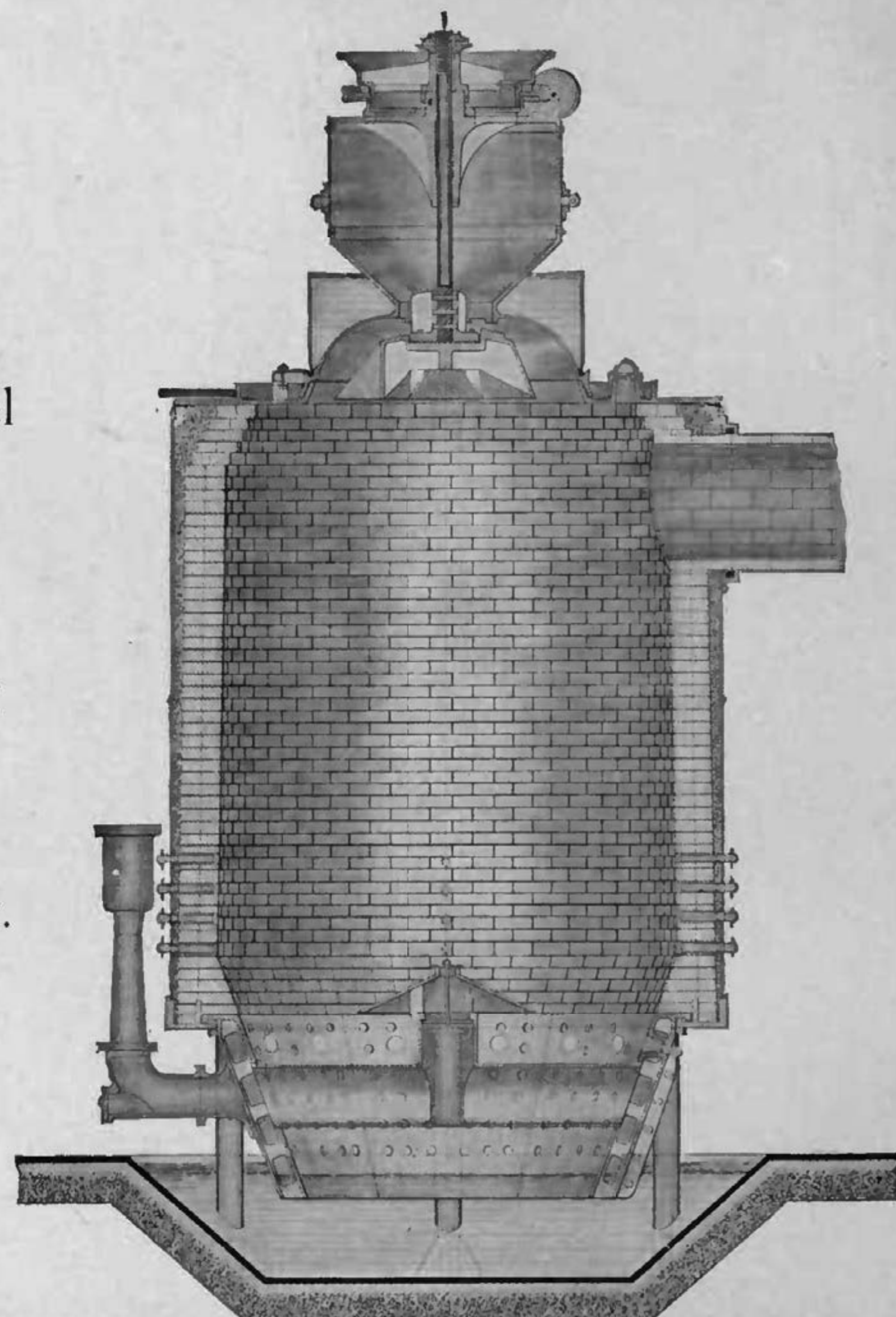
WITH INCLOSED CONE ASH DISCHARGE
OR WATER SEAL BOTTOM.

(SEND FOR TAYLOR GAS PRODUCER PAMPHLET.)

For Steel Works,

Ore Roasting Plants,

Kilns, etc.



For Chemical Works,

Glass Works,

Muffles, etc.

No. 8 TAYLOR PRODUCER WITH CONTINUOUS AUTOMATIC
FEED AND WATER SEAL BOTTOM.

PREFACE.

IN presenting this publication, illustrating and describing the **Mond Producer Gas Process,** we feel that we are simply making another step forward in the work we have been doing for Producer Gas for some years past.

It is our conviction that in no one direction can the great problem of cheap power and heat be so well solved as in this.

In the larger plants hereinafter described, the saving of by-products lends a most important aid, and therefore we have turned to Dr. Mond, who of all scientists has most successfully worked out this problem, and have secured from him the right for the manufacture of his process in this country.

This publication is largely a reprint of the English work which illustrates several plants in most successful operation there.

The engineering data is almost wholly the result of practical work and experiments conducted by Herbert A. Humphrey, A. M. I. C. E., M. I. Mech. E. and I. E. E.

PHILADELPHIA, April, 1903.

CONTENTS.

"MOND GAS"—WHAT IS IT?

EFFICIENCY, CLEANLINESS, ECONOMY.

It is to the Progressive Manufacturer the Last Word upon these three All-Important Considerations.

EFFICIENCY is obtained by the conversion of the fuel into the form in which it can be utilized to the best advantage, uniformly representing the maximum heat energy obtainable therefrom.

CLEANLINESS naturally follows with the abolition of the smoke nuisance; there is no chimney and no smoke, and that which formerly caused the nuisance is transformed within the apparatus to combustible gas, and duly supplied to the gas engines or to the furnaces.

ECONOMY results from every pound of fuel being utilized at its full strength, without waste; from the use of common coal or dross instead of expensive steam coal; and from the large proportionate reduction in wages. In large installations the ammonia obtainable from the fuel enables the consumer to save a large proportion of its original cost.

No manufacturer who recognizes the necessity of keeping abreast of the times can afford to ignore "Mond Gas," for it reduces the all-important cost of production.

STANDARD MOND GAS INSTALLATIONS.

WITHOUT THE APPARATUS FOR RECOVERY OF AMMONIA.

		Approximate equivalent in Indicated Horse Power.
Daily Fuel Consumption (per 24 hours)	2½ gross tons	250
" " " "	5 " "	500
" " " "	10 " "	1,000
" " " "	20 " "	2,000
" " " "	30 " "	3,000

WITH THE APPARATUS FOR RECOVERY OF AMMONIA.

Daily Fuel Consumption (per 24 hours)	30 gross tons	3,000
" " " "	40 " "	4,000
" " " "	60 " "	6,000
" " " "	80 " "	8,000
" " " "	100 " "	10,000

We will be glad to prepare estimates and submit propositions for complete Mond gas installations for either heating or power.

THE ORIGIN OF MOND GAS.

VIEW IN MESSRS. BRUNNER, MOND & CO.'S WORKS AT NORTHWICH, CHESHIRE, ENGLAND, SHOWING THE MOND GAS PLANT.

MOND gas is the outcome of many years of scientific research and of practical work upon the largest industrial scale. The processes for its production, and for the recovery of ammonia therefrom, were patented by Dr. Ludwig Mond, F.R.S., and developed at the works of Messrs. Brunner, Mond & Co., at Northwich, Cheshire, England, where about 700,000 tons of slack coal have already been dealt with in gas producers under the control of the patentee. The experience gained in operating upon so large a quantity of fuel has resulted in the perfecting of the plant and apparatus employed, and has placed this process far beyond the realm of experiment.

THE FIRST INSTALLATION OF MOND GAS AND ITS SUBSEQUENT DEVELOPMENT.

THE first apparatus for the conversion into combustible gas of bituminous small coal, commonly known as slack, and for the simultaneous recovery in the form of sulphate of ammonia of the most important of the by-products obtainable therefrom, designed by Dr. Ludwig Mond, F.R.S., was constructed and put into operation at Messrs. Brunner, Mond & Co.'s Works at Northwich, Cheshire, England, and was intended to gasify a few hundred-weights of small coal per hour. From this relatively small beginning the gas producer plant at Northwich was step by step enlarged and extended in order to meet the ever-increasing calls that were made upon it as its many advantages were recognized and appreciated, until at the present time it is capable of gasifying daily some 250 tons of slack, from each ton of which there is obtained the ammonia equivalent of about 90 pounds of sulphate of ammonia, and from 140,000 to 160,000 cubic feet of Mond gas, equal to about 37,000,000 cubic feet per day. The immense volume of gas thus generated day by day is employed in a variety of ways: it provides fuel for heating and evaporation, and in addition to being put to various other uses suited to the special requirements of the chemical industry there carried on, including some of the most important operations of the works, dependent for their success upon the absolute reliability and constancy of the gas, it also provides fuel for the large gas engines that are used for the generation of electricity for the works and for lighting the neighboring township of Northwich.

LIST OF MOND GAS INSTALLATIONS.

THE following list will show where the Mond gas plants are either in active operation, or where the installation of the necessary plant is in progress; and some idea of the extent of the operations involved may be gathered from the following figures, which show at a glance the daily coal capacity of each installation, together with the equivalent horse power obtainable from the gas so produced:

	Coal Capacity. Tons per Day.	Indicated Horse Power.
Messrs. Brunner, Mond & Co., Ltd., Northwich	250	25,000
Messrs. The South Staffordshire Mond Gas Co. (first station only)	160	16,000
Compañia General de Productos Quìmicos del Aboño, Gijòn, Spain	120	12,000
The Salt Union, Ltd., Liverpool	120	12,000
The Solvay Process Co., Detroit, U. S. A.	120	12,000
Messrs. The Farnley Iron Co., Ltd., Leeds	120	12,000
Messrs. The Castner-Kellner Alkali Co., Ltd., Runcorn, Cheshire	100	10,000
Messrs. The Trafford Power and Light Co., Ltd., near Manchester	80	8,000
Messrs. Albright & Wilson, Ltd., Oldbury	60	6,000
Messrs. Monks, Hall & Co., Ltd., Warrington	40	4,000
Messrs. D. & W. Henderson & Co., Ltd., Glasgow	20	2,000
Messrs. Cochrane & Co., Dudley	20	2,000
The Great Southern Railway Co., Buenos Aires	20	2,000
Messrs. Ashmore, Benson, Pease & Co., Ltd., Stockton-on-Tees (The Power-Gas Corporation's Works)	15	1,500
The Premier Gas Engine Co., Ltd., Nottingham	10	1,000
Messrs. Handyside & Co., Ltd., Derby	10	1,000
Messrs. The United Turkey Red Co., Ltd., Alexandria, N. B.	10	1,000
The Railway and General Engineering Co., Ltd., Nottingham	10	1,000
Messrs. Tweedales & Smalley, Castleton, Manchester	10	1,000
Messrs. Cadbury Bros., Ltd., Birmingham	5	500
Messrs. Crossley Bros., Ltd., Manchester	5	500
The University, Birmingham	5	500

NOTE.—1 ton=2240 lbs.

SOME OF THE ADVANTAGES OF MOND GAS.

SOME ADVANTAGES OF USING MOND GAS AND SOME FACTS ABOUT IT.

MOND gas is produced from the cheapest quality of coal, namely, slack or dross, thus obviating all necessity of expensive steam coal for the generation of power in the works.

The amount of labor required for the production of Mond gas is extremely small.

The heating value of Mond gas is equal to from 81 per cent. to 86 per cent. of the total heat energy contained in the fuel used for its production.

The cost of Mond Gas, when produced on a large scale, is less than 1 cent ($\frac{1}{2}$ of a penny) per thousand cubic feet.

One gross ton of rough slack produces about 140,000 cubic feet of Mond gas of a calorific value of 140 B.T.U. per cubic foot.

The quantity of Mond gas required to produce an indicated horse-power hour in a large gas engine is about 60 cubic feet.

When converted into Mond gas and used in a large gas engine, one ton of slack gasified is sufficient to produce about 2500 indicated horse-power hours, or 2500 horse power for one hour.

Mond gas is the best for gas engines, because they require a clean gas of regular quality. It is interesting to note that a gas engine of 150 horse power which, when running with ordinary town gas, had to be stopped every fortnight to be cleaned, has been kept running with Mond gas, day and night, for six months without stoppage. For some particulars of other actual results obtained, see pages 42 to 44.

In every steam plant working with a variable or intermittent load, a considerable proportion of the fuel consumed is wasted. Some loss under this head is unavoidable, but the employment of Mond gas reduces such stand-by losses to a minimum.

Mond gas is, therefore, very advantageous for intermittent working. The stand-by losses of a 1000 horse-power plant are about 224 pounds of fuel per night of 14 hours.

When standing for eight days, the stand-by losses of a 1000 horse-power Mond gas plant are at the rate of only about $7\frac{1}{2}$ pounds per hour, and the plant can be restarted in a few minutes.

After the week-end stoppage, the time required for starting is only three minutes for a Mond gas plant generating 1000 horse power.

The total capacity of the installations already in operation and now in course of construction (October, 1902) is 270,000,000 cubic feet of Mond gas per day.

The fuel cost of an indicated horse-power hour, obtained from a gas engine running with Mond gas generated from slack at $1.45 (6s.) per ton, is $\frac{1}{20}$ of a cent ($\frac{1}{40}$ of a penny).

By using Mond gas in gas engines a given quantity of fuel will produce about four times the power obtainable from it with ordinary steam engines.

Mond gas has passed out of its experimental stage.

Gas engines producing 18,000 horse power are running with Mond gas at the present time.

The Mond gas plant in the works of Messrs. Brunner, Mond & Co., of Northwich, is capable of producing about 37,000,000 cubic feet per day.

The employment of Mond gas abolishes the smoke nuisance.

The distribution of Mond gas to the power house or into the furnaces, etc., by means of ordinary pipes obviates the necessity for carrying coal and ashes through the works.

Mond gas is delivered cool and clean from the apparatus, and can be carried considerable distances, and delivered at any number of places.

Mond gas is regular in composition, and the supply from the producers can be regulated in accordance with the variable requirements of the engines, stoves or furnaces, thus preventing waste.

By recovering the sulphate of ammonia from Mond gas a large proportion of the initial cost of the fuel is saved. Seventy per cent. of the nitrogen contained in the fuel is converted into ammonia and recovered, this being about four times as much as is obtained in ordinary gas works.

The commercial value and the agricultural uses of sulphate of ammonia are briefly referred to on pages 81 and 82.

Owing to its cleanliness and regular composition, Mond gas is invaluable in all heating operations in which the flame comes into direct contact with the products to be heated, such as glass, china, glazed earthenware, etc.

The use of Mond gas in a furnace insures the maintenance of a perfectly even temperature.

Mond gas is an ideal gas for metallurgical purposes, an oxidizing or reducing flame being obtainable at will.

Mond gas contains a higher percentage of hydrogen and a smaller percentage of carbon monoxide than most other producer gases, and is therefore less poisonous.

By employing regeneration, extremely high temperatures are easily obtained.

The employment of Mond gas reduces repairs to a minimum. The life of boilers fired by Mond gas is lengthened, and the case of some large cast-iron pans under which the flames pass and through which the heat is transmitted may be quoted. With gas-firing they now last four times as long as formerly, and the output of the furnace during this process is more than quadrupled.

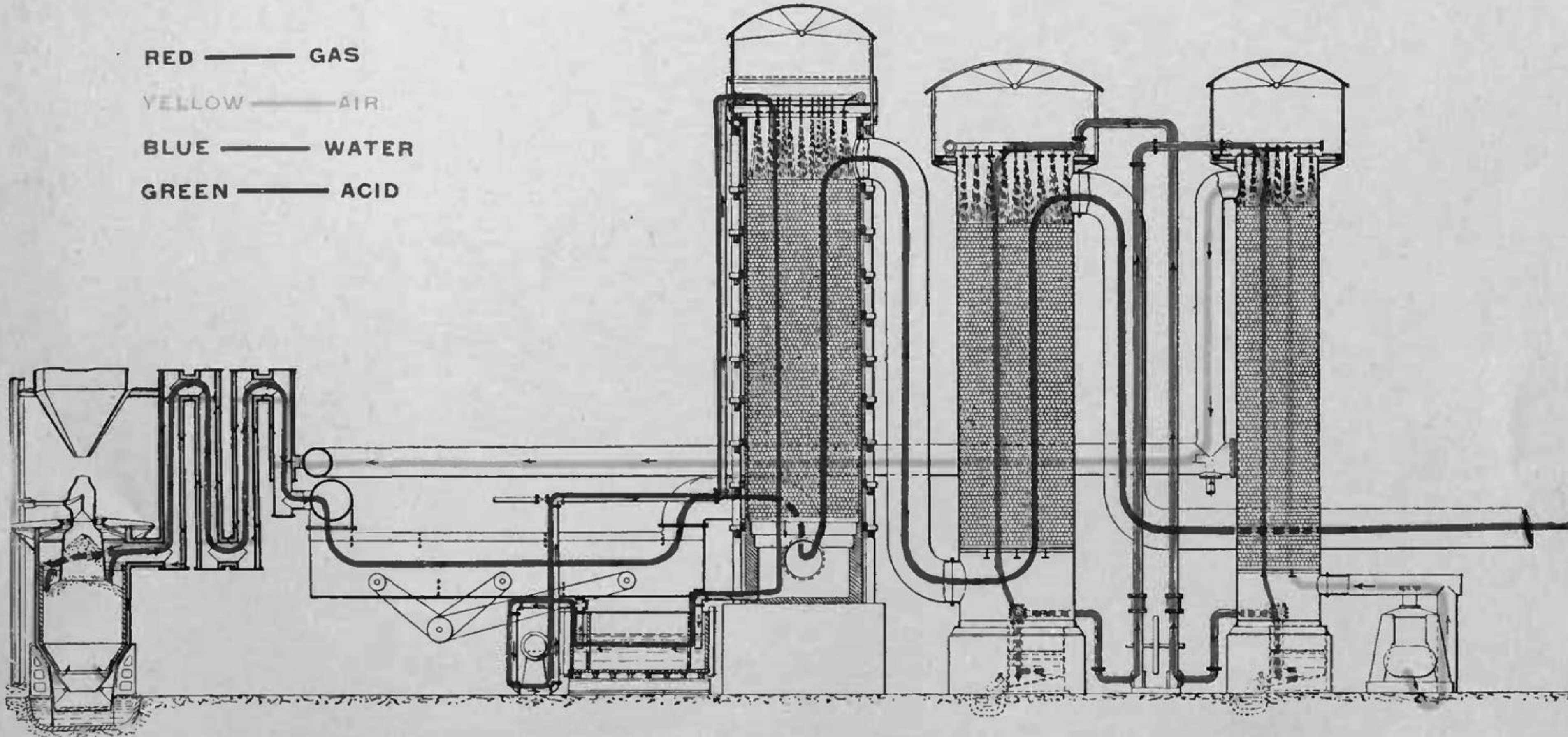


DIAGRAM OF MOND GAS PLANT WITH BY-PRODUCT RECOVERY.

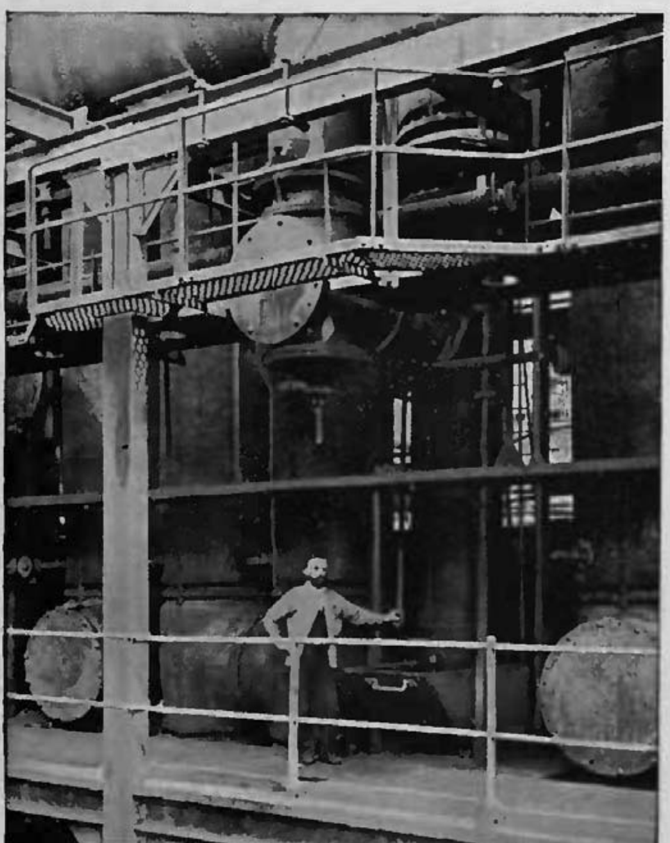
PROCESS OF THE PRODUCTION OF MOND GAS AND THE RECOVERY OF AMMONIA THEREFROM.

THE PROCESS OF THE PRODUCTION OF MOND GAS,

AND OF THE RECOVERY OF AMMONIA THEREFROM.

THE following description and the accompanying diagram of the method of production of Mond gas, with the recovery of ammonia therefrom, will serve to make it easily understood, and the illustrations from installations already in operation will give an idea of the plant and apparatus employed.

Wherever possible the slack to be gasified is discharged direct from the railway trucks into an elevator boot.

