BEFORE THE

WASHINGTON UTILITIES & TRANSPORTATION COMMISSION

UG-__

GENERAL RATE APPLICATION

OF

NORTHWEST NATURAL GAS COMPANY

December 31, 2018

Direct Exhibit of Andrew C. Middleton

ENVIROMENTAL MITIGATION HISTORY

Exh. ACM-5

PROCEEDINGS

OF THE

American Gas Institute

ELEVENTH ANNUAL MEETING

OCTOBER 17, 18, 19, 20, 1916

CHICAGO, ILL.

Part I

PUBLISHED BY THE INSTITUTE
EDITED BY THE PUBLICATION COMMITTEE
1917

MANUFACTURING SECTION (Continued).

Third Session, Wednesday 9:30 A. M., October 18.

MR. H. C. ABELL, *Vice-President,* presiding.
MR. J. S. JACKSON, *Secretary.*

The Chairman called the meeting to order at 9.30 A. M.

THE CHAIRMAN: The first paper we have this morning is "New Oil Gas Plant—Portland, Oregon," by Mr. E. L. Hall. Is there any one present representing Mr. Hall?

I will ask Mr. Flower to abstract this paper hurriedly. I think he has gone over part of it.

NEW OIL GAS PLANT—PORTLAND, OREGON.

INTRODUCTION.

Portland, Oregon, is located at the junction of the Willamette River and the far-famed Columbia, and by reason of this fortunate geographical position, has become one of the largest cities on the Pacific Coast, the leading lumber producing city in the world, the second largest grain shipping center in the United States, and is also noteworthy as a financial center.

The territory served is shown in Fig. 1.

Due to the phenomenal growth since the Lewis and Clark Exposition in 1905, the old site of the gas works at Front and Everett Streets, consisting of a few city blocks on the water front, became inadequate to take care of the continuous additions to plant and machinery, while the business center drawing its cordon tighter around the manufacturing activities, brought about increased complaints against the smoke and odor in connection with manufacturing operations. Growing inefficiency and inadequacy of the old machinery, most of which had been in use for many years, called for a reconstruction of the plant. It was, therefore, decided in 1910 that the time had come to move the manufacturing plant to the outskirts of the city.

PRELIMINARY ENGINEERING.

The site selected, admirably located, consists of about 40

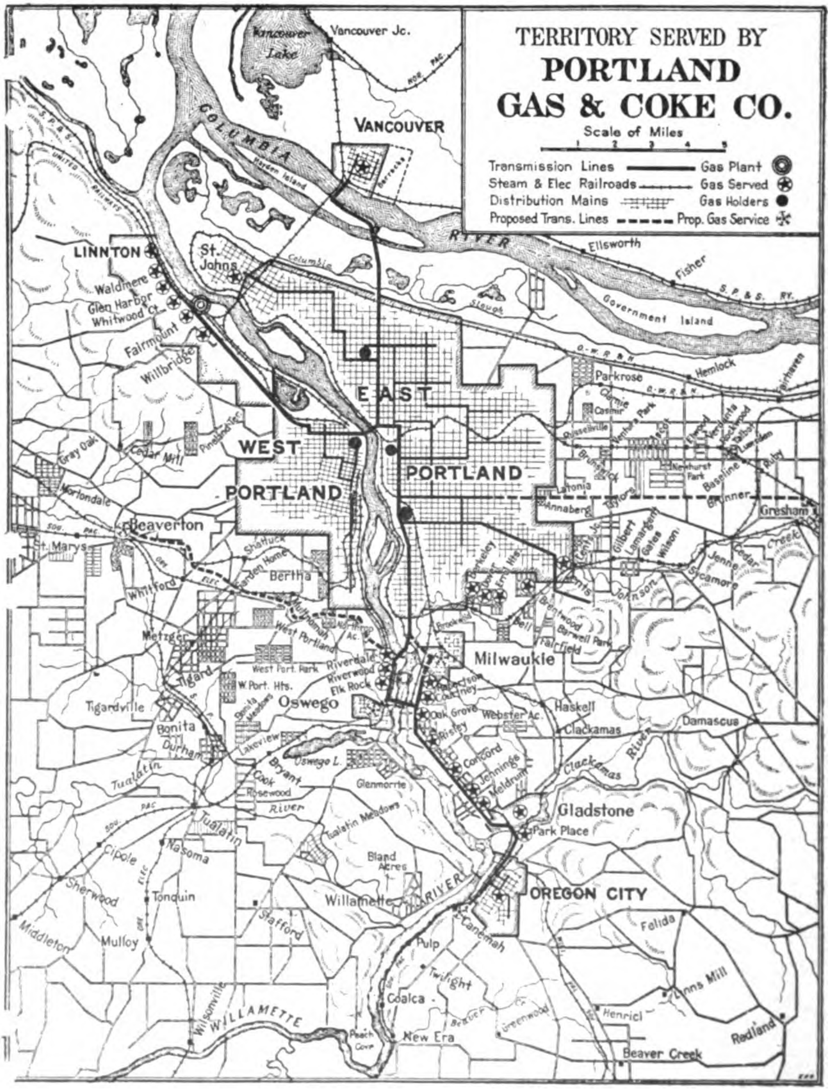

TERRITORY SERVED BY
PORTLAND
GAS & COKE CO.
Scale of Miles
Transmission Lines
Steam & Elec Railroads
Distribution Mains
Proposed Trans. Lines
Gas Plant
Gas Served
Gas Holders
Prop. Gas Service
VANCOUVER
Vancouver Jc.
Vancouver Lake
COLUMBIA
RIVER
LINNTON
St. Johns
Waldmere
Glen Harbor
Whitwood Ct.
Fairmount
Willbridge
EAST
PORTLAND
WEST
PORTLAND
Ellsworth
Fisher
Government Island
Parkrose
Hemlock
Fairhaven
Beaverton
St. Marys
Bertha
Whitford
Metzger
Tigard
Tigardville
Bonita
Durham
Oswego
Oswego L.
Milwaukie
Gresham
Haskell
Clackamas
Damascus
Gladstone
Park Place
OREGON CITY
Willamette
Canemah
Pulp
Twilight
Coalca
New Era
Felida
Linns Mill
Redland
Henrici
Beaver Creek
Tualatin
Nasoma
Cipole
Sherwood
Tonquin
Middleton
Mulloy
Wilsonville
WILLAMETTE
Stafford
Glenmorrie
Bland Acres

FIG. 1.

acres of low-lying meadows, 6 miles below the city. Being located on the main line of the Northern Pacific Railroad, it has excellent railroad facilities.

The property presented, however, certain drawbacks from a construction standpoint; namely, the low elevation above the Willamette River and the character of the subsoil on certain portions of the tract.

Before anything was done in preparing the plans and specifications for the new plant, it was necessary to thoroughly examine and test the soil conditions in order to make the lay-out conform, thereby avoiding undue expenditures for foundations and insuring continuous operation during abnormal periods of high water.

Accurate surveys were made of the property and contour lines established, and that portion of the tract presenting the largest area of high ground was selected for the approximate location of the plant. Meanwhile, several tentative lay-outs had been drawn up and these were staked out on the ground, and borings were made from October 15, 1911, till October 30, 1911, to depths ranging from 30 to 100 feet.

As a result of the information contained in these borings, a layout, shown in Fig. 2, was located, necessitating a few additional borings, which were begun December 31, 1911, and completed January 12, 1912.

There was not sufficient high ground available to locate all the buildings above the highest known flood state of the Willamette River, which was approximately 34 feet above the government datum, and it was therefore necessary to fill in the property to this elevation. This operation was rapidly and economically made possible by the large government dredges operating in the Willamette and Columbia Rivers.

For this purpose it was necessary to drive a double bulkhead around the area to be filled. This construction work was advantageously combined with dock and wharf, the latter to serve for the bringing of construction supplies and later to afford anchorage for fuel oil steamers from California.

Progress of Construction Work.

Water pile driver arrived on the job April 1, 1912, and drove eight temporary piles along the water front to anchor log rafts and barges. This date represents the beginning of construction work. Simultaneously work was begun with the land pile driver and the whole job including the bulkhead, dock and wharf, was completed on June 1, 1912.

On account of the large quantity of drift at certain seasons in the Willamette River, it was necessary to build a sheer boom to protect the dock and wharf, consisting of 13 three-pile dolphins, connected with boomsticks.

All the fill, consisting of 180,381 cubic yards, was made with the Port of Portland 30-inch suction dredge Columbia. Pumping started on June 3, 1912, and was completed on June 24, 1912. Illustrations of the work are shown herewith.

After the completion of the fill, it was necessary to remove certain high ground, which excess earth was deposited against the bulkhead, in order to form a permanent protection for the sand fill after the decay of the bulkhead. There were removed in this manner approximately 7,900 cubic yards, at a cost of approximately 21 cents. Part of this work was done by steam shovel and part with teams.

Very careful elevations were taken immediately after completion of the sand fill and for a period of 3 months, during which period an average settlement was shown of 10-5/16 inches.

The property was now ready for the erection of the buildings.

The Northern Pacific Railway located spur tracks on June 28, and on July 3, stakes for the buildings and holders were set, on which actual construction work was started July 17, 1912.

Additional careful soil tests were made on the bearing power of this sand fill, and since it was not practical to carry the footings to bed-rock, or to the original formation, it was decided to use spread footings and mats.