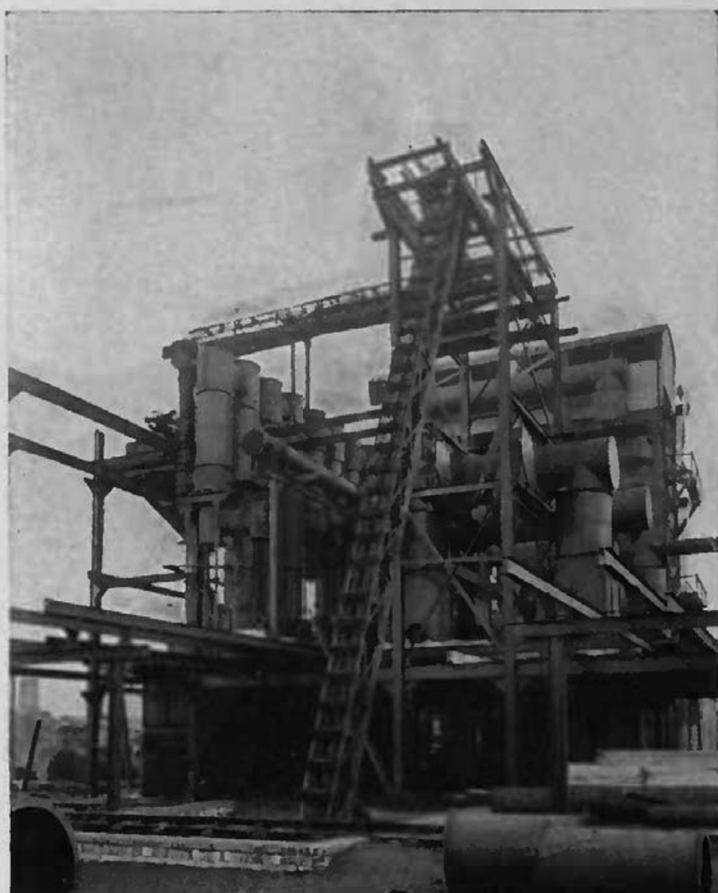


REGENERATORS AT MESSRS. BRUNNER, MOND & CO.'S CHEMICAL WORKS AT NORTHWICH.

From this boot the slack is mechanically conveyed to the storage hoppers. The first of the two succeeding illustrations shows a typical coal elevator and conveyor; the second, on the opposite page, a set of storage hoppers, showing their position above the gas producers. From these coal hoppers the slack is fed into the producers, where the combustible matter is converted into gas. Our illustrations from the installation at Messrs. Brunner, Mond & Co.'s Winnington works give a very good idea of the appearance of the producers.

The producer is provided with a water seal, and is so constructed as to allow the ash, which is the only residue, to descend into the water, from which it is easily removed without interfering in any way with the working of the producer.

The process of combustion in the producer is carried out at a comparatively low temperature, with the twofold object of preventing the formation of clinkers in the producer and of providing against the destruction of the ammonia. This is accomplished by introducing into the producer a blast of hot air and steam. The quantity of steam required, when it is desired to recover

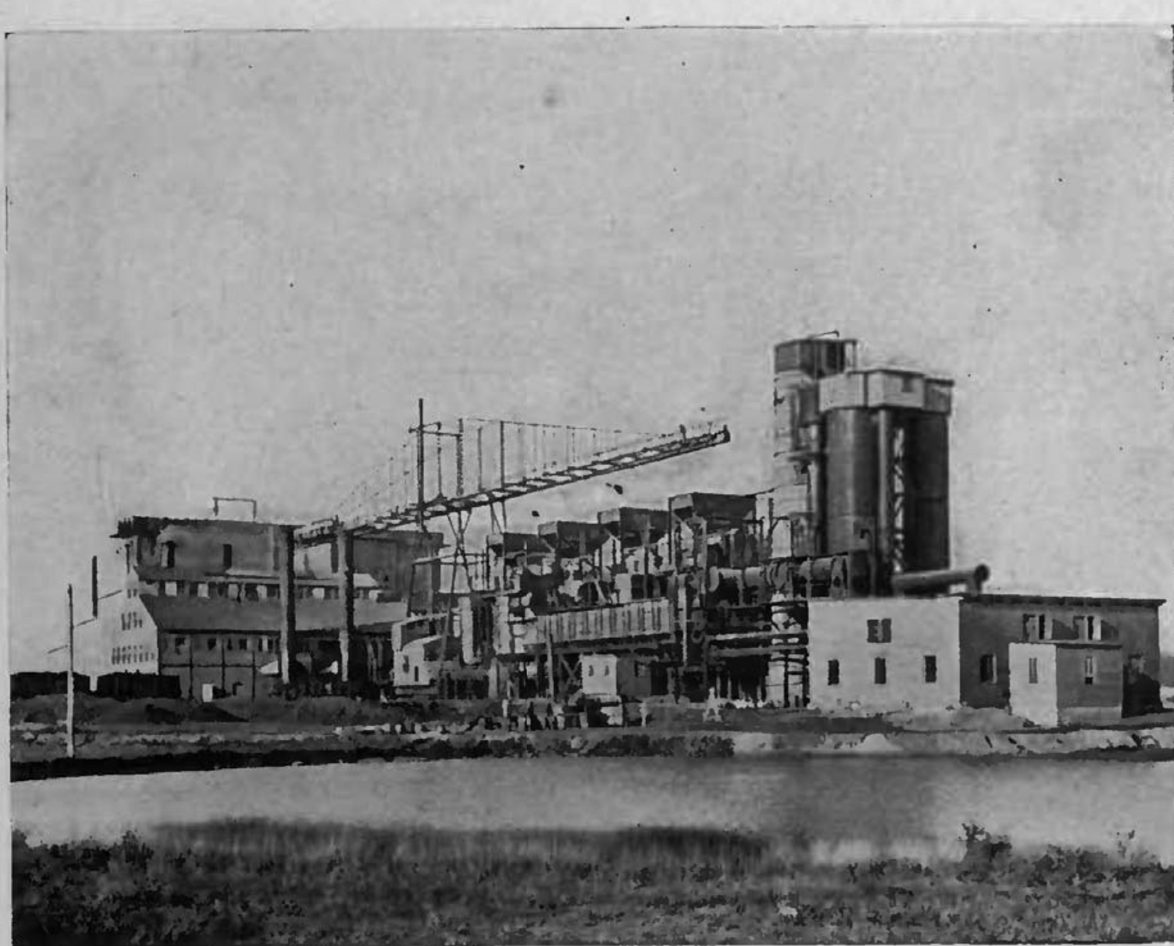


THE COAL ELEVATOR AND CONVEYOR AT THE FARNLEY IRON WORKS, NEAR LEEDS.

the ammonia from the gas, is equal to two and a half tons for every ton of fuel gasified, but of this about one ton is automatically recovered in the way hereafter described, and this is used over and over again. In the case of installations where it is not proposed to recover ammonia, the quantity of steam necessary is reduced to about one ton for each ton of fuel gasified.

After leaving the producer the gas passes through a regenerator so arranged that part of the heat of the gas and steam entering it is transferred to the blast of air and steam on its way from the air-heating tower to the producer, the gas being consequently cooled to a corresponding extent.

The gas is then delivered into a mechanical washer, a rectangular iron chamber, where it is thoroughly washed with water thrown up into a fine spray by a system of rapidly revolving dashers. By the intimate contact thus obtained with the water the temperature of the gas is



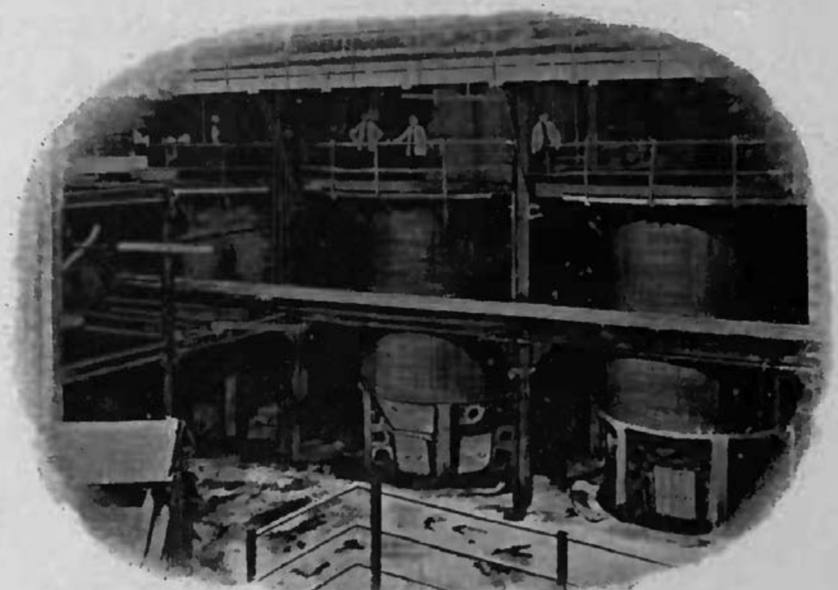
GENERAL VIEW OF THE MOND GAS INSTALLATION AT THE WORKS OF THE SOLVAY PROCESS COMPANY, DETROIT, U. S. A.

further reduced, and all the dust and sooty substances are washed out of it. These are easily removed by an arrangement of lutes in the side of the washers, as shown in our illustrations. After the gas has thus been washed, the next step is the recovery of the ammonia contained in it, and for that purpose the gas passes through the acid tower. The two views on pages 29 and 30 show the acid tower, the air-heating tower and the gas-cooling tower while in course of erection at the Farnley Iron Company's works, near Leeds, England.

While the gas is passing through the acid tower, the ammonia is almost completely washed out by a weak solution of sulphuric acid, with which it enters into combination, thus forming sulphate of ammonia. This acid solution of sulphate of ammonia circulates through the acid tower again and again, until it contains from 36 to 38 per cent. of sulphate of ammonia. In order to provide for the continuity of the process, fresh supplies of sulphuric acid are from time to time added, and corresponding quantities of the sulphate liquor are withdrawn and evaporated, thus yielding solid sulphate of ammonia of good quality, which finds a ready sale.

The gas having now given up its ammonia, is next passed through the gas-cooling tower, where it is subjected to a further cooling and cleaning by means of a downward flow of cold water. It is then ready for use, and passes direct into the mains leading to the works.

As the gas is cooled in this tower, the steam with which it was burdened becomes condensed, and the water which entered the tower as cold water is delivered from it as hot water,

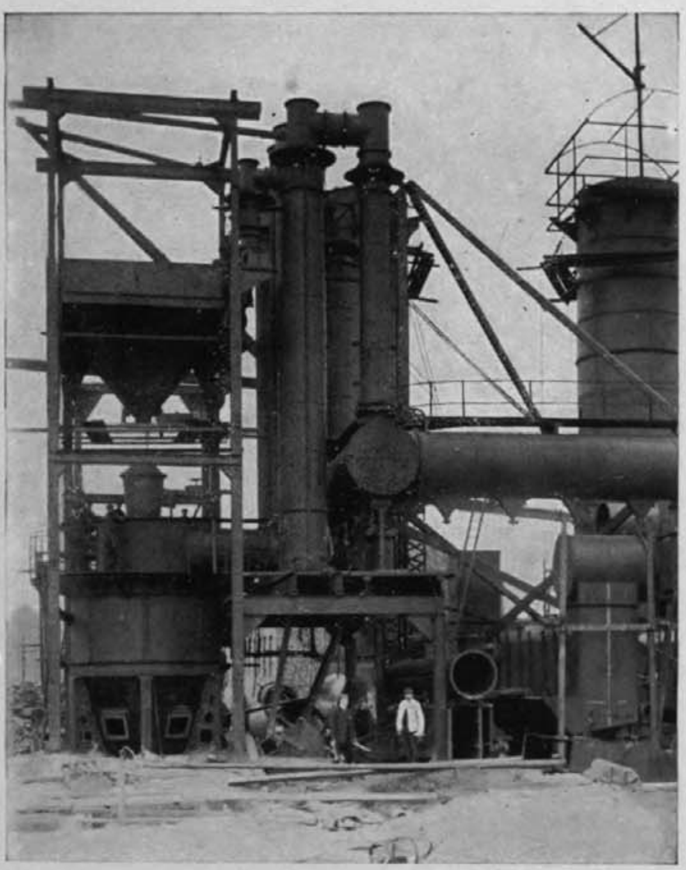


SOME GAS PRODUCERS AT MESSRS. BRUNNER, MOND & CO.'S CHEMICAL WORKS, WINNINGTON, CHESHIRE.

and this, after passing through a vessel suitably constructed for separating the tar which is mixed with it, is again pumped to the top of the neighboring air-heating tower, when it serves to heat the air blast required for the producer.

Into this air-heating tower a blast of air is forced by a blower, and its contact with the descending stream of hot water results in the production of a hot-air blast saturated with vapor which is duly carried into the regenerator and thence delivered into the producers, as already described. The water which was delivered hot into the top of the air-heating tower, after having transferred its heat to the air blast, is drawn off sufficiently cold at the bottom to be returned to the top of the gas-cooling tower to repeat its cycle of utility.

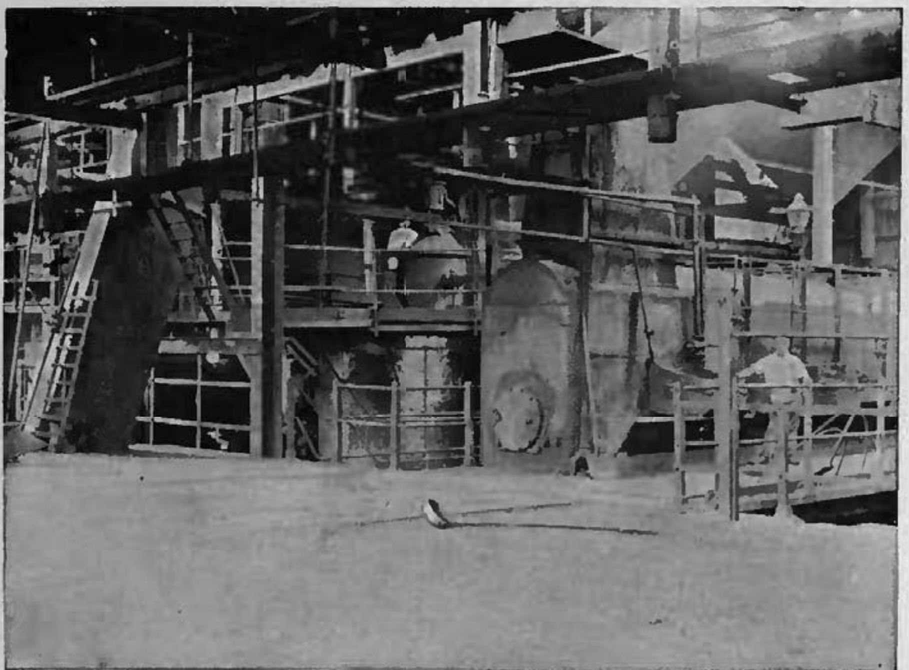
This method of continuously employing the water in circulation as the heat-carrying agent between the hot gas in one tower and the cold air in another, and the method of recovering



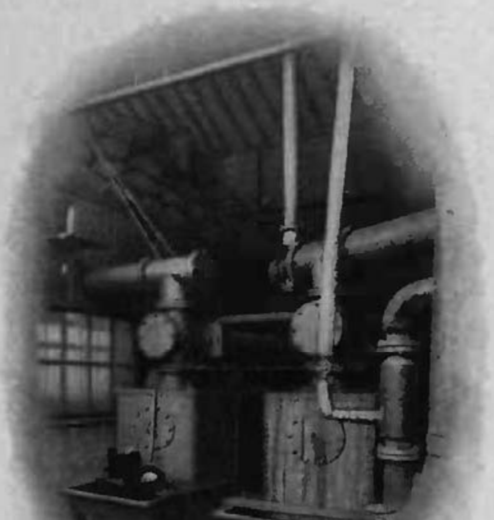
VIEW OF THE MOND GAS PLANT AT MESSRS. MONKS, HALL & CO.'S WORKS AT WARRINGTON, SHOWING THE PRODUCERS AND REGENERATORS.

from the hot gas, by this continuous cyclical exchange of heat, a large proportion of the steam required for the producer blast, form distinctive features in the economy of the process.

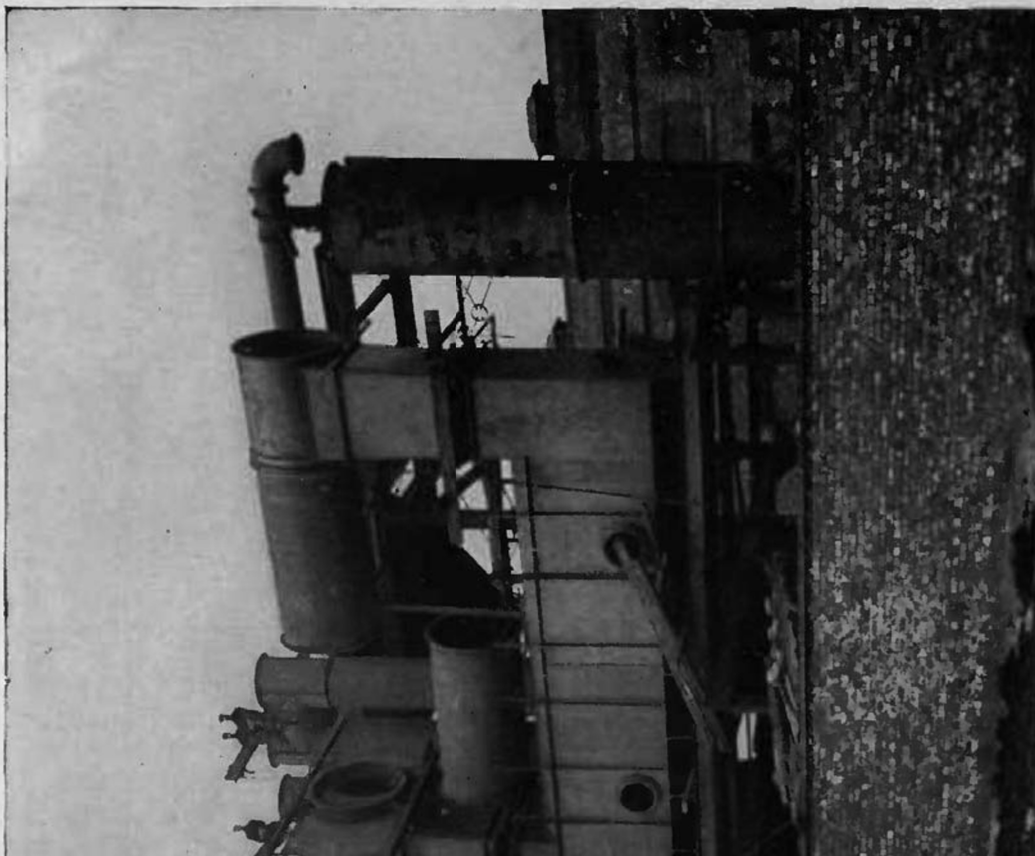
VIEW OF THE MOND GAS PLANT AT THE WORKS OF THE UNITED TURKEY RED COMPANY, LTD., ALEXANDRIA, NEAR GLASGOW, SCOTLAND, (SHOWING THE WATER-SEAL TO THE PRODUCER).



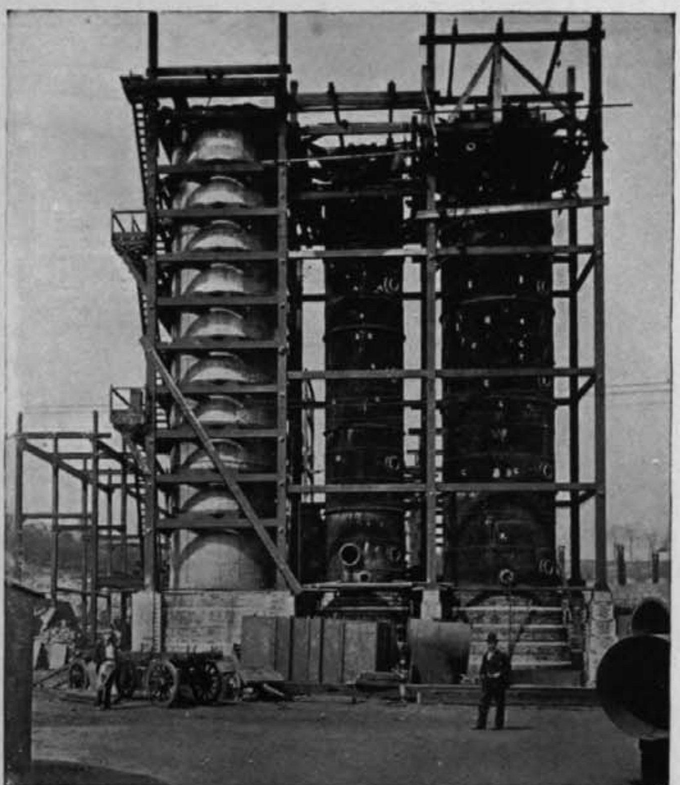
MECHANICAL GAS WASHER AT MESSRS. BRUNNER, MOND & CO.'S CHEMICAL WORKS AT NORTHWICH.



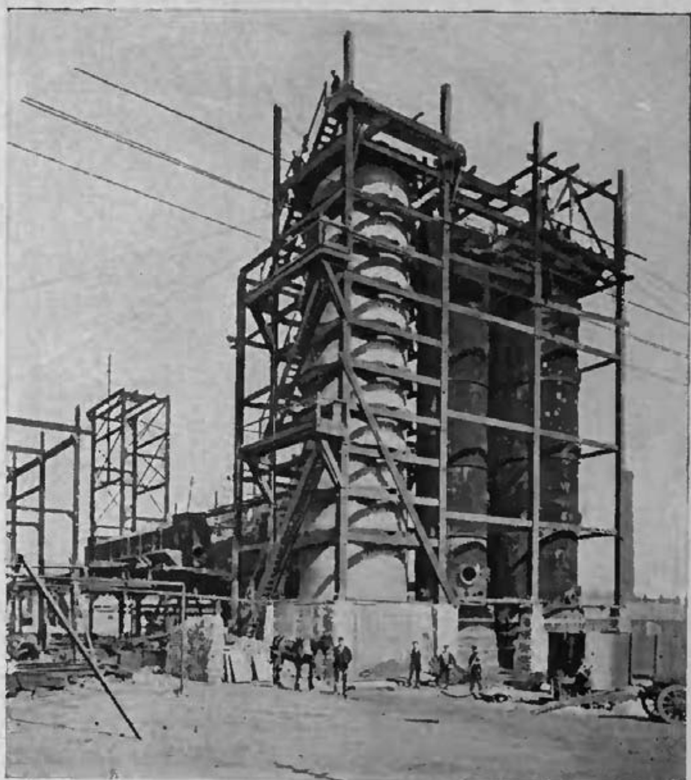
SMALL MOND GAS WASHERS
AT MESSRS. CROSSLEY BROTHERS' ENGINEERING WORKS,
OPENSHAW, MANCHESTER.



VIEW SHOWING THE MECHANICAL GAS WASHER AT THE WORKS OF THE TRAFFORD ELECTRIC SUPPLY COMPANY, LTD., TRAFFORD PARK, NEAR MANCHESTER.



ACID, AIR HEATING AND GAS COOLING TOWERS.
(FARNLEY IRON CO.'S PLANT.)



ACID, AIR HEATING AND GAS COOLING TOWERS.
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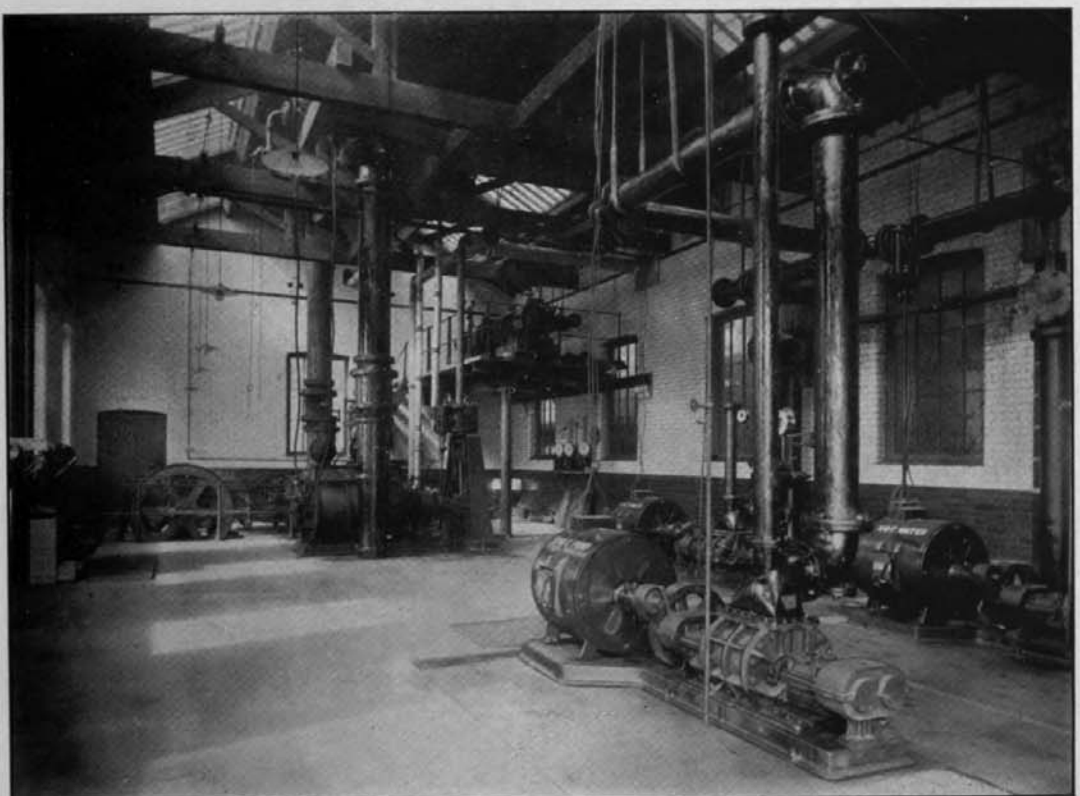
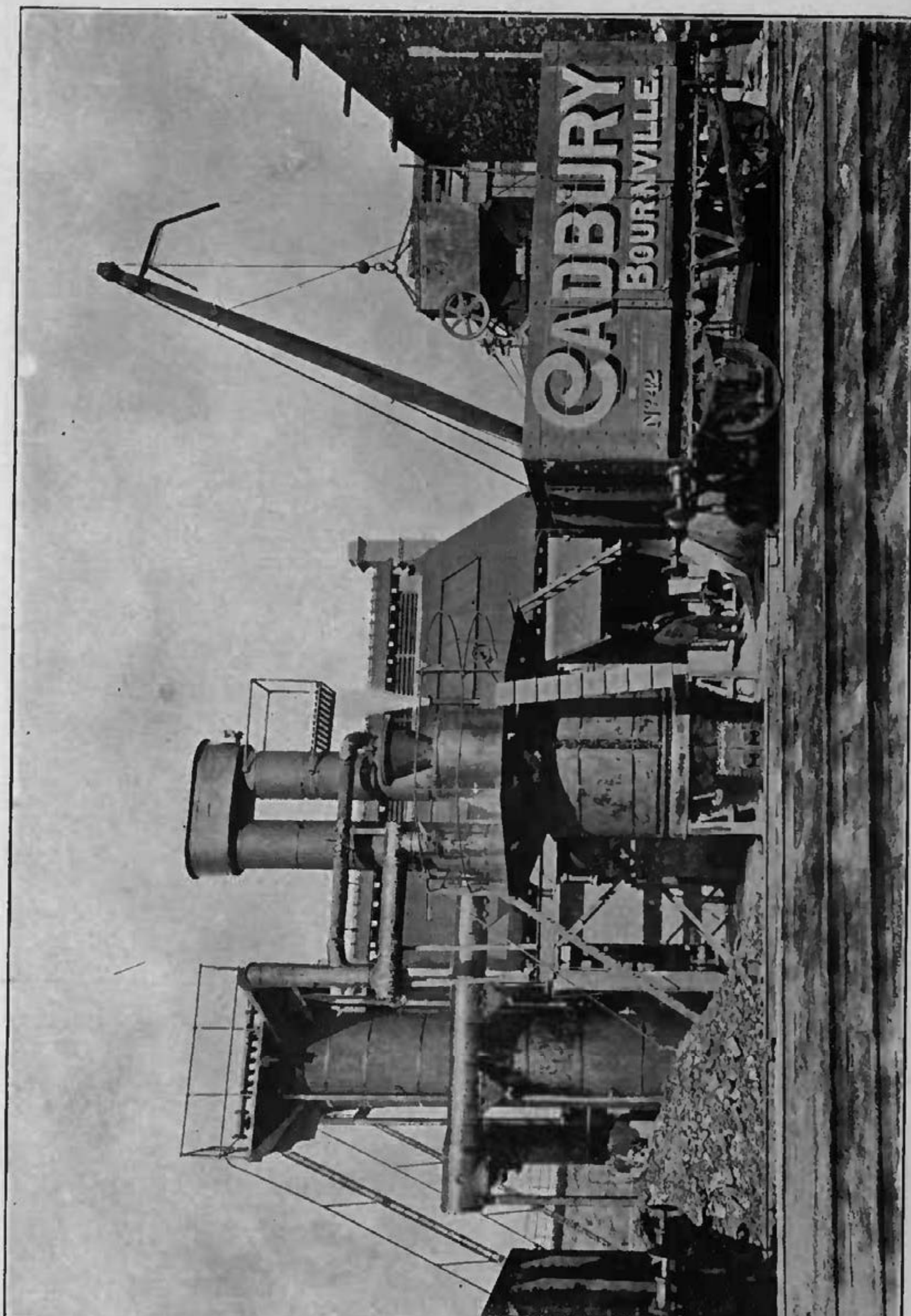


INTERIOR OF THE PUMP HOUSE AT THE FARNLEY IRON WORKS, NEAR LEEDS.



VIEW OF THE MOND GAS PLANT IN THE MESSRS. CADBURY BROTHERS' COCOA WORKS AT BOURNVILLE, NEAR BIRMINGHAM, ENGLAND.

TYPICAL WORKING FIGURES OF MOND GAS INSTALLATIONS.

(1) WITH AMMONIA RECOVERY.
(2) WITHOUT AMMONIA RECOVERY.
(3) COMPARATIVE ANALYSIS OF GASES.

TYPICAL FIGURES OF A 20,000 HORSE-POWER MOND GAS INSTALLATION, WITH AMMONIA RECOVERY.

Average Analysis of Fuel (by weight)—	Slack as received. Per cent.	Calculated on dry slack. Per cent.
Moisture at 100° C. (212° F.)	8.60	nil.
Volatile matter (excluding carbon)	18.29	20.01
Total carbon	62.69	68.59
Ash	10.42	11.40
	100.00	100.00

Analysis of Ashes leaving the Producer—	Per cent.
Ash on dry sample, by weight	87.0
Carbon	13.0
Carbon lost in ashes, calculated on the fuel	1.56

Calorific Value of Fuel (tested on dry sample)—

Determined in a bomb calorimeter—	
Kilogram-calories per kilo of dry fuel	6,786
British thermal units per pound of dry fuel	12,213

Average Volumetric Analysis of Gas—	Volume. Per cent.
Carbonic oxide (CO)	11.0
Hydrogen (H)	27.5
Marsh gas (CH_4)	2.0
Carbonic acid (CO_2)	16.5
Nitrogen (N)	41.3
Water vapor (H_2O)	1.7
Total volume	100.0
Total combustible gases	40.5

Calorific Value of Mond Gas (saturated at 15° C.)—

In kilogram-calories per cubic meter	1,296.8
In British thermal units per cubic foot	145.6

Calorific Value of Mond Gas (dry at 0° C.)—

In kilogram-calories per cubic meter	1,392.2
In British thermal units per cubic foot	156.3

Weight of Mond Gas (saturated at 15° C.)—

In kilograms per cubic meter	.9792
In pounds per 1000 cubic feet	61.11

Weight of Mond Gas (dry at 0° C.)—

In kilograms per cubic meter	1.0371
In pounds per 1000 cubic feet	64.72
Cubic meters of gas (of the above composition) saturated at 15° C. yielded by 1 kilogram of (moist) fuel, having the analysis given	3.828
Cubic feet of gas as above (saturated at 15° C.) yielded by 1 ton of moist fuel	*137,349
The equivalent of this in cubic feet of gas having a calorific value of 140 British thermal units per cubic foot is	142,857

NOTE.—1 ton = 2240 lbs.

* N. B.—Coals having a higher percentage of carbon than the sample, the analysis of which is given above, would yield a proportionately larger volume of gas per ton.

STATEMENT OF ANNUAL WORKING COST OF 20,000 I.H.P. PLANT WITH AMMONIA RECOVERY, WORKING CONTINUOUSLY AT FULL LOAD FOR 365 DAYS OF 24 HOURS.

	£	s.	d.	
Total Fuel (91,250 tons*) including that required to raise all necessary steam at 6s. ($1.45½) per ton............	27,375	0	0	$132,768.75
Wages at Producers, boilers, sulphate recovery and evaporating plants, including handling of coal and ashes, also shipping of sulphate	4,859	0	0	23,566.15
Sulphuric Acid at 30s. ($7.27½) per ton, also lubricants, lighting, stores, repairs (including wages and materials for same)	6,456	0	0	31,311.60
	£38,690	0	0	$187,646.50
Less 2920 tons of sulphate at £10 ($48.50) per ton.........	29,200	0	0	146,000.00
Net cost per annum..............................	£9,490	0	0	$41,646.00

	Pence.	Cents.
Cost of available gas per 1000 cubic feet.................	0.2213	0.4426
Cost of one indicated horse power per hour..............	0.0133	0.0266
Cost of one indicated horse power for one year of 365 days of 24 hours..................................	s. 9 d. 8.3	$2.35
If coal be taken at 8s. ($1.94) per ton—	Pence.	Cents.
Cost of available gas per 1000 cubic feet.................	0.4371	0.864
Cost of one indicated horse power per hour..............	0.0262	0.0524
Cost of one indicated horse power for one year of 365 days of 24 hours..................................	s. 19 d. 1.8	$4.64

STATEMENT OF ANNUAL WORKING COST OF A 20,000 I.H.P. PLANT WITH AMMONIA RECOVERY, WORKING CONTINUOUSLY, BUT UNDER A VARIABLE LOAD, WHICH IS EQUAL TO HALF LOAD THROUGHOUT.

	£	s.	d.	
Total Fuel (46,125 tons*), including that required to raise all necessary steam, and also stand by losses of half plant when standing for 12 hours every day at 6s. ($1.45) *per ton*.....	13,837	10	0	$67,112.87
Wages at Producers, boilers, sulphate recovery and evaporation plant, including handling of coal and ashes, also shipping of sulphate	4,133	15	0	19,948.68
Sulphuric Acid at 30s. ($7.27½) per ton, also lubricants, lighting, stores, repairs (including wages and materials for same)	4,010	10	0	19,450.92
	£21,981	15	0	$106,611.47
Less 1460 tons sulphate at £10 ($48.50) per ton..........	14,600	0	0	70,810.00
Net cost per annum..............................	£7,381	15	0	$35,801.47

	Pence.	Cents.
Cost of available gas per 1000 cubic feet................	0.3467	0.6934
Cost of one indicated horse power per hour..............	0.0208	0.0416
Cost of one indicated horse power for one year of 365 days of 24 hours................................	s. 15 d. 2.3	$3.68
If coal be taken at 8s. ($1.94) per ton—	Pence.	Cents.
Cost of available gas per 1000 cubic feet................	0.5633	1.1266
Cost of one indicated horse power per hour.............	0.0338	0.0676
Cost of one indicated horse power for one year of 365 days of 24 hours................................	£ 1 s. 4 d. 8	$5.98

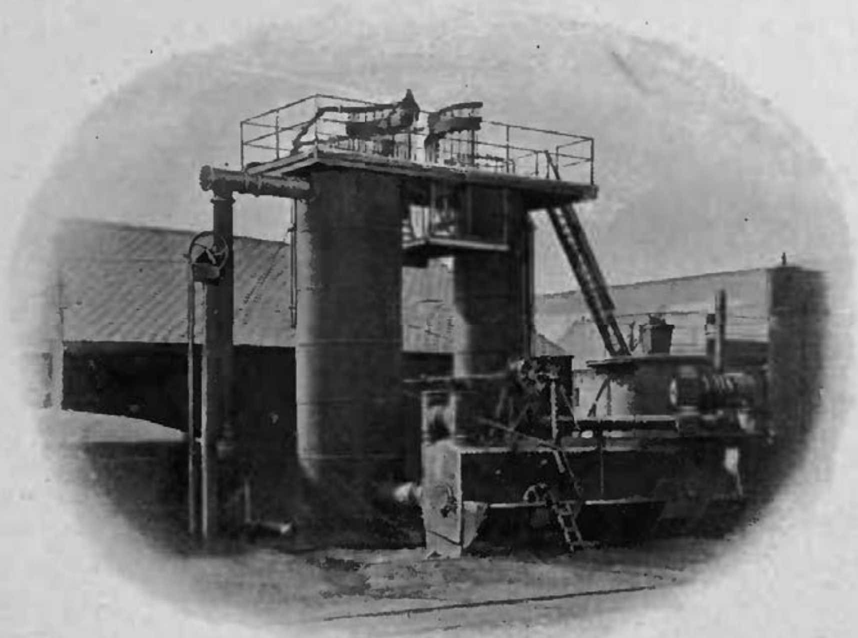
* NOTE.—1 ton = 2240 lbs. £1 = $4.85.

AVERAGE ANALYSIS AND CALORIFIC VALUE OF MOND COMPARED WITH ILLUMINATING GAS.

Volume per cent. (gases saturated at 15° C.)—	Mond Gas from Bituminous Fuel.	London Illuminating Gas.
Carbonic oxide (CO)	11.0	7.8
Hydrogen (H)	27.5	52.9
Marsh Gas (CH_4)	2.0	31.8
C_nH_{2n} + Benzol	nil.	5.0
Carbonic acid (CO_2)	16.5	nil.
Nitrogen + moisture ($N + H_2O$)	43.0	2.5
Total volume	100.0	100.0
Total combustibles	40.5	97.5
Calorific value (gas dry at 0° C.)—		
In kilogram-calories per cubic meter	1,392.2	5,823.3
In British thermal units per cubic foot	156.3	641.9

TYPICAL FIGURES OF A 1000 HORSE-POWER MOND GAS INSTALLATION, WITHOUT AMMONIA RECOVERY.

BY the use of Mond gas in gas engines, power is obtained at a lower cost than by any other means, and, in view of the growing appreciation of this fact and of the increasing numbers of inquiries received for Mond gas plants of comparatively small capacity for use in conjunction with gas engines, there are now being constructed in England gas plants



MOND GAS PLANT AT THE WORKS OF THE PREMIER GAS ENGINE CO., SANDIACRE, NEAR NOTTINGHAM, ENGLAND.

of 250 H.P. and upwards; but it is obvious that many of these are not of sufficient capacity to warrant the inclusion of ammonia recovery plant (see page 9). Our illustration, page 37, shows a Mond gas plant, equal to the production of 1000 H.P., now in use at the works of the Premier Gas Engine Co., and on page 32 will be found a 500 H.P. plant, the gas from which is used in Westinghouse gas engines at Messrs. Cadbury Brothers' works, Birmingham, England.

These comparatively small power plants are capable of being worked with a widely varying load factor (even down to one-sixth load) without sacrifice of economy, and tests that have been made show that under extreme conditions the gas remains practically constant, both as to the composition and as to the quantity yielded per ton of fuel fed to the producer.

The following typical figures show some average results obtained from the working of a 1000 H.P. Mond gas plant:

Average Analysis of Fuel (by weight)—	Slack as received. Per cent.	Calculated on dry slack. Per cent.
Moisture at 100° C. (212° F.)	8.60	nil.
Volatile matter (excluding carbon)	18.29	20.01
Total carbon	62.69	68.59
Ash	10.42	11.40
	100.00	100.00

Calorific Value of Fuel (tested on dry sample)—

Determined in a bomb calorimeter.

Kilogram-calories per kilogram of dry fuel	6,786
British thermal units per pound of dry fuel	12,213

Average Analysis of Ashes from Producer—	Per cent.
Ash on dried sample, by weight	86.1
Carbon	13.9
Carbon lost in ashes	2.31

Average Analysis of Gas (tested when saturated at 15° C.)—	
Carbonic oxide (CO)	13.8
Hydrogen (H)	24.3
Marsh gas (CH_4)	2.0
Carbonic acid (CO_2)	13.9
Nitrogen + moisture ($N + H_2O$)	46.0
Total volume	100.0
Total combustible gases	40.1

Calorific value (gas saturated at 15° C.) in kilogram-calories, per cubic meter	1,284.3
Calorific value (gas saturated at 15° C.) in British thermal units, per cubic foot	144.2
Calorific value (gas dry at 0° C.) in kilogram-calories, per cubic meter	1,378.1
Calorific value (gas dry at 0° C.) in British thermal units, per cubic foot	154.8

The small power plants are specially constructed in such a way as to require only a minimum amount of labor and supervision, and it will be seen from the subjoined that the cost of labor in actual practice is extremely small.

STATEMENT OF ANNUAL WORKING COST OF A 1000 H.P. PLANT, WORKING CONTINUOUSLY AT FULL LOAD FOR 365 DAYS (OF 24 HOURS).

	£	s.	d.	
Total Fuel (4211 tons*), including that required to raise steam for the machinery and producers, etc. (Evaporation 6½ pounds per pound of fuel) at 6s. ($1.45½) per ton	1,263	6	0	$6,127.00
Labor—				
Three men (per day of 24 hours) each working 1 shift of 8 hours	246	7	6	1,194.91
Other expenses, including maintenance, repairs, cost of oil, waste, stores and sundries	195	12	6	948.78
Total working cost per annum	£1,705	6	0	$8,270.70

	Pence.	Cents.
Cost of available gas per 1000 cubic feet	0 8000	1.61
Cost of one indicated horse power per hour	0 0480	0.09696
Cost of one indicated horse power for one year of 365 days of 24 hours	£ 1 s. 15 d. 0.53	$8.5076
If coal be taken at 8s. ($1.94) per ton—	Pence.	Cents.
Cost of available gas per 1000 cubic feet	0.9987	2.017
Cost of one indicated horse power per hour	0.0599	0.121
Cost of one indicated horse power for one year of 365 days of 24 hours	£ 2 s. 3 d. 8.9	$10.55

STATEMENT OF ANNUAL WORKING COST OF A 1000 H.P. PLANT WORKING INTERMITTENTLY, SAY 300 DAYS PER ANNUM, FOR 12 HOURS PER DAY, AT AN AVERAGE OF TWO-THIRDS OF THE FULL LOAD.