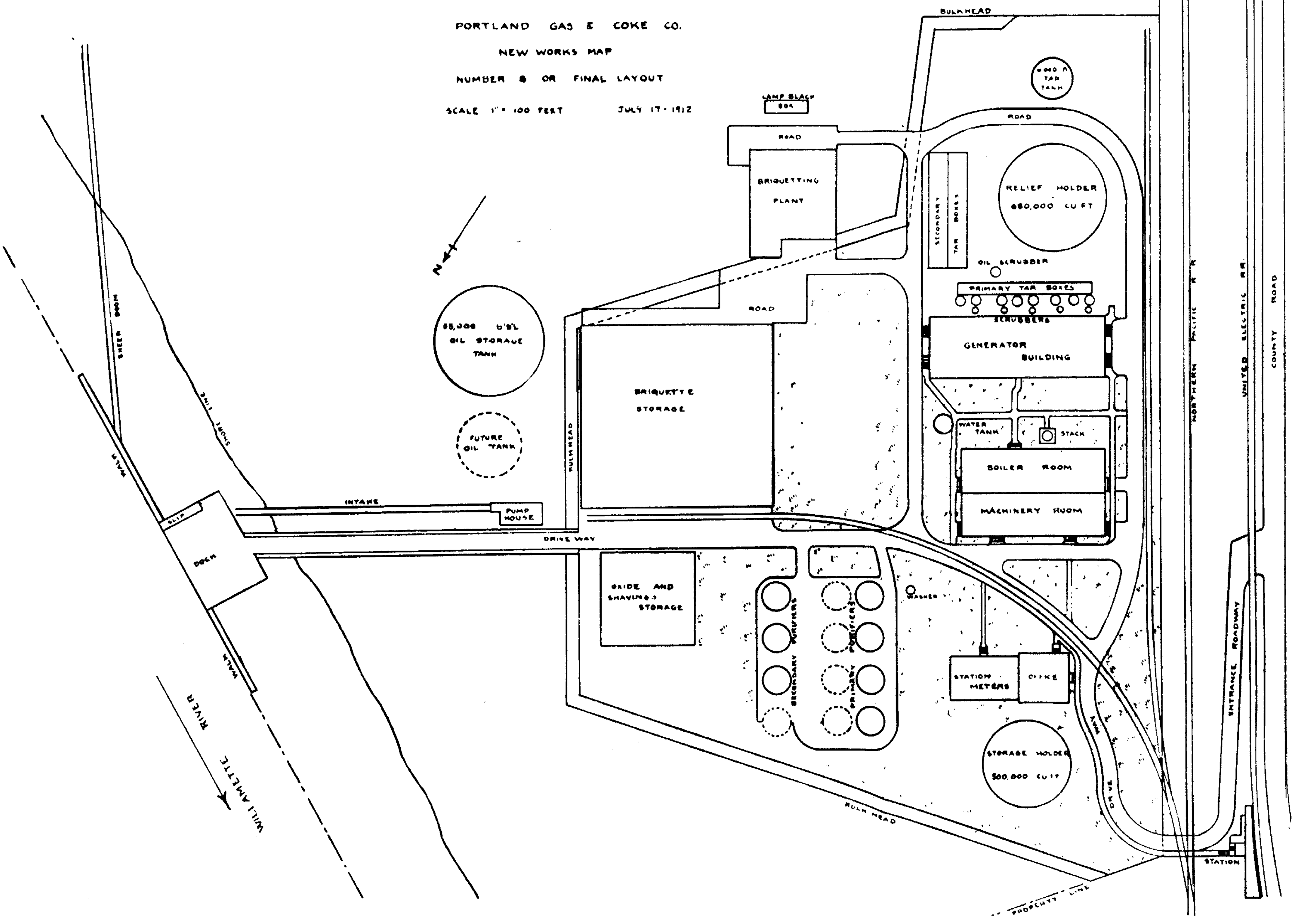
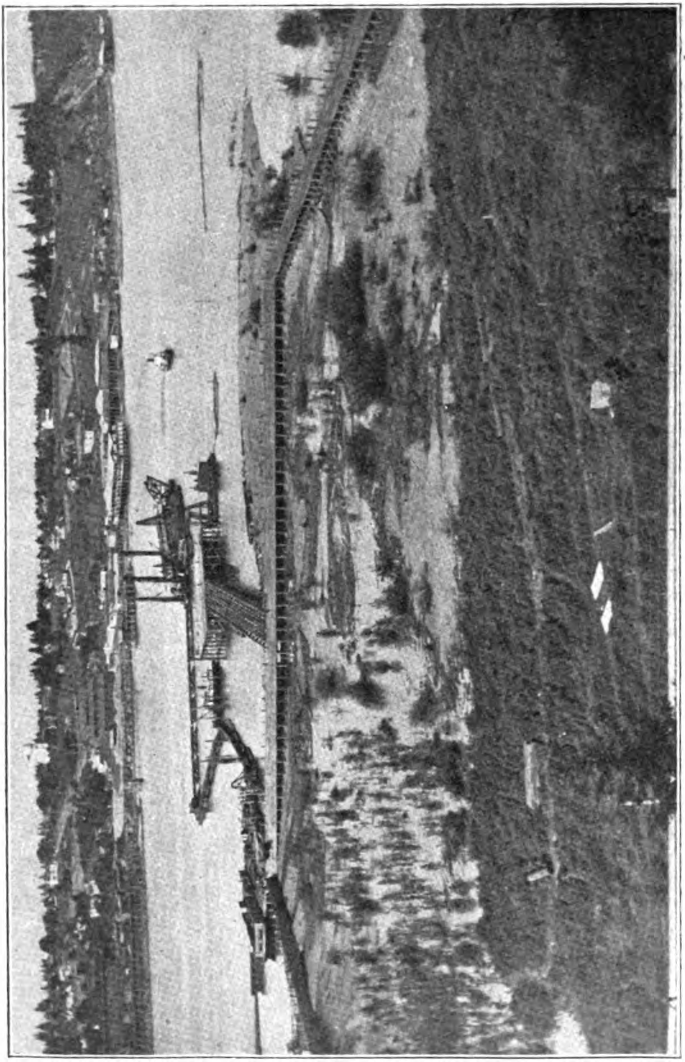
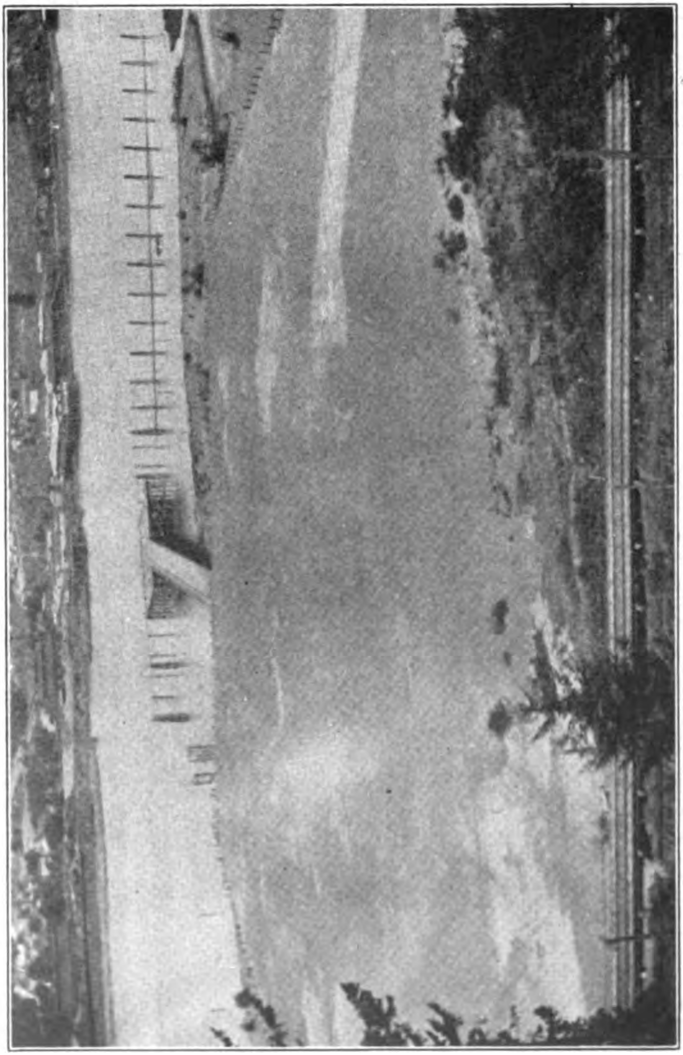