	£	s.	d.	
Total Fuel (1200 tons*), including that required to raise steam for the machinery and producer (evaporation 6½ pounds per pound of fuel), also for stand-by losses for 65 days of 24 hours and 300 nights of 12 hours at $1.45 per ton	360	0	0	$1,746.00
Labor—				
One man at 5s. ($1.21) per day for 300 days	75	0	0	363.75
Other expenses, including maintenance repairs, cost of oil, waste, stores and sundries	118	15	0	575.93
Total working cost per annum	£553	15	0	$2,685.68

	Pence.	Cents.
Cost of available gas per 1000 cubic feet	0.9486	1.916
Cost of one indicated horse power per hour	0.0569	0.114
Cost of one indicated horse power for one year of 365 days of 24 hours	£ 2 s. 1 d. 6.58	$10.075
If coal be taken at 8s. ($1.94) per ton—	Pence.	Cents.
Cost of available gas per 1000 cubic feet	1.1200	2.2624
Cost of one indicated horse power per hour	0.0672	0.1357
Cost of one indicated horse power for one year of 365 days of 24 hours	£ 2 s. 9 d. 0.67	$11.8960

* NOTE.—1 ton = 2240 lbs. £1 = $4.85.

In cases of intermittent working, no inconvenience is experienced nor time wasted in the daily stopping and starting of these plants, and the stand-by losses are extremely small.

When a plentiful supply of small coke and breeze from gas or coke ovens is available, the following figures will show the results obtainable in a non-recovery Mond gas plant from this fuel:

	Per cent.
Average Analysis of Mixed Coke and Breeze—	
Moisture	12.5
Ash	16.3
Volatile matter	3.9
Carbon	65.5
Analysis of Gas Made—	
Carbonic oxide (CO)	10.8
Hydrogen (H)	25.2
Marsh gas (CH_4)	0.4
Carbonic acid (CO_2)	16.8
Nitrogen (N)	46.8
Total volume	100.0
Total combustible gases	36.4
Calorific value in kilogram-calories per cubic meter	1,139
Calorific value in British thermal units per cubic foot	127.9

MOND GAS IN GAS ENGINES.

IT has been well said that, while the nineteenth century has been the era of the steam engine, the twentieth century will be that of the gas engine. Reviewing for a moment the position of the steam engine to-day, the conclusion is unavoidable that it is doomed to be displaced by its more economical rival, the gas engine. Its highest development has resulted in its capacity to produce a horse-power hour from about one and a half pounds of good steam coal, which corresponds to an efficiency of not more than twelve per cent. of the actual heat energy contained in the fuel. When moderate-sized engines are considered, say from 100 to 200 H.P., the percentage of efficiency obtainable must be considerably reduced; and, in the case of smaller engines, of from 20 to 30 H.P., it is even less than half; indeed, from six to twelve pounds of fuel are then usually consumed for the production of a horse-power hour.

In contrast with the above figures we have the modern gas engine, from which, even in the case of small powers, an efficiency is obtained considerably higher than that resulting from the use of the largest and most economical steam engine. One of the principal factors that contributes to this important advantage in favor of the gas engine is found in the more direct conversion of the heat energy contained in the fuel. In the case of the steam engine the heat has first to be transferred from the coal to the water in the boiler, and not until the heat finally appears in the form of steam under pressure, is it in a position to deliver its energy to the piston of the engine. In the case of the gas engine the heat is directly carried into the cylinder of the engine in the form of gas without undergoing any other conversion.

Notwithstanding the increased thermal efficiency to be obtained by the employment of gas engines, their adoption was until quite recently restricted to the employers of small powers; not so much by reason of any inability of the engineers to build larger gas engines, but owing to the lack of a cheap and suitable gas that could be produced from common fuel in an apparatus capable of working continuously with a minimum of labor. The Mond gas plant fulfills all these conditions, and constitutes a perfect system of producing a cheap power gas which, when used in gas engines, is undoubtedly the cheapest, the most scientific and the most economical fuel in existence.

Mond gas can be carried long distances without loss or deterioration, while, with steam, loss by condensation in the mains is unavoidable. The extent of this loss need not here be dwelt upon at length, it being generally recognized that when steam has to be carried any considerable distance the cost of power is greatly increased.

Mond gas producers respond immediately to a sudden increase in demand, while a steam boiler must be allowed time to increase its output; and it is, moreover, of still greater importance to note that the working as between the gas producers and the gas engines is automatically controlled, so that the quantity of gas produced is regulated precisely in accordance with the demand.

As regards regularity and reliability in actual practice, it may be here stated that an engine working with Mond gas has run continuously, day and night, at full load, for six months without stopping for any purpose whatever.

As regards fuel consumption, engines of varying sizes are working and indicating a horse-power hour on a consumption of less than 60 cubic feet of Mond gas, involving the gasification in the producer of less than nine-tenths pound of common slack. In cases of intermittent working, with varying loads, and after making provision for stand-by losses and steam raising, a perfectly safe basis for the calculation of fuel consumption is one pound of fuel per I.H.P. hour.

For large power stations, where economy of fuel is of paramount importance, an installation for the production of Mond gas, and for the recovery of ammonia therefrom, provides for the maximum power at a minimum cost, and not only are the working expenses of such a power plant far more economical than those of a steam plant of the same capacity, but the initial cost of a complete Mond gas installation on a large scale (comprising gas producers, washers, steam recovery towers, ammonia recovery apparatus and gas engines) compares very favorably with that of the best steam-driven plant of similar capacity, including therewith the cost of the necessary chimney, boiler-house and foundations, engines, boilers, mechanical stokers, condensers and auxiliary machinery.

The thermal efficiency of the gas engine quoted above is 37.76 per cent. of the original calorific value of the gas consumed, and in this connection it is worthy of note that the highest thermal efficiency ever reached with producer gas has been obtained with a gas engine of 500 H.P., working with Mond gas. This engine will indicate 650 H.P. when running at the moderate speed of 128 revolutions per minute.

TABLE OF RESULTS OBTAINED FROM A 500 HORSE-POWER GAS ENGINE OF THE TANDEM POSITIVE SCAVENGER TYPE WORKING WITH MOND GAS.

TRIAL WITH THE ENGINE, GIVING TWO-THIRDS OF ITS MAXIMUM OUTPUT.

Duration of test, 12.30 P.M. to 5.30 P.M. .... hours	5

Dimensions of Engine—

Two cylinders arranged tandem, each .... diameter, inches	28⅛
Pump cylinder, for scavenging air .... " "	43½
Length of stroke .... inches	30
The engine is direct coupled to a Mather and Platt dynamo.	
Average revolutions per minute	128.05
Load on engine, as fraction of maximum output	⅔
Number of explosions per minute, back cylinder	64.02
Number of explosions per minute, front cylinder	31.75
Mean effective pressure, average for back cylinder ..... pounds, square inch	109.1
Mean effective pressure, average for front cylinder ... " "	107.4
Mean effective pressure, average for pump cylinder .. " "	2.55
Indicated horse power, back cylinder	328.72
Indicated horse power, front cylinder	160.49
Indicated horse power, gross total	489.21
Indicated horse power, pump	21.39
Output of dynamo, average ampères	2320.0
Output of dynamo, average volts	110.1
Electrical horse power	342.4
Kilowatts	255.43

Efficiencies—

Electrical efficiency of dynamo .... per cent.	93
Mechanical efficiency of engine, excluding fluid losses .... "	81.22
Brake H.P. at dynamo coupling	368.2
Combined efficiency, E.H.P./I.H.P. per cent	70.0
Average temperature of jacket water, back	49° C. (120° F.)
Average temperature of jacket water, front	37° C. (98° F.)
Gas used.—Total as measured by meter .... cubic feet	136,100
Temperature of gas 14.6° C. (58.3° F.) Barometer 29.992 inches.	
Dry gas at 0° C. and 760 mm., used per hour .... "	25,482

Analysis of Gas—

CO_2	volume per cent.	16.0
CO	" "	12.2
H	" "	27.8
CH_4	" "	2.2
N	" "	41.8
Total combustible gases	" "	42 2

"Higher" calorific value, including latent heat of steam—

Kilo-calories per cubic meter, 0° C.	1,432.7
British thermal units per cubic foot	160.9

"Lower" calorific value, excluding latent heat of steam—

Kilo-calories per cubic meter, 0° C.	1,280.4
British thermal units per cubic foot	143.8

	Cubic Feet.
Mond Gas, at 0° C. per I.H.P. hour	52.09 = 0.88 lbs. slack.
Mond Gas, at 0° C. per B.H.P. hour	69.20 = 1.17 lbs. slack.
Mond Gas, at 0° C. per E.H.P. hour	74.42 = 1.26 lbs. slack.
Mond Gas, at 0° C. per Board of Trade Unit (kilowatt hour)	99.76 = 1.64 lbs. slack.

Thermal Efficiencies.	Calculated on "higher" calorific value.	Calculated on "lower" calorific value.
	Per cent.	Per cent.
Calculated on the I.H.P.	30.38	34.00
" " B.H.P.	22.87	25.59
" " E.H.P.	21.27	23.80

Mond gas is as equally suitable for use in small as in large engines, and the following table shows the result obtained over a period of two years with a 60 H.P. gas engine direct coupled to a 75 K.W. Siemens dynamo:

	Year 1898.	Year 1899.
Hours.—Total number of hours in year	8,760	8,760
Hours gas engine ran on load	8,356.5	8,574.4
Hours running as per cent. on total	95.4	97.88
Units Generated.—1000 watt hours generated and measured at the switchboard	558,726	562,855
Gas Used.—Cubic feet of Mond gas supplied to the engine during the year, measured saturated at the temperature of the meter house	64,281,240	67,349,650
Load.—Average ampères at 100 volts	668.5	656.5
Average E.H.P. at switchboard	89.6	88.0
Efficiency.—On the assumption that the electrical efficiency of the dynamo is 91 per cent. and the mechanical efficiency of the engine is 85 per cent., the combined efficiency will be 77.35 per cent., and the average I.H.P. for the year is	115.8	113.7
Consumption of Gas.—Per I.H.P. hour	60.4 c.ft.	69.0 c.ft.
Equivalent of slack fed into producer per I.H.P. hour	1.03 lbs.	1.08 lbs.
Per kilowatt hour at switchboard	115.0 c.ft.	119.6 c.ft.
or	3.25 m³	3.338 m³
Equivalent of slack fed into producer per I.H.P. hour	1.79 lbs.	1.86 lbs.
Calorific Value of Gas, in kilo-calories—		
Per cubic foot, as measured	38.2	37.5
Per cubic meter, as measured	1,350	1,325
Thermal Efficiency—		
Kilo-calories supplied per I.H.P hour	2,537	2,597
Efficiency calculated on I.H.P. per cent	25.4	24.8
Kilo-calories supplied per kilowatt hour	4,390	4,449
Efficiency calculated on kilowatts per cent	19.7	19.2

NOTE.—The dynamo was separately excited, and the current for the field magnets is not included in the above figures. Isolated experiments show the combined efficiency to be somewhat less than that assumed above, so that the I.H.P. upon which the efficiency has been calculated is certainly not too high.

(The above records were taken at Messrs. Brunner, Mond & Co.'s Winnington Power House, Northwich, Cheshire, England.)

RAISING STEAM BY THE EXHAUST GASES FROM GAS ENGINES.

IT is interesting to note that the steam required for the Mond gas plant can be raised by utilizing the heat contained in the exhaust gases leaving the gas engines. This increased economy is an important consideration, and particularly so in the case of central stations employing gas engines.

Formerly the heat of the exhaust gases was wasted, and the steam necessary for the saturation of the producer blast had to be raised in the ordinary way. Results recorded with a 500 H.P. gas engine show that by passing its exhaust gases through a specially designed tubular boiler, their heat can be so efficiently utilized as to provide all the extra steam required in the producer to furnish the supply of Mond gas necessary for the gas engine, thus increasing the fuel economy of the system by some 20 per cent.

This system of raising steam has already been adopted in one power station, where Mond gas is used to drive large gas engines producing several thousand horse power, and no trouble or difficulty is experienced in working.

The system is destined to play an important part in future installations where Mond gas and large gas engines are employed.

LIST OF BUILDERS OF LARGE GAS ENGINES.

FROM 300 I.H.P. TO 2500 I.H.P.

IN THE UNITED STATES.

The Alberger Co., Ellicott Square, Buffalo, N. Y.
The De la Vergne Co., Port Morris, New York City (Körting Engines).
The Otto Gas Engine Co., Philadelphia, Pa.
The Snow Steam Pumping Engine Co., Buffalo, N. Y.
Struthers, Wells & Co., Warren, Pa.
Westinghouse Machine Co., East Pittsburg, Pa.

IN EUROPE.

J. E. H. Andrew & Co., Ltd., Reddish, near Stockport, England.
The British Westinghouse Electric and Manufacturing Co., Ltd., Trafford Park, Manchester, England.
Borsig & Co., Tegel, near Berlin, Germany.
Campbell Gas Engine Co., Ltd., Kingston, Halifax, England.
Compagnie Française des Moteurs à Gaz, Paris, France.
Compagnie Letombe, Fives-Lille, France.
Crossley Brothers, Ltd., Openshaw, Manchester, England.
Deutsche Kraftgas-Gesellschaft, Berlin, Germany (Oechelhauser Engines).
Fielding & Platt, Ltd., Atlas Iron Works, Gloucester, England.
Fraser & Chalmers, Ltd., Erith, Kent, England (Körting Engines).
Gas Motoren Fabrik Deutz, Coln-Deutz, Germany.
Gebr. Körting, Körtingsdorf, near Hanover, Germany.
Mather & Platt, Manchester, England (Körting Engines).
The Premier Gas Engine Co., Ltd., Sandiacre, near Nottingham, England.
Richardsons, Westgarth & Co., Ltd., Middlesborough, England (Cockerill Engines).
Schweizerische Maschinen Fabrik, Winterthur, Switzerland.
Société Anonyme John Cockerill, Seraing, Belgium.
Société Génerale des Industries Economiques, Charon, Paris, France.
Tangyes, Ltd., Cornwall Works, Birmingham, England.
Vereinigte Maschinenfabrik Augsburg und Maschinenbau Gesellschaft, Nürnberg, Germany.

THE DISTRIBUTION OF MOND GAS FROM CENTRAL STATIONS.

THE DISTRIBUTION OF MOND GAS FROM CENTRAL STATIONS.

SOME PARTICULARS OF THE SOUTH STAFFORDSHIRE MOND GAS COMPANY OF SOUTH STAFFORDSHIRE, ENGLAND.

THE company was formed for the purpose of manufacturing and distributing Mond gas to manufacturers and others throughout the district which is defined by the South Staffordshire Mond Gas (Power and Heating) Company's Act of Parliament (1901), and which is shown in the map on the following page.

The area comprises 123 square miles, bearing a population of some 640,000.

The company is building central stations, probably six in number, throughout the district.

The first station will be capable of producing daily about 40,000,000 cubic feet of Mond gas, which will be distributed by means of mains to the consumers, and it is intended to fix the prices upon a basis that will enable them to participate in the advantages of the scheme to the fullest possible extent.

The advantages to be derived by consumers drawing their supply of Mond gas from a central station are not confined to the reduced fuel cost. The dirt and nuisance arising from the carting of coal and ashes through the works disappear. The cost of repairs, interest on capital and other charges are lessened with the introduction of the new system.

The complete installation throughout the entire district will probably cost a sum of about $3,900,000 (£800,000), and there is no doubt but that South Staffordshire will reap immense advantages from the distribution of Mond gas, placing, as it does, a supply of cheap power and cheap heating gas within the reach of all classes of manufacturers; and, indeed, many representatives of the iron, steel, glass, firebrick and other industries gave evidence before the Parliamentary Committee that such a supply of cheap gas would be of the greatest value to them as manufacturers and to the district as a whole.

MAP OF SOUTH STAFFORDSHIRE SHOWING THE AREA TO BE SUPPLIED WITH MOND GAS.

Local Authorities in Area.

Corporations:

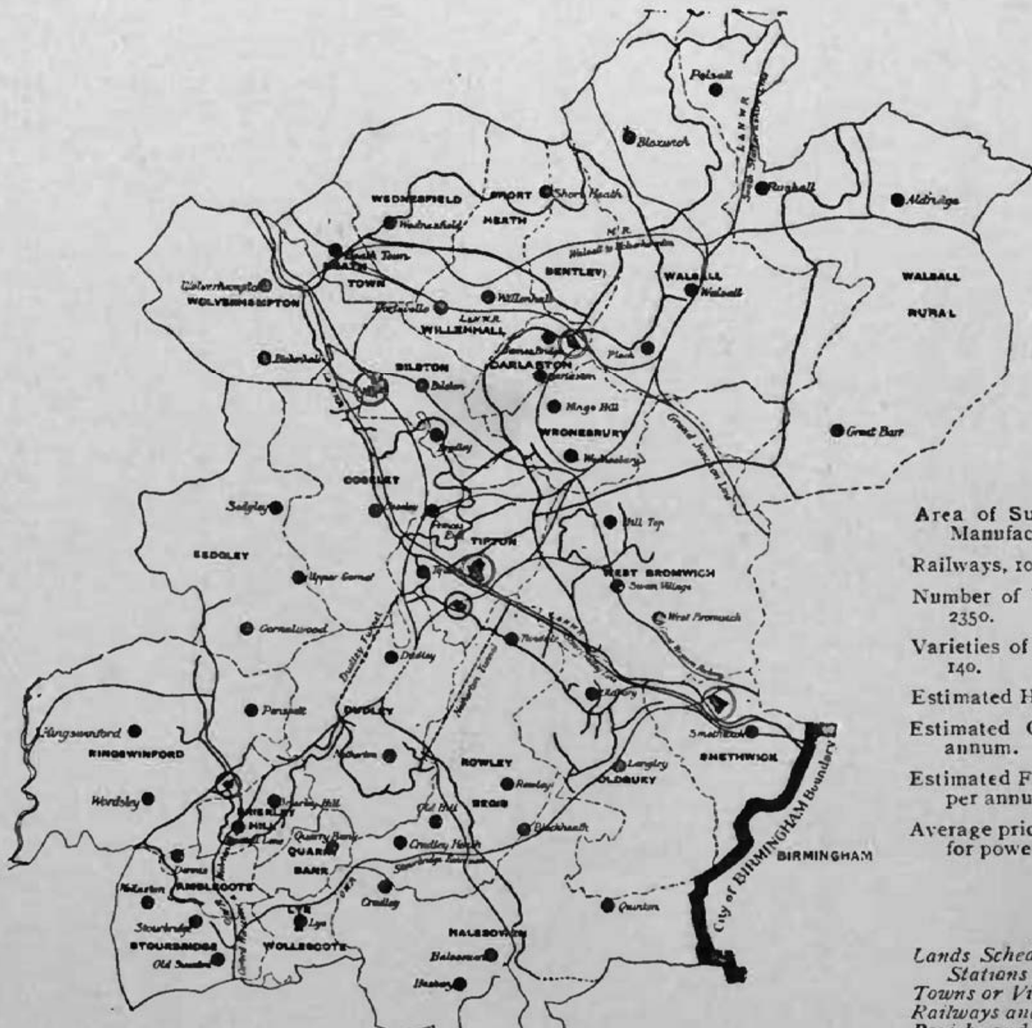
DUDLEY,
SMETHWICK,
WALSALL,
WEDNESBURY,
WEST BROMWICH,
WOLVERHAMPTON.

Urban District Councils:

AMBLECOTE,
BILSTON,
BRIERLEY HILL,
COSELEY,
DARLASTON,
HEATHTOWN,
LYE and WOLLESCOTE,
OLDBURY,
QUARRY BANK,
ROWLEY REGIS,
SEDGLEY,
SHORT HEATH,
STOURBRIDGE,
TIPTON,
WEDNESFIELD,
WILLENHALL.

Rural District Councils:

HALESOWEN,
KINGSWINFORD,
WALSALL
(including BENTLEY).



Area of Supply—123 square milea, chiefly Manufacturing and Mining.

Railways, 100 miles. Canals, 106 miles.

Number of Works requiring heat or power, 2350.

Varieties of Trades requiring heat or power, 140.

Estimated Horse Power, 300,000.

Estimated Coal raised, 4,000,000 tons per annum.

Estimated Fireclay and Ironstone, 340,000 tons per annum.

Average price of Ordinary Coal Gas in district for power purposes = 2/5 per 1000.

Lands Scheduled for Gas Generating Stations shown thus . . . . ◎
Towns or Villages shown thus . . . . . . ●
Railways and Canals shown thus . . . .
Parish and other Boundaries shown thus . . . .

MOND GAS

FOR CENTRAL ELECTRIC STATIONS.

ECONOMY OF GAS ENGINES FOR CENTRAL STATIONS.

GAS ENGINES FOR DRIVING DYNAMOS.

GAS ENGINES RUNNING ALTERNATORS IN PARALLEL.

WORKING ESTIMATE OF A 20,000 E.H.P. CENTRAL STATION.

THE NORTHWICH ELECTRIC SUPPLY COMPANY.

THE TRAFFORD POWER AND LIGHT SUPPLY COMPANY.

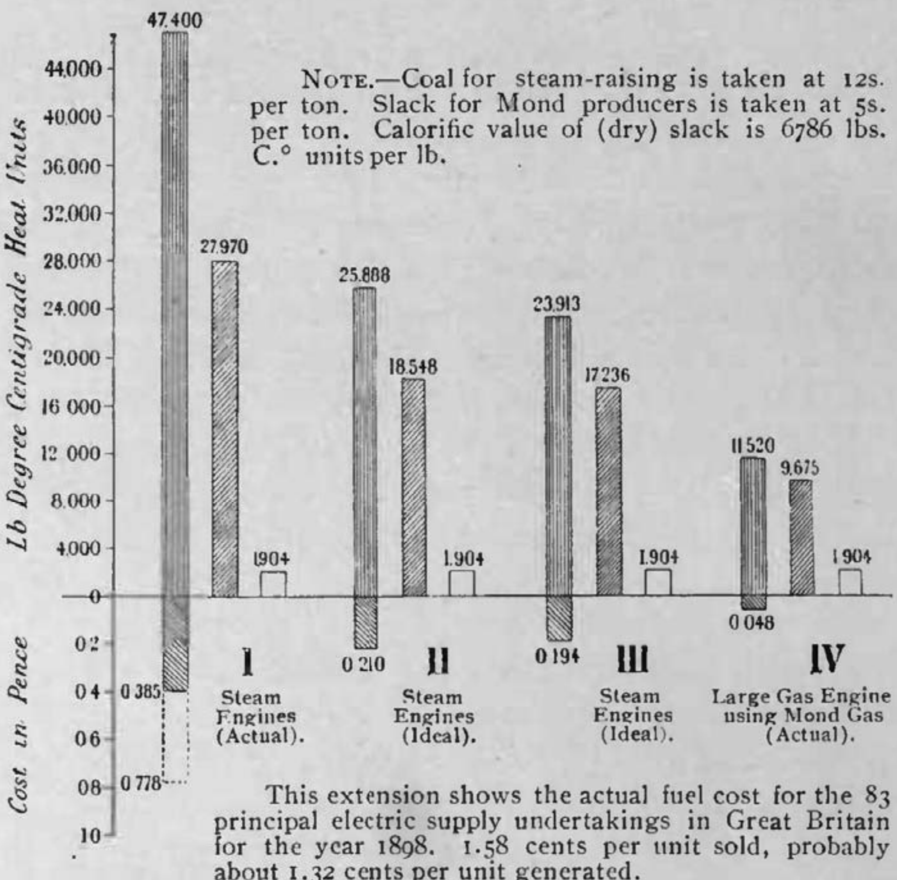
MOND GAS FOR CENTRAL ELECTRIC STATIONS.

THE central stations which have so far adopted power gas and gas engines in this country are comparatively few and small. The reason for this is not far to seek, for until recently no gas producer was commercially available which could make a reliable gas sufficiently cheap or from any but expensive fuel, such as anthracite or coke; and secondly, no gas engines of large size had been in use for a sufficient period to satisfy electrical engineers as to their suitability for working under station conditions. These reasons exist no longer, and the fuel cost per unit of electricity generated by means of gas dynamos running with Mond gas—including all cost of labor, repairs, etc., at the gas producer and recovery plant—is less than one-twentieth of a penny (one-tenth of a cent.) per unit at the switchboard. This figure represents the cost under actual conditions of continuous running and is arrived at without allowing full credit for the sulphate of ammonia recovered from the gas used.

The following diagram and figures (taken from Proceedings of the Inst. M. E., Vol. I, 1901) show the amount of heat consumed in producing one kilowatt hour by steam and by Mond gas, Case I being very good actual results for a central electric light station, using steam engines (the fuel used is here taken as 6 lbs. per unit); Case II, ideal figures for central electric light station (steam power), based on Professor A. B. W. Kennedy's estimate (viz., 10½ lbs. of water evaporated per pound of coal. 8½ lbs. of steam at engine per pound of fuel burnt. 16 lbs. of steam give one I.H.P. hour. Combined efficiency of engine and dynamo at three-quarters full load is 77 per cent.); Case III, ideal figures for continuous running (steam power), based on Professor W. C. Unwin's estimate of 2.1 lbs. of coal per B.H.P. hour for continuous work; an evaporation of 9 lbs. of steam per pound of coal, a 5 per cent. loss, and a dynamo efficiency of 93 per cent.;* Case IV, actual results for continuous running, at Winnington, Cheshire, with Mond gas used in gas engines. The slack used costs about 2s. 9d.† ($0.66) per ton at the pit, when prices are normal. Delivered at the Winnington Works the cost is about 7s.† ($1.70); and as the gas producers are worked as a separate department this price is charged to the gas engines for the gas from one ton of slack, the profit on by-products (after paying the cost of working the producers, etc.) being retained by the department. In the following diagram fuel has been taken at 5s. per ton as an intermediate figure, making some allowance for the above fact. If exhaust steam is not available for use in the Mond producers and live steam has to be raised in steam boilers, then 20 to 25 per cent. should be added to the amount and cost of the fuel.

* "Development and Transmission of Power," Unwin, page 64, 1893 edition. † 1 shilling = $0.24¼.

TABULATION OF HEAT CONSUMPTION PER KILOWATT HOUR.



Calorific value of fuel consumed (at 7900 lbs. C.° units per lb.).

Heat units in steam or gas reaching engine.

Blank Heat equivalent of one kilowatt hour at switchboard.

Cost for fuel used.

HEAT CONSUMED TO PRODUCE ONE KILOWATT HOUR OF ELECTRIC ENERGY AT SWITCHBOARD.

Calorific value of coal taken at 7900 centigrade heat units.
Calorific value of slack taken at 6786 centigrade heat units (on dry sample).
Price of coal taken at 12s. per ton.*
Price of slack taken at 5s. per ton.
Heat in 1 lb. of steam at 180 lbs. pressure = 666 lbs. centigrade heat units.

	Coal used per K.W. Hour.	Steam at Engine per K W. Hour	Heat Units in Coal.	Heat Units in Steam or Gas.	Cost of Fuel per K.W. Hour.	
Steam.	Lbs.	Lbs.				d.
Case I.—Central station (good actual).	6	42	47,400	27,970	27,970	0.385
Case II.—Central station (ideal) . . .	3.277	27.85	25,888	18,548	18,548	0.210
Case III.—Continuous running (ideal) .	3.027	25.88	23,913	17,236	17,236	0.194
Gas.						
Case IV.—Actual results	1.79	...	11,520	9,675	9,675	0.048

	Pence.	Cents.
Actual Fuel Cost for **167** electric supply stations (on units sold, year 1900-1902)	**0.952**	**1.904**

* NOTE.—1 ton = 2240 lbs. 1 cwt. = 112 lbs. £1 = 240d. = $4.85.

COST OF FUEL

PER UNIT OF ELECTRICITY SOLD, BEING AVERAGES TAKEN FROM 167 CENTRAL STATIONS (STEAM POWER) IN THE UNITED KINGDOM.

(Abstracted from the *Electrical Times*, England, Table of Electric Supply Costs and Records, page 832, December 4, 1902.)

COST PER UNIT SOLD OF COAL AND OTHER FUEL.

		Per Unit.*	Per Unit.
LIMITED COMPANIES (1900-1902).			
METROPOLITAN—			
15 Stations.	Average Cost Fuel	1.032*d.*	2.064 cents.
PROVINCIAL—			
37 Stations.	" " "	1.083*d.*	2.163 "
LOCAL AUTHORITIES (1900-1902).			
METROPOLITAN—			
7 Stations.	Average Cost Fuel	1.076*d.*	2.152 "
PROVINCIAL—			
108 Stations.	" " "	.886*d.*	1.772 "
For all above Stations (steam power).			
167 Stations.	Average Cost Fuel	.952*d.*	1.904 "

Equivalent to about 1.618 cents (0.809d.) per unit generated. Compare this with the actual cost for Mond gas of .096 (.048d.) per unit generated, with gas engines running continuously at Winnington.

ECONOMY OF GAS ENGINES

AS COMPARED WITH STEAM ENGINES OR CENTRAL STATIONS.

DEALING now with the question of fuel economy, the foregoing figures show in a striking manner how much more economical are gas engines running with Mond gas than are steam engines and steam boilers. The economy is threefold, because (a) the fuel for generating Mond gas is cheaper than the fuel used at central stations for producing steam; (b) for a given expenditure of heat, the calorific value of the Mond gas from the producer is greater than the calorific value of the steam from the boiler; and (c) the gas engine utilizes the heat received much more efficiently than does the steam engine. Referring to the diagram it will be seen that the actual results obtained at Winnington are not only far superior to the actual results for any central station using steam-driven plant, but are a long way better than the ideal figures for the latter.

* NOTE.—The word "unit" refers to the British "Board of Trade Unit" = 1 kilowatt hour.

WORKING ESTIMATE OF A 20,000 ELECTRICAL HORSE-POWER CENTRAL STATION.

Conditions of Working.—Mond Gas Producers and Recovery Plant worked in conjunction with gas engines and dynamos. The electric energy (1) consumed on the premises for an electrolytic plant, (2) transmitted a short distance and sold in bulk with a 50 per cent. load factor, or (3) with a 33⅓ per cent. load factor.

A gas dynamo at full load takes 105 cubic feet of Mond gas, at 0° C. to give one unit (kilowatt hour). Allowing for a somewhat reduced efficiency at part load, and for driving auxiliary machinery, etc., the liberal figure of 125 cubic feet per unit will be taken. Then 1 ton of coal will yield gas for 1059 units, and it is assumed that 1000 units are actually sold.

Output—	
Number of units sold per ton of slack gasified	1,000
Slack cost per unit sold (pence)—	*d.*
With slack at 3*s.* per ton	0.036
With slack at 4*s.* per ton	0.048
With slack at 5*s.* per ton	0.060
With slack at 6*s.* per ton	0.072
With slack at 7*s.* per ton	0.084
With slack at 8*s.* per ton	0.096
With slack at 9*s.* per ton	0.108
With slack at 10*s.* per ton	0.120

Working Producers, Recovery and Sulphate Plant—

Cost of discharging and handling slack, working producers, recovery and sulphate plant, and including administration, wages, repairs and maintenance, stores, acid, lighting, etc.

Per ton of slack gasified .... 3*s.* 6*d.*

Value of Sulphate Recovered—

At £10 per ton of sulphate, naked at works; and with 25 tons of slack gasified, yielding 1 ton of sulphate of ammonia.

Per ton of slack gasified .... 8*s.*

Profit due to Sulphate Recovery—

Being credit for sulphate less working expenses.

Per ton of slack gasified .... 4*s.* 6*d.*

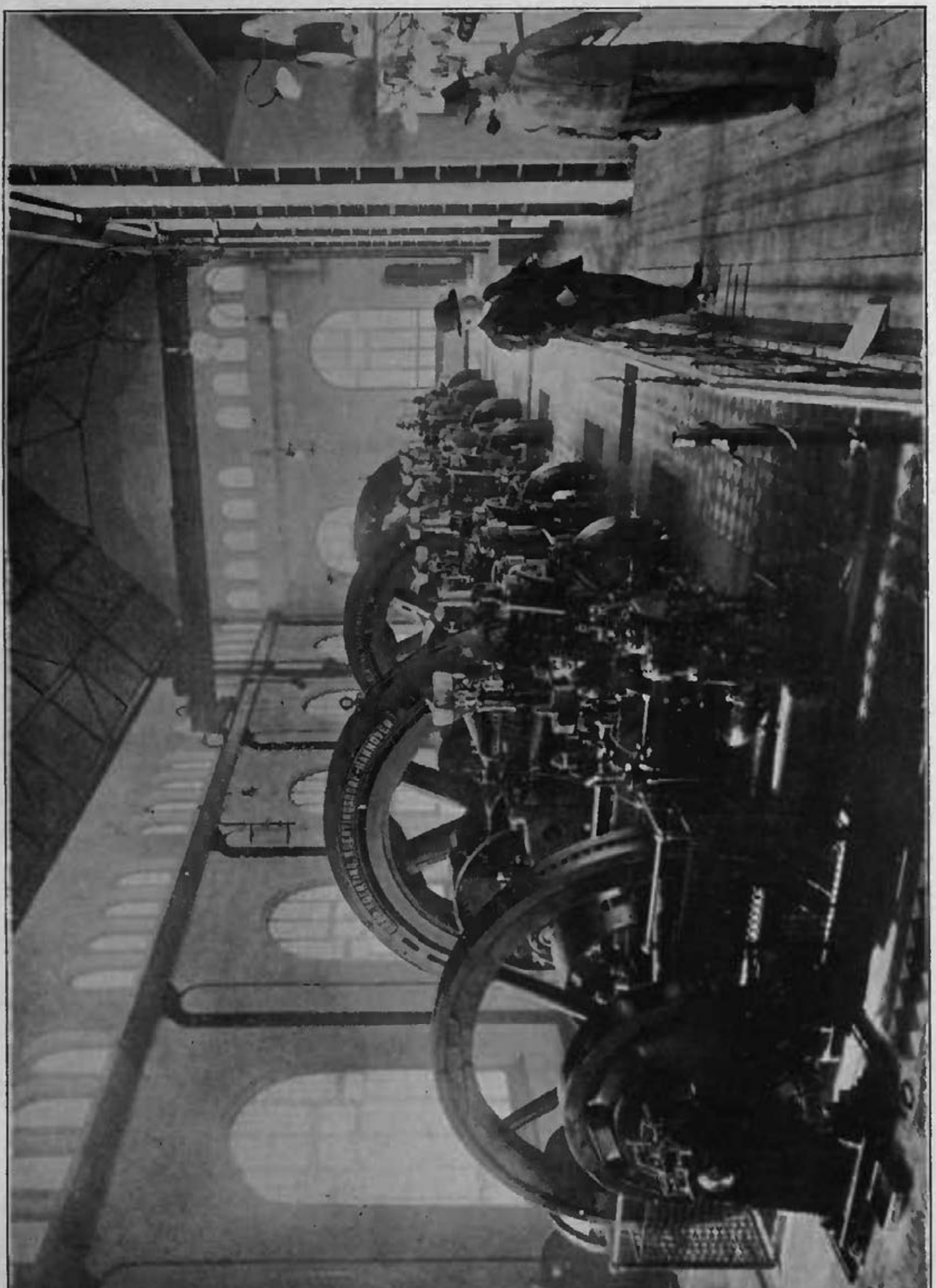
or per unit of electric energy sold .... 0.054*d.*

Net Cost of Mond Gas per Unit sold (pence)—

	d.
With slack at 4*s.* 6*d.* per ton	0.000
With slack at 5*s.* per ton	0.006
With slack at 6*s.* per ton	0.018
With slack at 7*s.* per ton	0.030
With slack at 8*s.* per ton	0.042
With slack at 9*s.* per ton	0.054
With slack at 10*s.* per ton	0.066

	Load Factor.		
	100 per cent.	50 per cent.	33⅓ per cent.
Power Plant (pence per unit sold)—			
Oil, Waste, and petty stores	0.030	0.030	0.030
Labor and attendance	0.034	0.051	0.068
Repairs and maintenance	0.036	0.058	0.077
Total Cost per Unit Sold (pence)—			
With slack at 3*s.* per ton	0.082	0.121	0.157
With slack at 4*s.* per ton	0.094	0.133	0.169
With slack at 5*s.* per ton	0.106	0.145	0.181
With slack at 6*s.* per ton	0.118	0.157	0.193
With slack at 7*s.* per ton	0.130	0.169	0.205
With slack at 8*s.* per ton	0.142	0.181	0.217
With slack at 9*s.* per ton	0.154	0.193	0.229
With slack at 10*s.* per ton	0.166	0.205	0.241

Note.—No charges on capital account, rent, rates or taxes included in the above figures. £1 = $4.85.



AN INSTALLATION OF GAS ENGINES AT JULIENHÜTTE, COMPRISING FOUR ALTERNATORS AND FOUR GAS ENGINES OF 300 B.H.P. EACH.

GAS ENGINES FOR DRIVING DYNAMOS.

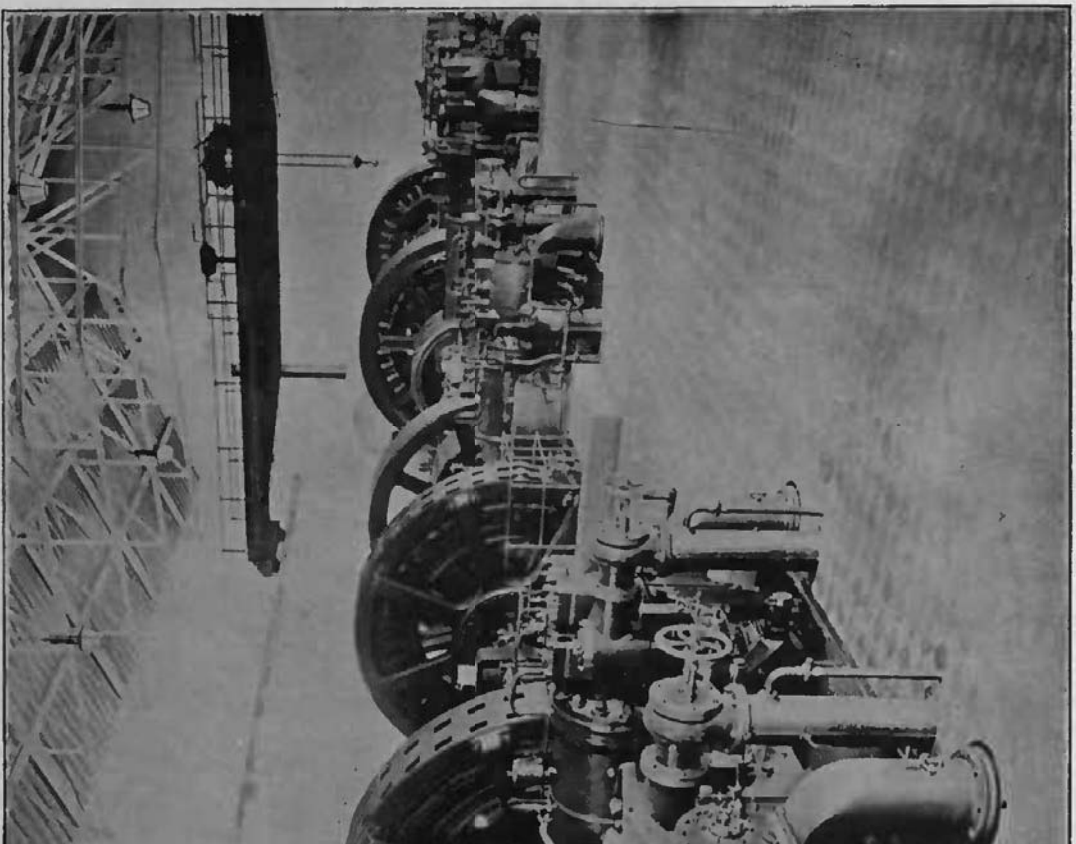
BEFORE the year 1900 few gas engines of over 400 H.P. were used direct-coupled to dynamos, but recently there has been a wonderful development in this direction, and now more large gas engines are being built for this purpose than for any other. Selecting three, out of more than twenty manufacturers of gas engines of 200 H.P. and upward, we find (August, 1902) they have delivered or partly completed 52 gas engines for driving dynamos, having a total of 34,150 B.H.P., or an average of 657 B.H.P. per engine. Gas engines for direct-coupling to dynamos are being constructed up to 2500 H.P., and engines of 5000 H.P. are designed and will be built for this purpose. On account of its cleanliness and very great uniformity of composition and calorific value, Mond gas is an ideal fuel for gas engines driving dynamos. It gives the governor a chance of doing its duty properly and permits exact regulation. Indeed, a gas of uniform quality is as important to a gas engine as is steady boiler pressure to a steam engine.

GAS ENGINES RUNNING ALTERNATORS IN PARALLEL.