PORTLAND GAS & COKE CO.
NEW WORKS MAP
NUMBER 8 OR FINAL LAYOUT
SCALE 1" = 100 FEET
JULY 17 - 1912
BULKHEAD
TAR TANK
LAMP BLACK BOX
ROAD
BRIQUETTING PLANT
RELIEF HOLDER
680,000 CU FT
SECONDARY TAR BOXES
OIL SCRUBBER
PRIMARY TAR BOXES
SCRUBBERS
GENERATOR BUILDING
55,000 BBL OIL STORAGE TANK
FUTURE OIL TANK
BRIQUETTE STORAGE
WATER TANK
STACK
BOILER ROOM
MACHINERY ROOM
INTAKE
PUMP HOUSE
DRIVE WAY
SLIP
DOCK
WALK
SHEER BOOM
SHORE LINE
OXIDE AND SHAVINGS STORAGE
SECONDARY PURIFIERS
PRIMARY PURIFIERS
WASHER
STATION METERS
OFFICE
STORAGE HOLDER
500,000 CU FT
DRIVE WAY
BULK HEAD
PROPERTY LINE
STATION
ENTRANCE ROADWAY
NORTHERN PACIFIC R R
UNITED ELECTRIC RR.
COUNTY ROAD
WILLAMETTE RIVER

FIG. 2.



BULKHEAD BEFORE BEING FILLED.



BULKHEAD AFTER BEING FILLED.

Buildings and holders, and the majority of the gas apparatus were erected simultaneously, and the heavy construction work was completed in June, 1913.

While the foregoing was in the progress of erection, all other installation work, consisting chiefly of piping machinery, sewers, electric conduits, wiring, etc., was being done and tested out, and by the 27th of October, 1913, the plant was practically completed and was placed in operation.

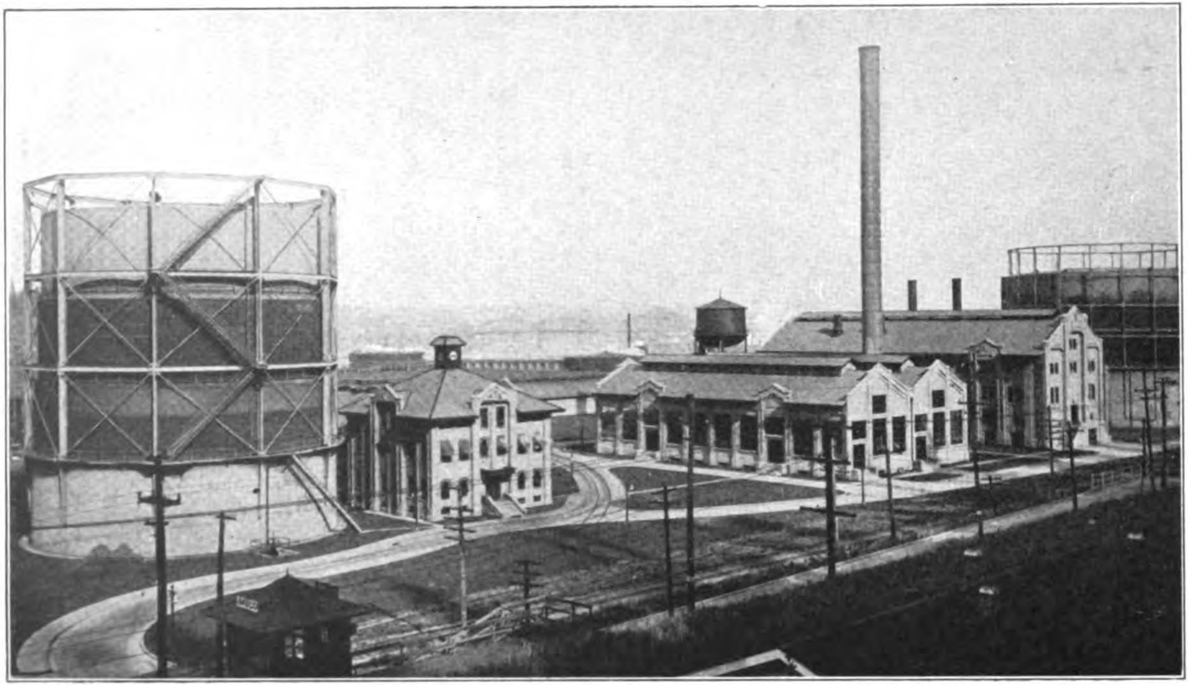
Considerable additional work, however, was done after the above date and it was not until the middle of January, 1914, that the concrete roadways and all other small details were completed.

Description of Plant.

Buildings and Grounds.

In the designing of this plant, two points were kept uppermost in mind: Firstly, to attain the highest possible efficiency in operation, profiting by our experience of oil gas manufacture at the old plant; and secondly, to eliminate what heretofore had been the principal source of complaints against the operation of gas works, namely, dirt, soot, smoke, cinders, etc., together with the untidy appearance of things and the gloomy, grimy and ugly buildings.

The second feature was therefore the uppermost consideration in designing the buildings and laying out the grounds. Several types of architecture were considered. The type finally selected conveys the impression of solidity, permanence and dignity, impressive both to the investor, by creating a feeling of solid strength and security, and to the citizen in the community by the pleasing and harmonious conformation to the ideals of municipal growth. The setting for the buildings is picturesque, namely, in the foreground, the wooded heights of spruce, hemlock and fir, and in the background, the glistening waters of the Willamette River. Concrete drives and walks unite the buildings and storage sheds, while the vacant spaces are covered with green lawns and attractive shrubbery.



BUILDINGS AND GROUNDS.

The buildings are of reinforced concrete, containing 1-inch sized crushed rock, which has been bush-hammered on the exterior to produce the effect of granite, this process, besides being comparatively as cheap as plastering, is more permanent and produces a greatly superior effect. The roofs are of terra-cotta colored shingles, layed on the French diagonal method. Streets and driveways are provided with curbs, sidewalks, sewer connections, etc., and are illuminated with gas arc lamp posts.

The office building is a two-story structure 50 by 50 feet in plan and houses, on the rear, the works station meter. On the lower floors are the superintendent's and clerks' offices, drafting room and lunch room, while on the second is the works laboratory. The machinery building, next in line, is 90 by 150 feet in plan, with a basement of 45 by 120 feet, and houses all the power plant and boilers, gas exhausters and gas compressors. A portion of this building reserved for future extensions, is now occupied by a men's dressing room and lavatory.

The generator building is 60 by 182 feet in plan and is designed for two rows of five 20-foot oil gas generators, space being left at the end of the building for the motor-driven air blowers. The building is carried on its own foundation, entirely separate from the generators, which are carried on concrete piers 12 feet high, on separate foundations. The basement thus formed serves for brick storage and, at the far end, for the oil heaters and strainers.

Other buildings are the oxide and shavings storage building, which is 100 by 100 feet, of heavy mill construction and is covered by hyrib metal lath, and located approximately to the purifiers. The briquette storage building is 200 by 206 feet and is built of similar material as the oxide shed. The briquetting plant building is 93 by 96 feet and is built of the same material as the foregoing.

Located near the dock and river front is a brick and concrete water and oil pump house, which is 15 by 45 feet in plan and comprises three floors, the upper of which is prin-

LABORATORY.

cipally a gangway and a location for motor controls and meters, while the second floor houses the oil pumps.