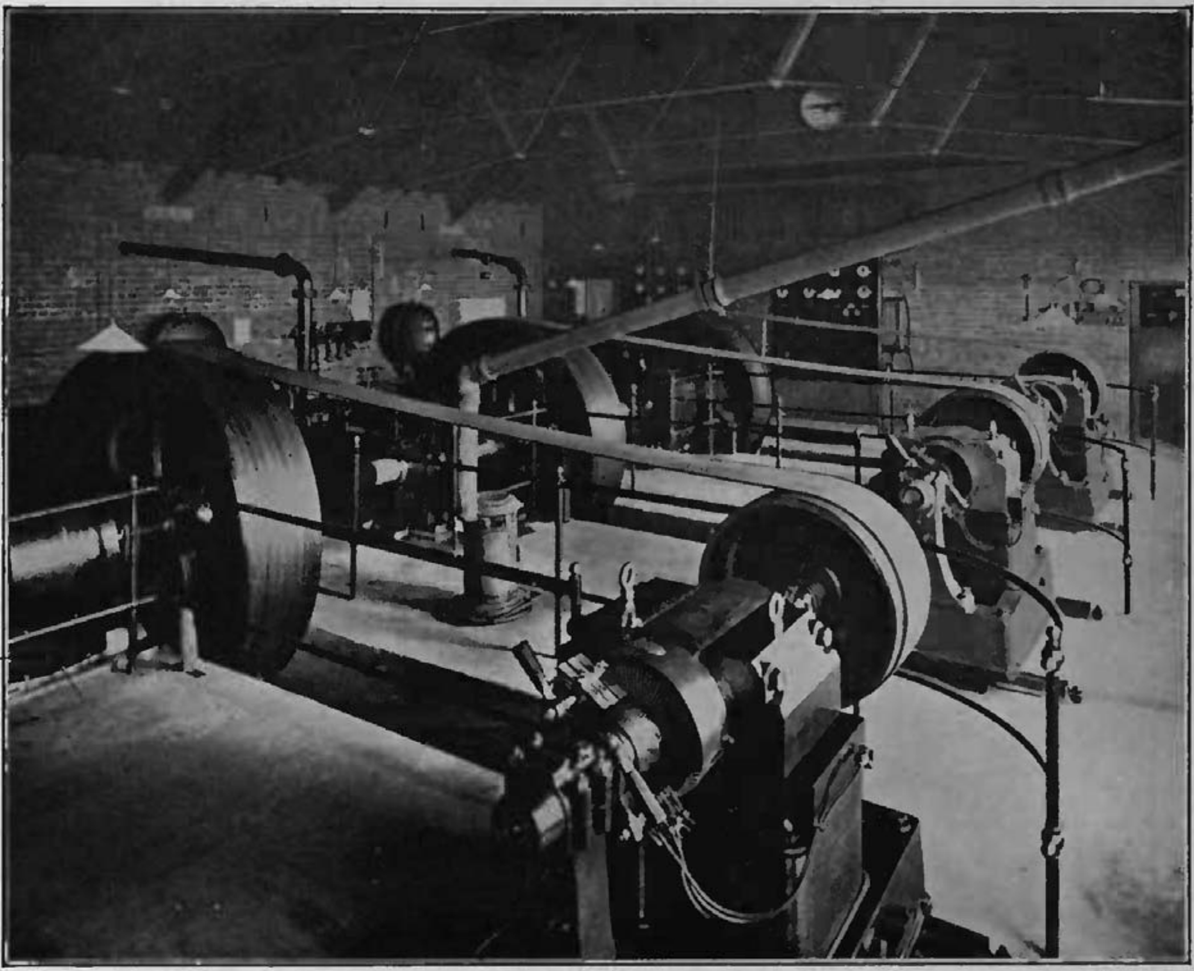
IN considering the application of gas engines to Central Station work, it must be borne in mind that the large Central Station of the future will employ three-phase alternating current.

A short time ago it was generally believed that there were insuperable difficulties in the way of running gas-driven alternators in parallel, but this is all changed now, and the leading builders of gas engines have numerous examples where their gas engines fulfill all the requirements of such parallel running with complete success. They are, in fact, prepared to guarantee a cyclical speed variation of $\frac{1}{200}$ to $\frac{1}{400}$, and a governor regulation equal to the best steam engine practice. Such guarantees are amply sufficient for gas engines intended for direct-coupling to three-phase machines working at 50 alternations per second. For power purposes the tendency is to reduce the cycles to 25 per second, so making the conditions of parallel running still more favorable. Instances can be quoted where gas engines with cyclical variations of $\frac{1}{160}$, $\frac{1}{180}$, and even $\frac{1}{80}$, have given good results in driving alternators in parallel, the last mentioned having a belt drive, and the other two being direct-coupled.

Direct-coupled sets with two single-acting gas cylinders have been used on alternators which have to work in parallel, but usually four such cylinders are used, and the best results have been obtained with double-acting cylinders—either two or four in number. The recent designs of double-acting gas engines, embodying important improvements in the system of governing by regulating the quantity of explosive mixture to the work to be performed, have placed gas engines upon an equal footing with steam engines as regards regularity of crank efforts, and suitably for direct-coupling to alternators in parallel.



AN INSTALLATION OF GAS ENGINES OF DÜDELINGEN. TWO ENGINES EACH 1000 H.P., AND TWO ENGINES EACH 600 H.P., ALL WORKING IN PARALLEL.



THE POWER HOUSE OF THE NORTHWICH ELECTRIC SUPPLY CO.

SOME PARTICULARS OF THE NORTHWICH ELECTRIC SUPPLY COMPANY.

THE distinction of possessing the first electric station to adopt Mond gas for the production of its motive power belongs to Northwich, a town of less than 20,000 inhabitants. It was originally intended to utilize water power, but it was found that very considerable economies both as regard capital outlay and working expenses could be affected by employing Mond gas.

The station was established in 1897, and the supply of gas is drawn from the neighboring works of Messrs. Brunner, Mond & Co., the price charged for it being 2d. per 1000 cubic feet. As a good example of the cleanliness of Mond gas, Mr. W. M. Beckett, A.M.I.C.E., one of the Directors of the Northwich Company, reported in March, 1902, as follows: "A few weeks ago we took out the pistons of the three large engines for the first time. One had been running over four years and another about three and a half years, and we found them in very good order."

A Table of Costs, published by the *Electrical Times*, London, on the 23d of January, 1902, shows that of all the public companies supplying electricity in Great Britain, the Northwich Electric Supply Company's is the lowest fuel cost per unit sold.

The following figures are abstracted from the same table and will be interesting as forming a basis for comparison of the cost of Mond gas with that of other fuels.

Name of Company.	No. of Units sold.	Cost per Unit sold. Pence.	Cents.
Charing Cross	4,997,181	1.24	2.48
City of London	12,472,968	1.50	3.00
Chelsea	1,672,026	.91	1.82
Metropolitan	9,855,175	1.68	3.36
Notting Hill	782,215	.91	1.82
Westminster	7,281,109	.95	1.90
Woolwich District	253,651	1.18	2.36
Bournemouth	675,242	1.13	2.26
Cambridge	357,435	1.01	2.02
Dover	613,093	1.21	2.42
Guilford	83,305	3.65	7.30
Liverpool District	102,925	1.24	2.48
Newcastle District	1,160,649	.79	1.58
Newcastle-on-Tyne	1,095,519	.80	1.60
Newmarket	46,866	1.48	2.96
Northampton	251,153	1.38	2.76
Northwich	**88,777**	**.47**	**.94**
Norwich	1,183,675	.96	1.92
Preston	808,358	.71	1.42
Reading	338,256	.99	1.98
Richmond	217,789	11.9	23.8

The fact of Northwich being so small a town makes the above comparison the more remarkable. These figures speak for themselves, but to gauge accurately the real extent of the advantage of employing Mond gas, it must not be overlooked that while the Northwich Company purchases its Mond gas at 2d. per 1000 cubic feet, it would be, in the case of a larger station, infinitely more desirable and profitable to generate their own Mond gas, and thus reduce their fuel cost to the lowest possible basis.

The cost of Mond gas, when produced on a large scale, is so low (see page 36) that a true comparison with the cost of other fuel can best be based upon the actual results obtained at

Messrs. Brunner, Mond & Co.'s Works, where the fuel cost per unit (K.W. hour) is .096 cents (.048d.). Compare this fuel cost with that of the Liverpool District Company, which stands at 2.48 cents (1.24d.) per unit sold.

The following is extracted from the last general meeting of the Northwich Company:

> "Mr. Saner, in returning thanks, said theirs was a company that one could take a very large amount of interest in. Not only was it a pioneer company in that district, but also in the whole of the kingdom, for from first to last there was not an atom of steam used. They had adopted Mond gas, and had set an example to the rest of the country in doing away with nasty smoky chimneys. He had noticed that the local council had been complaining of the smoky chimneys in the neighborhood. If they would only persuade the people to use the cheap power which was at hand they could dispense with the smoke. They were supplying the current at a lower rate than either Liverpool or Manchester, and he personally knew that there was a very large amount of saving in using it. They had merely to turn on a handle, and had no coals to cart nor cinders to remove; there was no steam time, boiler cleaning, no noise or dirt of any description, and, as some of the workmen expressed it, 'it was like Sunday in the works.'"

THE EQUIPMENT OF THE NORTHWICH STATION.

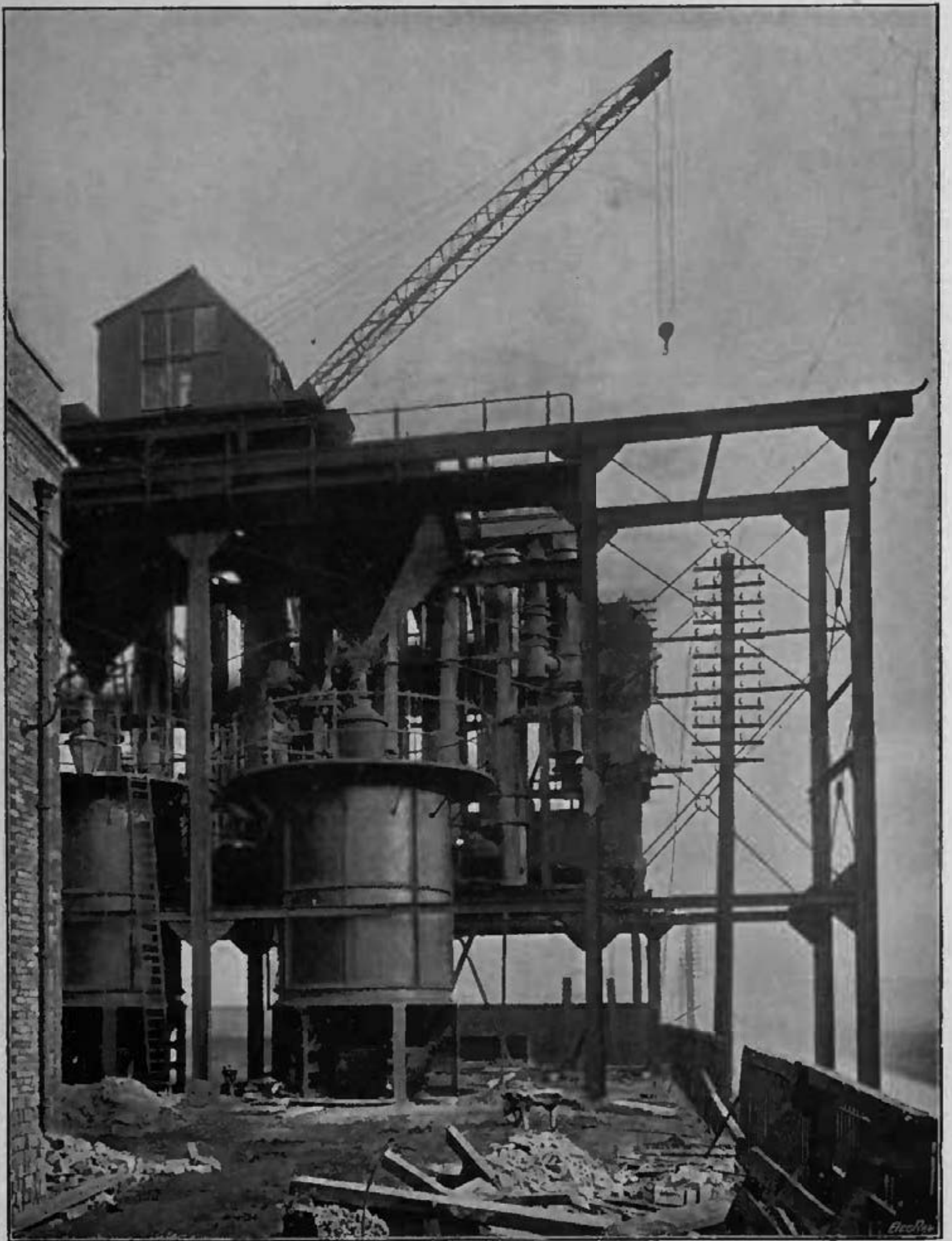
The equipment of the station consists of three generating sets, two boosters, also driven by a gas engine, a balancer and main switchboard. Each of the generating sets consists of a 60 kilowatt dynamo driven by a 100 B.H.P. engine. The dynamos are of the two-pole upright type, giving 125 ampères at 480 volts and are driven at 600 revolutions per minute. The machines are shunt wound. Two of the armatures have smooth cores, with bar winding and evolute end connections; the third has a toothed core. The brushes are of copper gauze, three a side, and the bearings have automatic ring lubrication. The pulleys are two feet wide. The whole machine is mounted on side rails to provide for the adjustment of the belt tension. The engines are of Messrs. Crossley's ordinary type, running at 210 revolutions per minute.

The battery consists of 256 elements of the Chloride type, with nine plates each, in glass cells, and has a normal capacity of 200 ampère hours. At present it is sufficient to take the whole of the night load after 12 P.M. and part of the forenoon. The battery is generally connected with the outers of the three-wire system, and a balancer is provided to equalize the loads, and consists of two dynamos, of 19 kilowatts capacity altogether, with two-pole overtype fields and toothed-core armature; these are coupled together by means of a short length of shaft, there being three bearings in all.

The neighboring village of Hartford is lighted by means of twenty-eight standards with double and treble arms; it is stated that Hartford claims the distinction of being the first village in England in which a parish council adopted electric lighting throughout. The district is chiefly residential, with good houses; many of them are quite two miles from the generating station. The public lighting circuit consists of two and a half miles of B.I.W. twin lead-covered cable, and is quite separate from the distributing mains for private lighting.

SOME PARTICULARS OF THE TRAFFORD POWER AND LIGHT SUPPLY CO.

TRAFFORD PARK, NEAR MANCHESTER, ENGLAND.



MOND GAS PLANT AT THE TRAFFORD POWER AND LIGHT SUPPLY COMPANY'S CENTRAL STATION.

SOME details of this electric station will prove of interest, for not only is it far larger than the Northwich Station, but it utilizes Mond gas in a totally different manner.

The Trafford Company possesses its own Mond gas generating plant, the gas from which is at present used entirely for firing boilers of the Babcock and Wilcox and Tinker type, which supply two sets of generators, each of 1000 H.P., while a third set is now being added. Each set consists of a vertical steam engine coupled direct to a multipolar continuous-current dynamo by means of a heavy cast-iron flywheel, which is fixed on to an extension of the crank shaft. The general appearance of the set is shown in our illustration on page 65.

It will be seen that, apart from all other considerations, the company have, by the adoption of gas firing, practically insured themselves against the waste and nuisance of black smoke, and the following extract from the *Manchester News,* 24th of January, 1902, seems to show that some additional incentive to the Trafford Company was furnished by the activity of the local authorities, whose example might perhaps be more generally followed to advantage.

BLACK SMOKE IN TRAFFORD PARK.

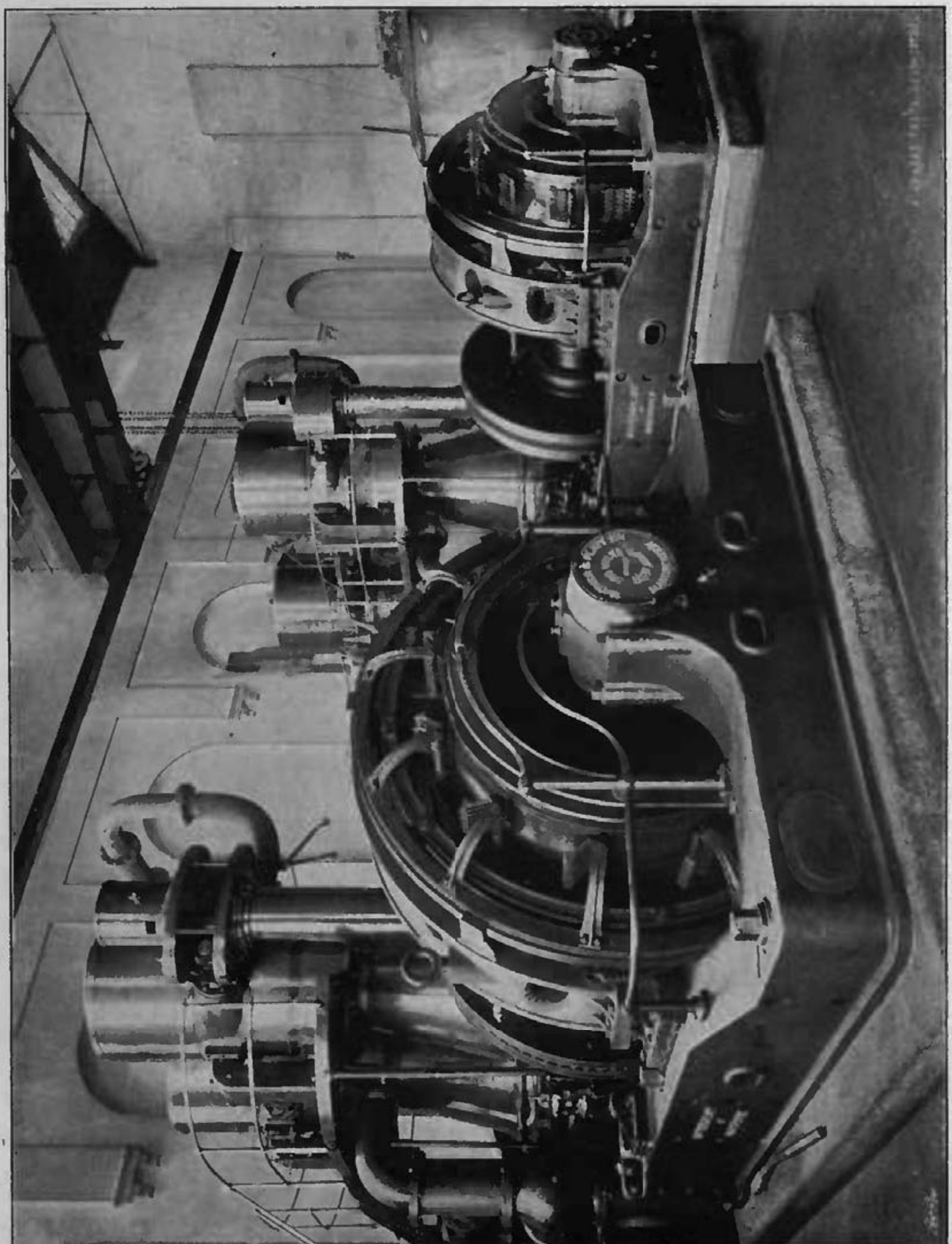
MOND GAS AS A PREVENTIVE.

THE Trafford Power and Light Company, Limited, Trafford Park, were summoned to the Manchester County Police Court, to-day, for disobeying an order of the Court, made in October, 1900, for the abatement of smoke nuisance.

Mr. Hawkins, who represented the Company, admitted the offense, but explained that further complaints would be obviated when the Mond gas plant, which was being erected, had got into working order. He promised that in a fortnight's time the Mond gas would be in use for the purpose of firing up, and there would then be no black smoke.

On this explanation Mr. W. Goldthorpe, the Chairman, adjourned the case for a month.

In the case of W. T. Glover & Company, Trafford Park, a similar explanation was offered by Mr. Hawkins. The Mond gas would shortly be connected up from the previous defendants' works, and the nuisance would not occur again. This case was also adjourned for a month.



GENERATING PLANT AT THE TRAFFORD POWER AND LIGHT COMPANY'S STATION, SHOWING ENGINES DRIVEN BY STEAM FROM BOILERS FIRED WITH MOND GAS.

MOND GAS FOR STEEL MAKING.

MOND GAS FOR STEEL MAKING.

THE question of using washed gas for steel melting is one which has claimed the attention of manufacturers both in the United States and Europe.

It is well known that Mond gas is a particularly clean gas, and a question naturally arises as to the possibility of obtaining from it so high a temperature as is obtained from ordinary producer gas from which the tar has not been separated nor the ammonia recovered.

As to the question of tar, it has already been explained (see page 24) how a considerable proportion of it is turned to a fixed gas in the producer-bell, from which it passes into the main body of the gas produced. The flame produced by Mond gas is not so luminous as if the particles of tar were present to be burnt; it is, nevertheless, sufficiently so to enable the actual burning of the gas to be very clearly seen by the furnace men, who can make their adjustments accordingly.

It may here be noted that the use of clean gas prevents the flues, etc., from becoming blocked up with dust and tar.

As regards the extraction of ammonia from the gas, this is of no consequence whatever, as must be readily recognized when it is remembered that in the ordinary gas producers at present in general use for steel melting, the ammonia is not burnt with the gas in the furnaces, but is practically all destroyed in the body of the producer as soon as it is formed.

The cooling of Mond gas in contact with water has no appreciable effect upon the combustion temperature attainable, and actual results show that the temperature reached is quite as high as when hot uncleansed producer-gas is used; in short, the intensity of the heat produced in a furnace fired by Mond gas is all that can be desired for rapid steel melting.