The lower floor is usually below the river level and here are located the water pumps, which in this manner, operate under little or no suction. This building is flanked on one side by a water intake, 6 feet in width by 270 feet long, consisting of creosoted sheet piling, driven interlocking and with heavy timber bracing, equipped with a rack or screen at the river end, and a gate and supplementary screens. Immediately adjoining the pump intakes is a dock 70 by 106 feet, with walks extending at either end to five mooring dolphins, communicating with the shore by a trestle about 250 feet long.

The dock and water intake are protected by sheer booms, connected together with boom sticks, arranged to raise and lower with the water level of the river.

Oil Gas Apparatus.

Theory.

The production of gas from crude petroleum is essentially a process of high temperature cracking. There has been much apparatus designed for this purpose but the variations can all be reduced with but few exceptions to construction details of size, form and dimensions, rather than to essential difference in the process.

We may repeat therefore that the oil gas production as a process, must be treated purely as an oil cracking process, subject to the same factors of temperature, pressure and contact with highly heated surfaces.

The gas maker as a merchant must consider how to cheapen his product by all the manufacturing economies, among which the most important is the utilization of by-products. In other words, he strives to produce the greatest number of B. t. u.'s per dollar. This is true of all the gas making methods.

This problem, from the standpoint of oil production has been attacked in two different ways:

1. By elimination of all by-products, *i. e.*, by conversion of all the raw material into gas.

2. By the production simultaneously with the gas of the largest amount of merchantable by-products on the theory that weight for weight the latter are worth more than the raw material.

The first method has been developed under the auspices of Mr. E. C. Jones of San Francisco, and the results described in a paper by his son, Mr. L. B. Jones.

The process is of great theoretical interest, but unfortunately has not as yet evoluted to its maximum possibilities, *i. e.*, the complete elimination of lampblack as a by-product. The further development of this process to its logical end is hindered by the high standards of quality of gas prevalent in California, *i. e.*, a 600 B. t. u. or higher.

The second method is of more universal application and is exemplified in most of the coast cities in so far as the by-products are marketed, by Los Angeles, San Diego, Oakland, California, and Portland, Oregon. Nearly all the other oil gas plants produce lampblack, but have not sufficient volume to briquette.

Both methods have their merits and their advocates and in the final outcome it will no doubt be found that local conditions will determine the process to be adopted.

Where there is a good fuel market and oil is cheap, it will unquestionably pay to produce by-products.

Investigations made by the Portland Gas & Coke Company, at the instance of the Bureau of Standards, showed that for our local conditions, a 525 B. t. u. gas would, if by-products were fully manufactured and sold, deliver to the consumer the most B. t. u. for a dollar. The present standard of 570 B. t. u. in force in the State of Oregon therefore represents, from a gas making standpoint, an incomplete and wasteful process.

If, however, this standard were maintained it is interesting to consider what should be the composition of a gas produced from crude oil in order that the minimum percentage of the original carbon should be utilized in producing the necessary B. t. u. per cubic foot. Without going into the calculation, an analysis is given below of which a 560 B. t. u. gas containing the minimum carbon, and which would, therefore, produce the greatest amount of carbon residue per thousand cubic feet of gas.

This analysis represents a methane-hydrogen gas and is predicated on the assumption that the carbon dioxide and nitrogen will remain the same in volume, which is not necessarily the case.

The selection of oil gas apparatus for the new plant was further investigated relative to costs per 1,000 cubic feet of daily gas capacity and it was decided that the installation costs for a single shell type per unit of gas making surface were considerably lower—as was to be expected.

560 B. T. U. GAS WITH MINIMUM CARBON.

CO_2	1.2
C_6H_6	None
C_2H_4	None
O_2	0.7
CO	7.2
CH_4	37.0
H_2	51.5
N_2	2.4
	100.0

Before proceeding with a description of the gas apparatus, it may be interesting to some gas engineers to describe the oil gas process, by which the greater portion of manufactured gas on the Pacific Coast is procured.

Oil gas, while manufactured in apparatus and by a process somewhat similar to the manufacture of water gas, produces a gas strikingly characteristic to coal gas, as may be seen by the following analysis of gas as produced by the Portland Gas & Coke Company, for typical 570 B. t. u. oil gas:

Carbon dioxide	1.4
Benzene	1.4
Ethylene	3.1
Oxygen	0.2
Carbon monoxide	6.0
Hydrogen	52.45
Methane	28.3
Nitrogen	7.18
Gross B. t. u. calculated	578.5
Specific gravity	0.4135

A striking and essential difference in this process is the fact that the only important by-product is a large quantity of very pure carbon, comprising frequently as high as 50 per cent. of the weight of the original oil.

The principal problems arising in the manufacture of oil gas present themselves in connection with this residual.

Firstly; by reason of the mechanical difficulties introduced of cleansing of the gas and the recovering of this valuable substance.

Secondly; by the fact that there are produced with this carbon, varying amounts, of a very pitchy tar, with but very little commercial value, which, if allowed to condense, at the same time the lampblack is removed, produces a spongy substance most difficult to handle and which, in a short time, will completely block up the apparatus and passageways.

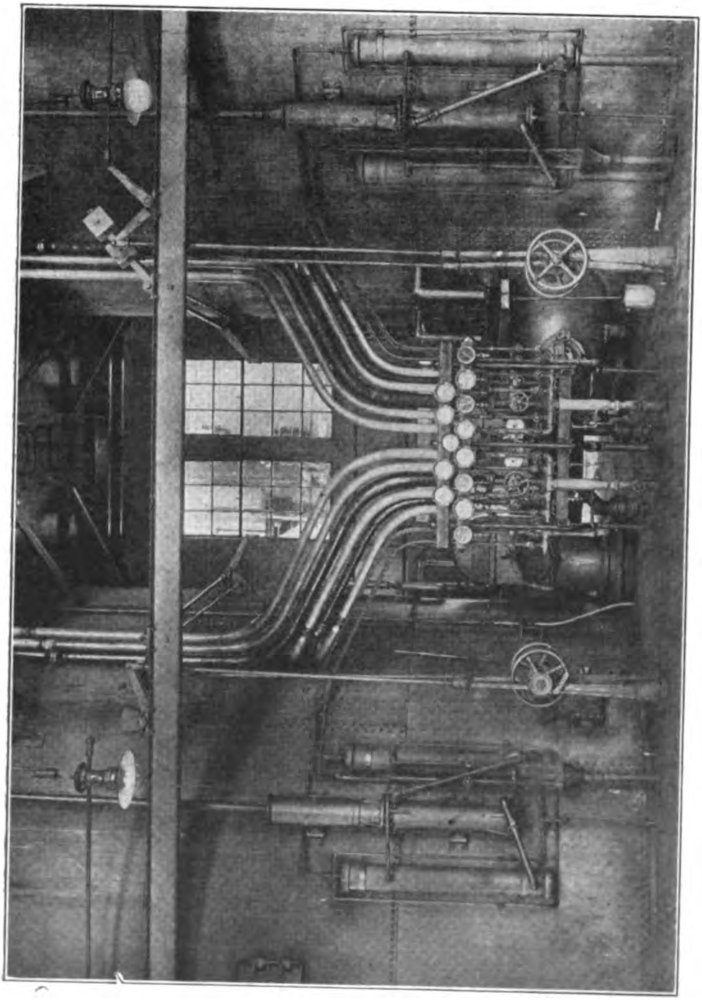
As is usual in manufacturing problems of this description, the means used by the pioneers of the art to handle this substance were both cumbersome and complicated. The writer has frequently seen plants in California and Oregon, where from one to five hours were consumed daily in ridding the washers and scrubbers of this accumulation. As the art progressed and the theory of oil gas condensing and washing was better understood, the apparatus was so designed as to mechanically and automatically separate the lampblack from the tar at appropriate stages in the process. The manufacture is also troubled with the usual bug bears of naphthalene, cyanogen and sulphur, without the compensation of ammonia recovery, which substance is present in only the faintest traces.

Gas Generators.

The five gas machines have each a capacity of generating 2,000,000 cubic feet of gas per day. Each consists of a cylindrical shell 20 feet in diameter and 30 feet 6 inches in height, with conical-shaped top 4 feet high, all of which is constructed of ⅜- and ½-inch steel plating. On the sides near the bottom are two 36-inch diameter drums for the blast connections and in the rear is a 36-inch diameter off-take nozzle. Just above each of the two inlets are two 10-inch diameter nozzles for the gas-making burners. Eight cast-iron manholes are distributed about the shell for access below the arches and to the checker brick, and on the top is a 34-inch diameter stack valve which operates by steam hydraulic cylinder. Steam and oil piping connects to all of the burners, which are controlled from an operating panel located between each pair of generators. Here also valves for operating the stack valve, gauges for all steam and oil connections and oil meters, and also hand operating stands for the 24-inch diameter blast valves.

An all steel platform is provided around each generator for access to the gas making burners and an additional platform at the top for cleaning the stack valve. Steel stairways lead to these platforms, all of which are equipped with pipe hand-rails and wire guards.

The lining of the generators is 16½ inches in thickness, consisting of 13½ inches of firebrick and 3 inches of asbestos. At the bottom, thirteen arches, 9 inches in width and having an air space of 6 inches between, are installed for supporting the checker brick. These arches span half the width of the machine and rest on the center on a wall, which extends entirely across the shell and the latter is provided with two small arches for permitting the air blast to get from one side of the generator to the other. The crown is composed entirely of wedge-shaped blocks, which are supported on large skew backs, placed on the top of the lining wall. Special shaped blocks are provided for the air inlet and off-take connections and also for the burners and manholes. The operation of these units has been