A Mond gas plant may be installed in steel works either with or without ammonia recovery. In the latter case the plant is very much simplified, but, on the other hand, the large revenue from the sulphate is of course not obtained. If the plant is worked without recovery of sulphate of ammonia, the advantages to be derived over ordinary producers are, in the first place, a greater efficiency—20 to 25 per cent. of the original fuel being saved in accomplishing the same amount of work; secondly, production of clean, washed gas that may be carried any distance without deposit; thirdly, a reduction of the percentage of sulphur contained in the gas; fourthly, a substantial saving of labor at the producer and low cost of repairs; and there are also many other minor advantages with this producer which, in the aggregate, become an important factor.

The following are some particulars of results obtained by Mr. J. H. Darby in a 3-ton regenerative furnace, measuring 12 feet between the blocks.

The best performance was a complete charge in 7 hours 35 minutes, thus working rather faster than three charges per day of twenty-four hours. No hitch of any kind occurred in working this furnace, nor did any trouble develop itself with the washed gas.

The steel made contained from 0.14 to 0.45 per cent. of carbon, 50 per cent. containing under 0.2 per cent. of carbon.

The average analysis of nine cases gave the following results:

Carbon	0.240 per cent.
Silicon	0.038 "
Sulphur	0.039 "
Phosphorus	0.037 "
Manganese	0.457 "

The mechanical test of twelve samples of the steel containing from 0.16 to 0.22 per cent. of carbon gave the following results:

Cast No.	Carbon. Per cent.	Diameter. Inches.	Breaking Strain per Sq. In. Tons.	Elongation in 8 In. Per cent.	Percentage of Contraction of Area.	Limit of Elasticity per Sq. In. Tons.
20/1	0.17	1.14	25.6	35	50	16.4
2		"	25.5	32	51	16.4
25/1	0.22	"	25.8	35	53	16.6
2		"	27.6	32	53	17.0
30/1	0.16	"	25.8	36	53	16.4
2		"	25.8	33	53	15.9
35/1	0.16	"	25.4	33	56	16.7
2		"	25.2	35	56	16.1
40/1	0.18	"	27.3	32.5	53	17.6
2		"	27.1	33	53	17.3
41/1	0.17	"	26.2	35	53	17.1
2		"	26.3	34	51	17.4

There were no skulls in the ladle from the beginning to the end of the experiment, the metal always being hot and settling quietly in the molds.

During the experiment forty-one charges were converted into steel. Average time: charging, 18 minutes; melting, 3 hours 9 minutes; working, 5 hours 39 minutes. Average duration of charge, 9 hours 6 minutes. Shortest time taken, including charging and repairs, 7 hours 35 minutes. Total make of steel, 99 tons 3 cwt. Yield on the metals charged, 95.33 per cent.

Description.	Weight of Materials charged.				Used per Ton of Steel
	Tons	Cwt.	Qrs.	Lbs.	Cwt.
Hematite pig iron	79	10	3	0	16.04
Steel scrap	23	12	3	0	4.77
					Lbs.
Ferro-manganese	0	16	2	2	18.7
					Cwt.
Iron ore	16	10	0	0	3.39

One of the points of difference observed between the Mond gas in the steel furnace and ordinary producer gas is the considerable length of the flame. In a shorter furnace than the one referred to sufficient gas could not be kept on without reaching right across from port to port. With the furnace of the size given the gas seemed to thoroughly expend itself, and kept the steel at a satisfactory temperature during the whole operation with apparently a very small consumption of gas. The bath seemed to boil all over equally, and as an indication of the equal temperature in the furnace may be mentioned the fact that the circulation of the slag floating on the metal, which is generally toward the incoming gas, apparently in this case ceased altogether; or, if there was any circulation, it was in the same direction as the gas in the furnace.

It has been shown conclusively that Mond gas is entirely satisfactory for the manufacture of the softest kinds of steel, and that it does not contaminate the metal with sulphur.

In the following table, No. 1 is the analysis of the Mond gas, taken before it entered the regenerative chambers; No. 2 is the analysis of the same gas after it had passed the regenerator and been heated. The comparative calorific value is given in each case. Average analysis of ordinary Wilson producer gas, which is being employed continually for the manufacture of steel before entering the regenerator, and of the same gas after it has passed the regenerator and been heated, have been given before. The great difference in composition will be noted. In the Mond gas there is a great fall in the percentage of hydrogen and a rise in the carbonic oxide, while the carbonic acid has been materially reduced. In the ordinary producer gas the reverse takes place as far as the hydrogen is concerned, the carbonic oxide is increased, while the marsh gas and carbonic acid are diminished. It seems probable in the case of the ordinary producer gas that the hydrogen is partly increased at the expense of the decomposition of the marsh gas and olefines, and that the carbonic oxide is increased by the decomposition of part of the carbonic acid by liberated carbon from the decomposed hydrocarbons. The results are the average of those obtained by two separate chemists, and they agree within the limit of experimental error.

The alteration in the composition of producer gases, when raised to a high temperature, is a question of great importance. There would seem to be a tendency to form one composition at which producer gases most easily maintain themselves when highly heated, the composition of the Mond gas after heating being somewhat similar to that of the ordinary producer gas in general use in steel works.

	Mond Gas.		Ordinary Producer Gas.	
	No. 1 Before Regenerator.	No. 2 After Regenerator.	No. 1 Before Regenerator.	No. 2 After Regenerator.
Carbonic anhydride	17.8	10.5	7.63	5.19
Carbonic oxide	10.5	21.6	21.73	24.79
Ethylene	0.7	0.4	1.06	.41
Methane	2.6	2.0	3.05	1.33
Hydrogen	24.8	17.7	12.60	19.17
Nitrogen	43.6	47.8	53.80	48.98
	100.0	100.0	99.87	99.87
Calorific value	1430	1444	1487	1524

It has been frequently stated that non-luminous gas would not work satisfactorily in the steel furnace. Before heating, Mond gas burns with a non-luminous flame. In the steel furnace, however, the men found no difficulty in working with it, and it seemed in practice when highly heated to burn with a brilliant white flame, and possibly the change in composition in the regenerators may have something to do with this, as in every case examined the gas contained finely divided carbon, which was deposited on the walls of the apparatus. Great care was exercised in making the various analyses given, and they are in almost all cases the average of a large number made.

SOME OTHER DIRECTIONS IN WHICH MOND GAS MAY BE APPLIED.

MOND GAS FOR FIRING BOILERS.

IT is now generally recognized that the results obtainable from a given quantity of fuel, when burnt under steam boilers in conjunction with the best modern steam engines, are far inferior to those obtained by first gasifying the fuel and using the gas in gas engines. There are, however, many cases in which the surrounding circumstances render the employment of steam boilers imperative and, under such conditions, the following advantages obtainable by firing with Mond gas are worthy of careful consideration:

A large proportionate economy of labor is secured.

The cost of repairs to the boiler is reduced to a minimum.

The life of the boiler is lengthened owing to the regularity of the temperature preventing the alternate strains of expansion and contraction inseparable from the heating and cooling action of coal firing.

In cases of intermittent working, better value is obtained from all the fuel consumed, for with coal firing it is impossible to avoid waste from banking flues and from forcing fires.

Gas firing helps you over the peak of the load, and saves fuel during times of standing-by.

The smoke nuisance is completely obviated.

Where large quantities of fuel are used, the ammonia in the gas can be recovered, yielding a return of about $1.10 per ton of fuel gasified, after providing for all expenses connected with the ammonia recovery plant.

IN GLASS WORKS.

Mond gas is an ideal fuel for glass works, since the bulk of the sulphur contained in the fuel is removed; and its cleanliness renders it especially suitable for melting glass in open pots, and to a great extent obviates the necessity of using covered pots where purity of color is of importance.

It is most economical and efficient where high temperatures and large bulks of material are dealt with, as in tanks for sheet glass, etc.

It is equally suitable both for the harder glasses, viz., crowns, etc., and for the softer grades, flints, etc., and owing to the ease with which it is regulated and to the constancy of its composition, it is especially adapted for flattening sheets, and for all kinds of glass blowing, as well as for that most difficult of glass works operations, viz., annealing.

IN IRON AND STEEL WORKS.

For melting steel (see page 69).
For heating iron piles for mill furnaces.
For heating steel ingots.
For firing forging furnaces.
For annealing and tempering armor plates.
For puddling iron.
For heating ship and boiler plates.
For plate bending.
For welding and flanging iron and steel tubes.
For firing rivet and bolt-making furnaces
For heating steel billets.
For spring making and tempering.
For annealing iron and steel sheets.
For annealing iron and steel wire.
For heating plates for flanging and dishing, etc., etc.

REHEATING FURNACES FIRED WITH MOND GAS AT THE FARNLEY IRON COMPANY'S WORKS.

IN FOUNDRIES.

For use in core stoves.
For drying molds.
For drying pipe molds in pits or on bogies.
For firing crucible furnaces for melting brass, steel, malleable iron, etc.
For heating ladles.
For annealing castings.

IN METAL WORKS.

For heating brass and copper muffles for plates and sheets.
For heating tube muffles.
For melting metal in crucibles.
For annealing brass and copper sheets, tubes and wire.
For tempering and hardening steel.
For case-hardening, tinning and japanning.
For heating enameling ovens and soldering irons.
For heating stoves.

IN CHEMICAL WORKS.

For furnace work of all kinds.
For distilling and evaporating liquors, tar, oil, varnish, etc.

NOTE.—Mond gas is used for some of the most delicate operations in chemical works with complete success.

IN BREWERIES.

For firing coppers and stills.
For evaporating liquors.
For drying malt and grain.

IN CHINA, EARTHENWARE AND FIRECLAY WORKS.

For firing kilns for porcelain and china glazed ware.
For firing kilns for earthenware.
For firing kilns for glazed fireclay articles; bricks, tiles and sanitary ware.
For firing kilns for ordinary fireclay goods, such as bricks, slabs, ornamental tiles and pots.
For firing kilns for terra-cotta ware.
For firing kilns for blue or other hard bricks and tiles.

NOTE.—The regularity of the temperature produced by Mond gas reduces loss from breakages and wastes to a minimum.

IN ELECTROLYTIC WORKS.

For use in gas engines to generate electric energy.

IN BLEACHING, DRYING AND DRESSING WORKS.

For all heating purposes.
For drying cloth and all textile goods.

IN GAS WORKS.

For firing coal-gas retorts.

In the course of a discussion at the Institution of Engineers in Scotland, both Mr. W. Foulis and Mr. Alexander Wilson were able to speak from a lengthy experience of the use of fuel gas for retort heating purposes at Glasgow. The latter gentleman stated that at the Dawsholm Gas Works there were more than two hundred producers, though many of them were small; while Mr. Foulis said that at the new Provan Gas Works the whole of the retorts are to be heated by means of producers placed outside the retort house. In Mr. Foulis's opinion, no one having experience of heating by gas would ever go back to open fires; and he has no doubt whatever that gas will be the fuel of the near future.—From *The Journal of Gas Lighting*, London, May 20, 1902.

FOR SMELTING.

For roasting and calcining ores.
For smelting and refining copper, zinc, etc.

SULPHATE OF AMMONIA.

SULPHATE OF AMMONIA.

IT has already been pointed out that the most important of the by-products resulting from the manufacture of Mond gas is sulphate of ammonia, and the method of its recovery is explained on page 24.

OATS OVER SIX FEET HIGH.

Sulphate of Ammonia is one of the most potent manures known, and there is a steady and increasing demand for it, both for home consumption and for import. The advantages to the crops attendant upon its use may be shortly stated as follows:

LARGELY INCREASED PRODUCTION.
BETTER QUALITY OF THE CROPS.
BETTER FEEDING PROPERTIES.
BETTER KEEPING QUALITIES.

Nitrogenous manures are not required for clover, bean, pea, or any other leguminous crop, their nitrogen being drawn from the air; but for every other crop sulphate of ammonia is the best purelynitrogenous material that can possibly be used. We reproduce a photograph of a field of oats which were grown with sulphate of ammonia, and which measured over 6 feet in height; and on page 83 we have a giant crop of mangels also so grown.

It has proved itself to be of immense service in market-gardening; *vide* our illustration of a potato crop. It gives very beneficial results in floriculture, and has been proved to be the most valuable of all sources of nitrogen in fruit culture.

The Sulphate of Ammonia Committee, 4, Fenchurch Avenue, London, E.C., issues a series of interesting pamphlets on the subject, and we are indebted to them for the views here reproduced.

POTATO CROP

The following are the London market prices of Sulphate of Ammonia between September, 1901, and September, 1902:

	Per Ton F. O. B.
September, 1901	£10 17*s.* 6*d.* to £11 0*s.* 0*d.*
March, 1902	£11 16*s.* 3*d.* to £11 18*s.* 9*d.*
April, 1902	£12 6*s.* 3*d.* to £12 8*s.* 9*d.*
June, 1902	£12 7*s.* 6*d.* to £12 10*s.* 0*d.*
September, 1902	£12 2*s.* 6*d.* to £12 7*s.* 6*d.*

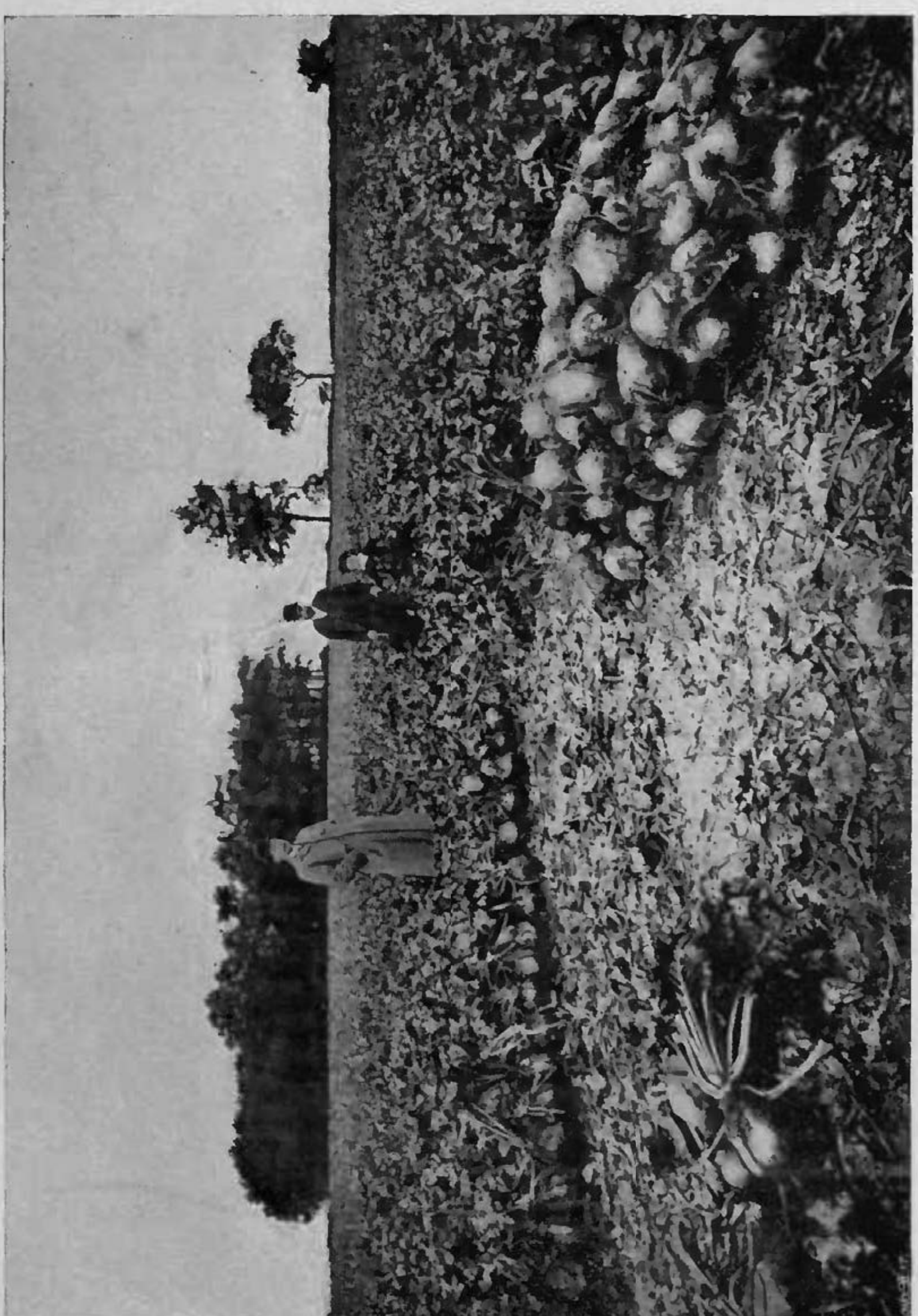
The total production of Sulphate of Ammonia in England during the year 1901 was about 220,000 tons from all sources, viz.:

	Tons.
Gas Works	148,500
Iron Works	16,000
Shale	36,500
Coke and Carbonizing Works and Mond Gas	19,000
	220,000

A comparison with the output of the previous five years shows a steadily increasing production:

	Tons.
1896	191,000
1897	198,000
1898	196,500
1899	205,500
1900	213,000

There is no doubt but that the advantages to agriculturists arising from the use of Sulphate of Ammonia are now better appreciated in England, and while about two-thirds of last year's total production was exported, the home consumption amounted to the substantial total of 68,000 tons.



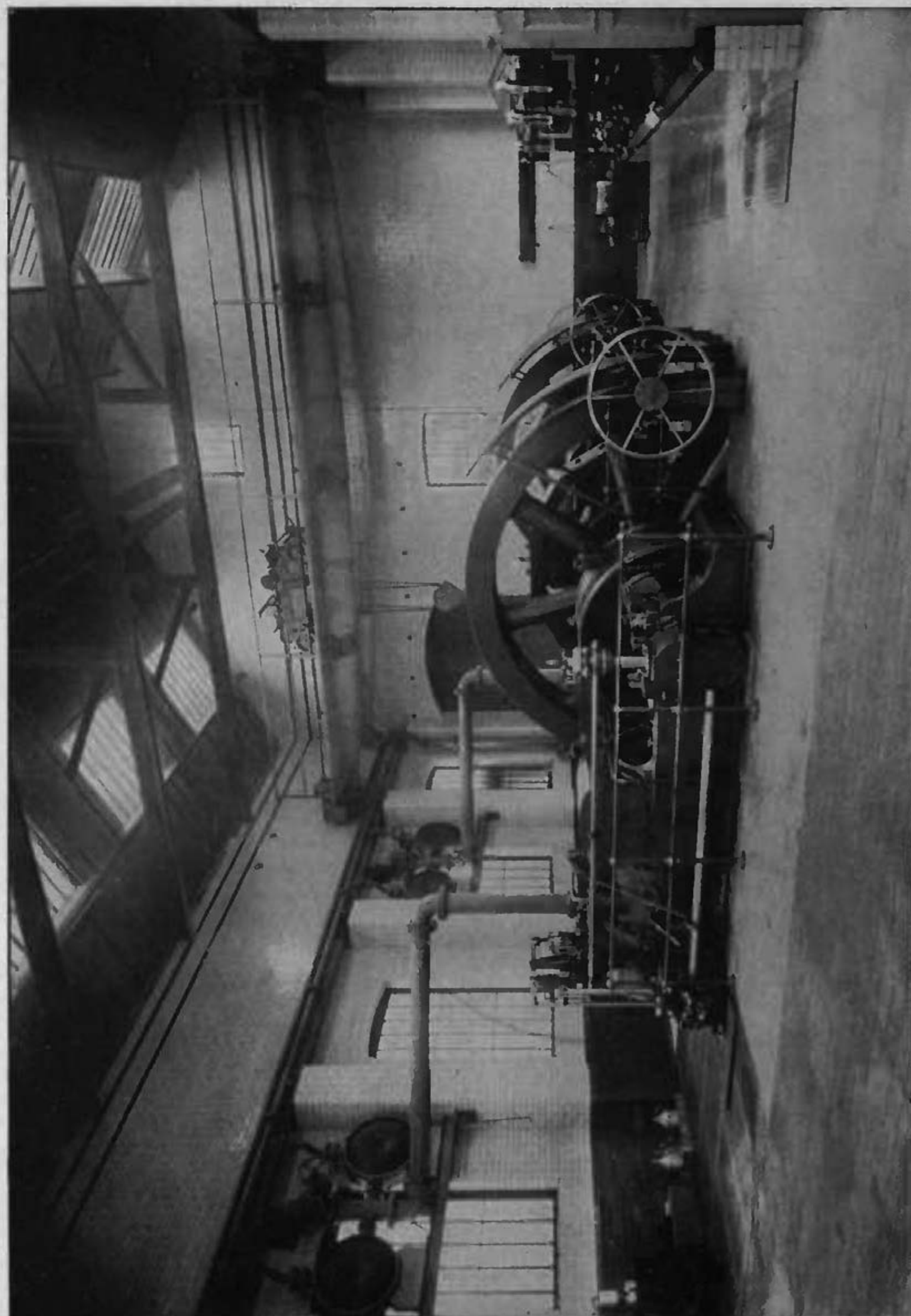
A GIANT CROP OF MANGELS, 80 TONS PER ACRE.

OLD METHODS AND THE NEW METHODS.

OLD STYLE.

INTERIOR OF A STOKEHOLE, SHOWING MECHANICAL STOKERS IN OPERATION.

NEW STYLE.



INTERIOR OF THE POWER HOUSE AT THE WORKS OF THE FARNLEY IRON COMPANY, LEEDS, WITH TWO PREMIER GAS ENGINES, EACH OF 250 H.P.

MISCELLANEOUS REPRINTS.

MISCELLANEOUS REPRINTS.

FIGHTING MOND GAS.

(An unsolicited testimonial.)

Reprinted from *The Manchester Guardian*, May 8, 1902.

MANCHESTER CITY COUNCIL.

Mr. Alderman Gibson moved a resolution to reduce the price of gas used for motive or power purposes by 9d. per thousand cubic feet—*i.e.*, from 2s. 9d. to 2s. within the city and from 3s. to 2s. 3d. without the city. It would be admitted, Mr. Gibson said, that the cheaper the price at which a manufacturer could purchase power for his machinery the better able he would be to compete with others, the more labor he would be likely to employ, and the better it would be for the community all round. But there was another reason why the Gas Committee recommended this reduction in price, and that was the advent of Mond gas. Mond gas had come to stay—(hear, hear)—and there was no doubt that it could be manufactured and supplied for power purposes at something like 3d. per 1000. It might be that four or five times the quantity of Mond gas would be required as an equivalent for a given quantity of ordinary gas; but even then the Mond gas would be exceedingly cheap, and it was necessary for the Committee to place themselves in a position to fairly compete with the Mond gas undertaking that had been established already in Trafford Park. The Mond gas had obtained the right to supply an area of 135 square miles in the Black Country in spite of most determined opposition on the part of every gas company and corporation in that district, and although they in Manchester might say that they could not allow any other company to put down mains because the streets were already overcrowded, that would not have much weight. Manchester could not play a dog-in-the-manger policy, and they could not prevent Parliament from doing what had been done in the Black Country unless they demonstrated that they themselves were prepared to provide all that was wanted in the way of cheap power for business purposes. Personally, Mr. Gibson added, he would be glad to reduce the price of gas all round; but that was not at present possible, and he could only say that the Gas Committee would take the very earliest opportunity that offered itself for taking some such step as they could take consistently with their obligation to pay £50,000 annually to the relief of the rates.

Mr. Alderman Briggs seconded the resolution.

Mr. Heenan said that, speaking as a manufacturer and not as a councillor, it would be a very good thing for trade if they could create competition between the chairman of the Electricity Committee and the chairman of the Gas Committee. He thought the chairman of the Gas Committee had overstated the weakness of his enemy, the Mond gas. He knew that Mond gas could be produced at a tenth of a penny per horse power per hour. He thought, therefore, that the Corporation would do well to reduce the price of gas for power to 1s. 6d. or even 1s. a thousand. He did not think they would lose by the transaction. On the contrary, if they did not look out he feared the time was not far distant when they would meet with great opposition from the use of Mond gas.

MISCELLANEOUS REPRINTS *(Continued)*.

SOUTH STAFFORDSHIRE MINES DRAINAGE.

Reprinted from *The Birmingham Post,* May 8, 1902.

THE MOND GAS QUESTION.

Yesterday afternoon a meeting of the Commissioners was held at the Drainage Offices, Dudley. Colonel J. B. Cochrane, who presided, moved the adoption of the reports, a summary of which has appeared in the *Post*, remarking that during the month there had been a decrease in the quantity of water pumped. The rapidity with which repairs had been executed at the new engine at the Mond station demonstrated the importance of having duplicates of all parts of pumps liable to breakage.

In seconding the resolution, Alderman R. Williams was gratified to find that there had been a reduction in the cost of fuel at the Deepfields engine. He noticed that they had not heard anything about Mond gas lately. They were looking to it for the salvation of the Commission, and were not only expecting to be supplied with a motive power at a less cost, but to get rid of the abominable smoke in the atmosphere.

The Chairman remarked that Mond gas could be made very quickly, but the plant necessary to manufacture it required a long time to construct. The land had been bought for the first instalment, and he believed that arrangements had been made for the manufacture of the plant for the first station, but that was as far as the Mond Gas Company had gone at present. It was a very big task to canvass all the manufacturers of the district to see how far and where the gas would be used. It was, of course, important to the Mond Gas Company that they should lay down their mains where the gas was most likely to be wanted, and they desired that the first installation in the district should be a success. The matter was in the hands of the engineer, who helped the bill through Parliament, and he was instructed to get the fullest information possible for the directors of the Mond Gas Company so that they could proceed with the work without any delay.

SOOT IN THE ATMOSPHERE OF TOWNS.

Reprinted from *The Mechanical Engineer,* April 12, 1902.

At a meeting of the Manchester section of the Society of Chemical Industry last week Mr. W. Irwin gave some interesting particulars respecting the amount of suspended soot in the atmosphere of that city, deduced from observations he made during the heavy snowfall which occurred in February. A sample of snow, which had been lying on the ground for ten days at a point about three miles from the center of the city was melted, and the dry residue weighed and analyzed. This was found to be equivalent to 10.7 pounds per acre, or a little over three tons to the square mile for the ten days and consisted of 48.6 per cent. carbon, 6.9 per cent. of greasy matter and 44.5 per cent. ash; while another sample, analyzed by Dr. Knecht, of the Technical School, and taken from near the center of the city, disclosed about three times the amount revealed by Mr. Irwin's analysis, or nearly one ton per square mile per day. The figures furnish eloquent evidence of the extent to which the smoke nuisance exists in large towns, and how much remains to be done in the way of its suppression before the atmosphere of the town can favorably compare with that of the country.

MISCELLANEOUS REPRINTS *(Continued)*.

THE ECONOMY OF GAS-FIRED FURNACES.

Reprinted from *The Iron and Coal Trades' Review*, April 18, 1902.

Messrs. Ruston, Proctor & Company, of Lincoln, who are intending to build a new works, have recently been making inquiries with regard to the relative economy of gas-fired and coal-fired furnaces. Their representatives have visited Scotland and procured figures in regard to the weight of plates that could be heated in a certain number of hours, the quantity of coal used, and the price of coal, with a view of getting the cost of heating each ton of plates. They saw a furnace which was gas-fired, of about the same dimensions as the one they were firing with coal at Lincoln, and on the ordinary coal-fired furnace they were heating 17 tons of plates in a week of 53 hours. The coal consumed was 6 tons 14 cwt., and the price of coal was 11s. 6d. per ton. Consequently, the cost of heating those plates ran up to 4s. 5d. per ton. The gas-fired furnace heated 45 tons in the week of 53 hours, the coal consumption being 11 tons 10 cwts., and the price of coal used was 8s. 6d. per ton, so that the cost of heating the plates in the gas-fired furnace was 2s. 2d., as against 4s. 5d. per ton.

At Messrs. A. Macmillan & Sons, Limited, of Dumbarton, a test was made a few days ago with regard to the time required for heating certain angle bars in a new gas-fired furnace recently erected, and it was found that the angle bars could be perfectly heated in from 15 to 16 minutes, whereas previously the time for the same class of work was 35 minutes. That was distinctly in favor of the gas-fired furnace. Very similar information has been obtained from Messrs. Workman, Clark & Company, Limited, of Belfast. They are heating channel bars 9 in. by 3½ in. by 3½ in. in 20 minutes, the length of the bars being about 60 ft. This information emphasizes the fact that reheating by producer gas can be done more thoroughly, and in much less time, and also that a cheaper class of fuel could be used than was usually the case with coal-fired furnaces.

INDEX.

INDEX.—*Continued.*

INDEX.—*Continued.*

INDEX.—*Continued.*

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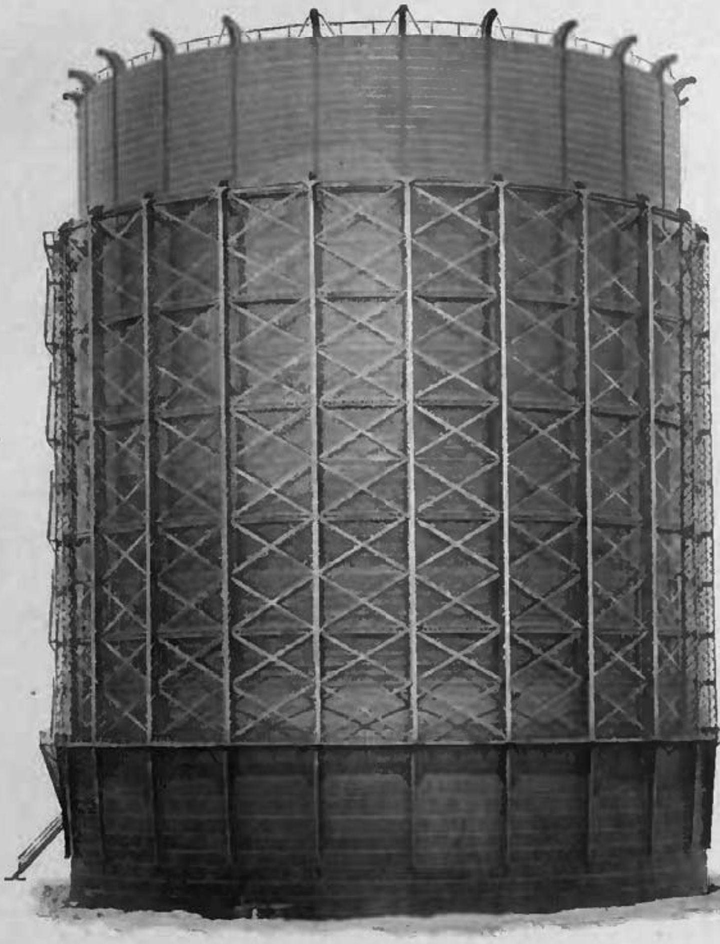

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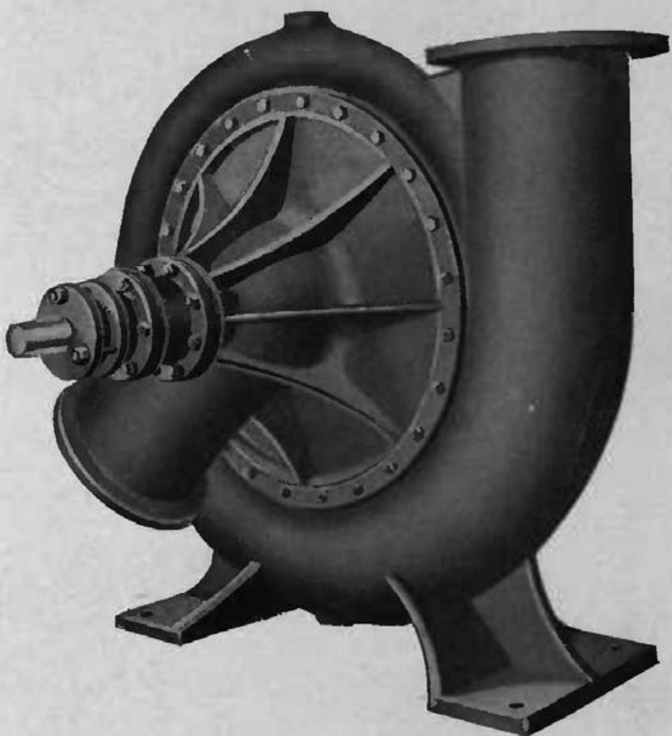

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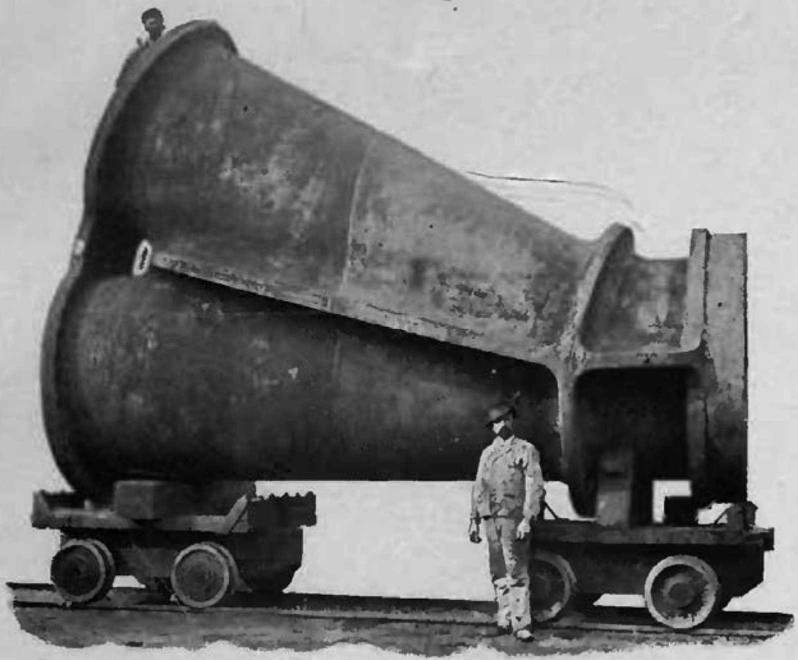

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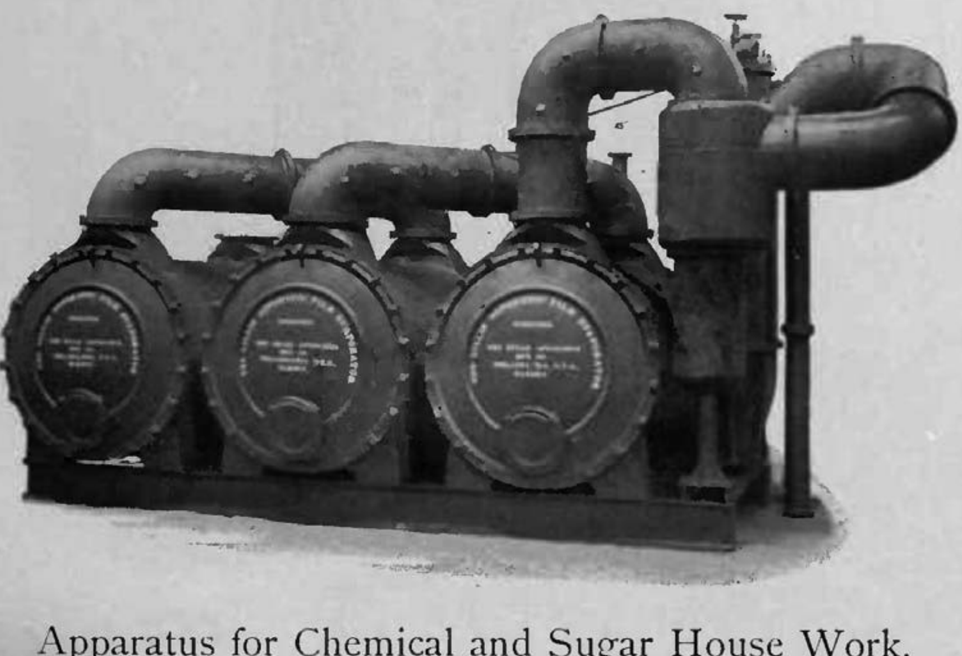

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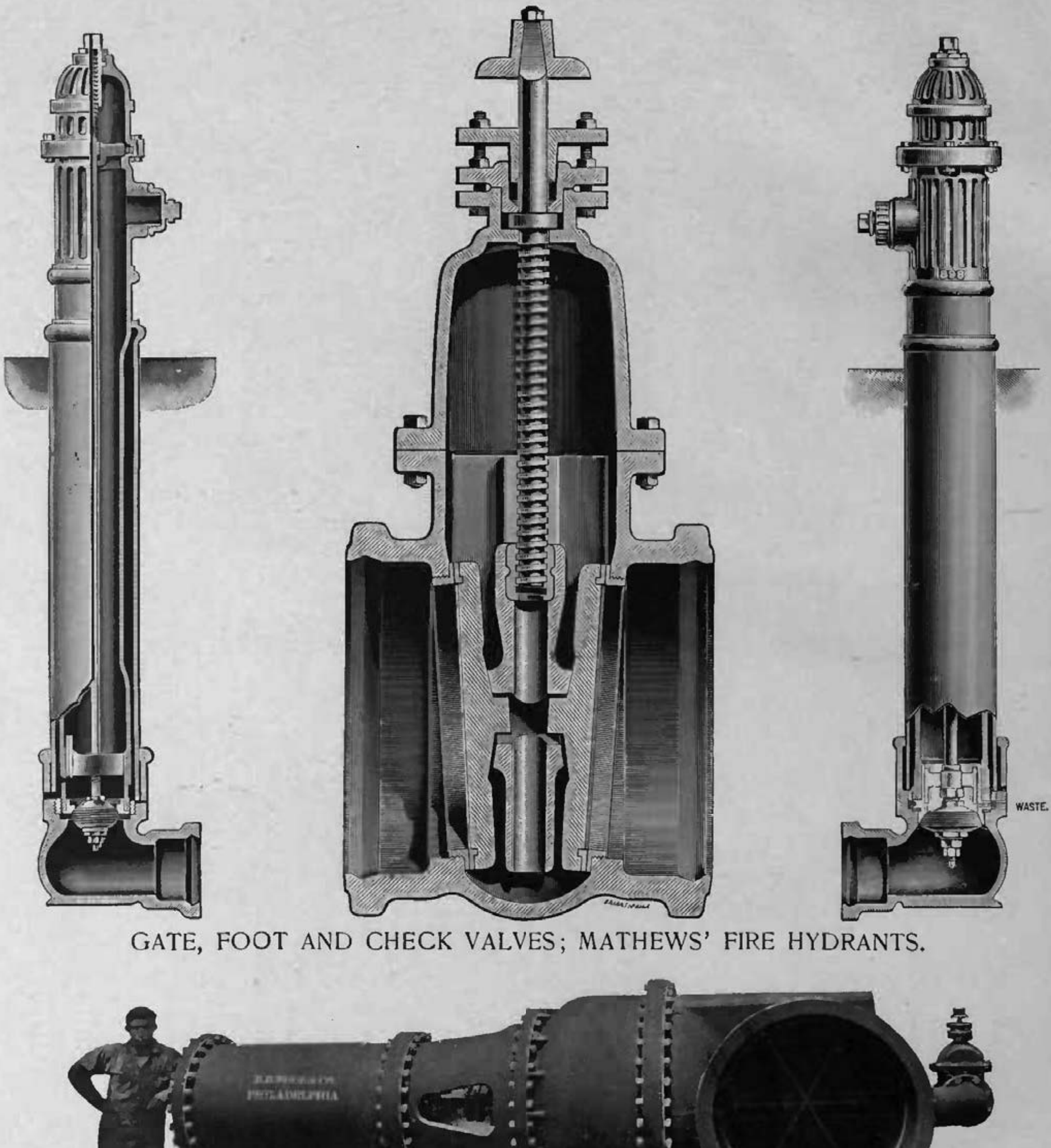

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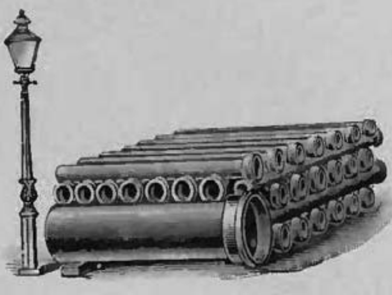

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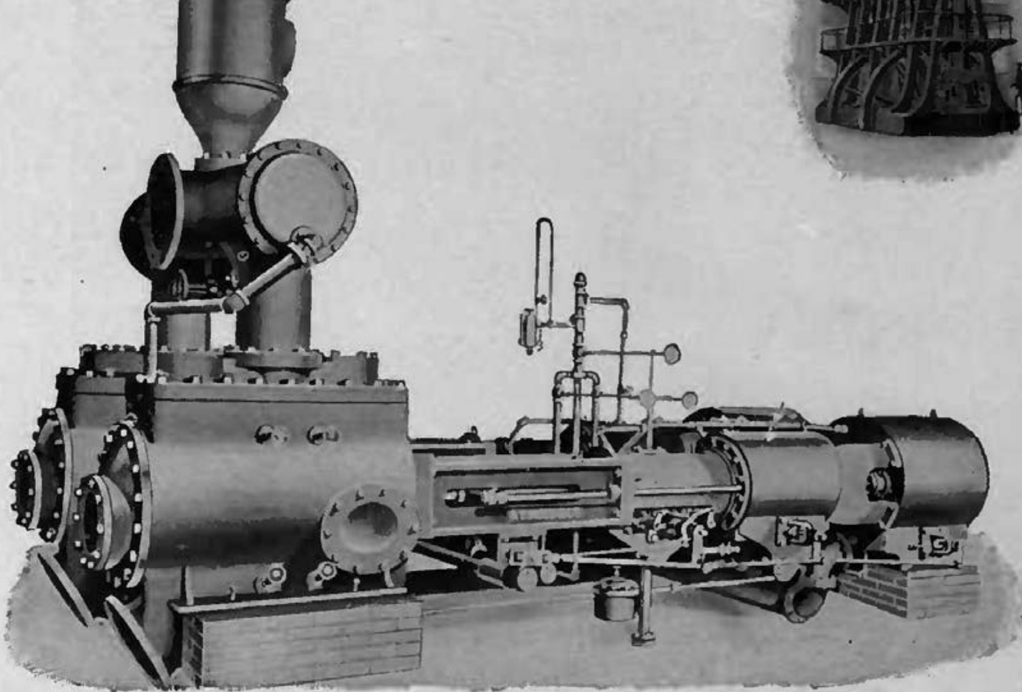

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