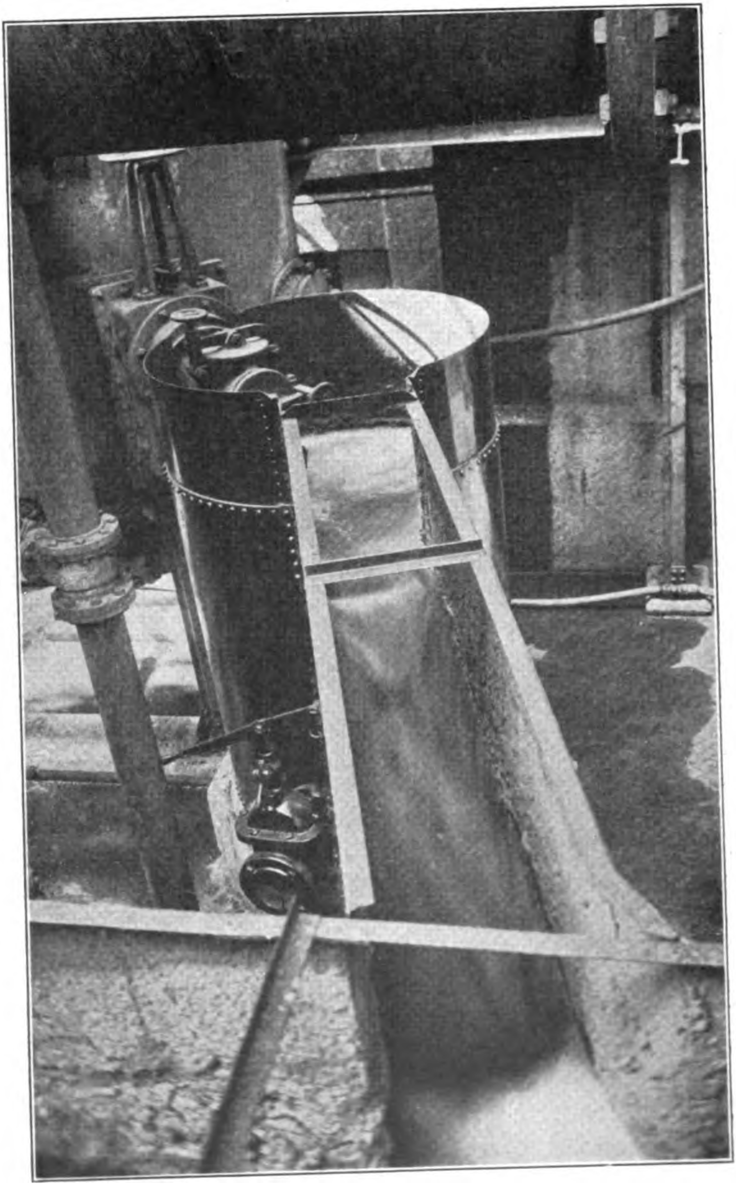
GENERATOR CONTROLLING VALVES AND GAUGES.

so standardized by means of the improved construction that the life of the checker work is at least two years.

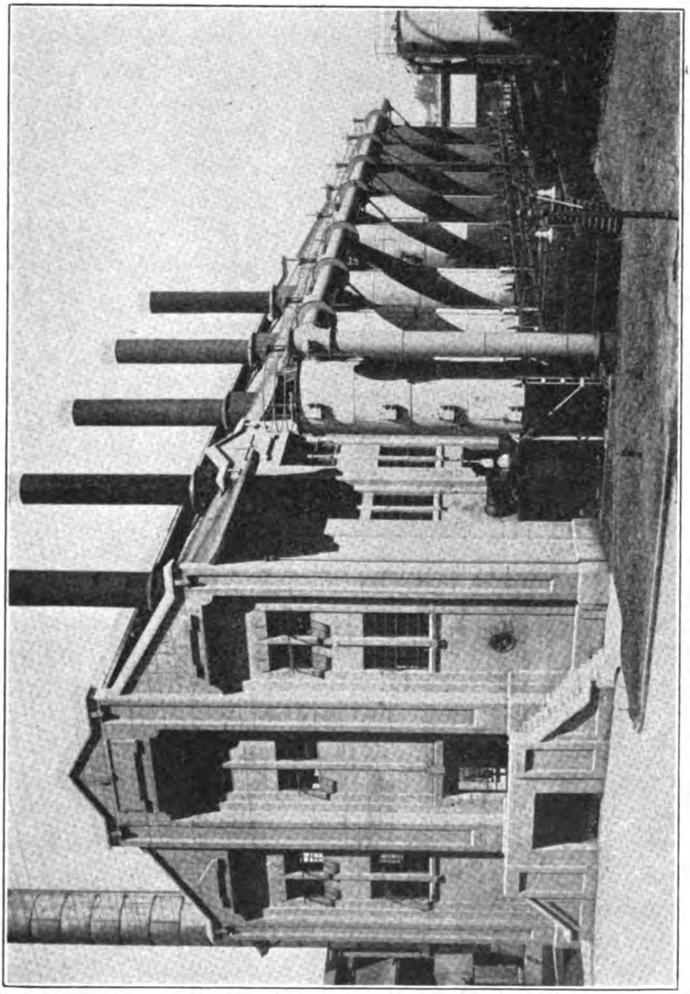
Wash Boxes.

In the rear of each generator and just outside of the building wall are five wash boxes, each of which is connected to a generator by a 36-inch diameter pipe, which is firebrick lined and which reduces to a 24-inch diameter cast iron ell with clean out doors at the wash box for connecting the dip pipe. The wash boxes are 8 feet in diameter and 7 feet in height and are constructed of ¼- and $^5/_{16}$-inch steel plating. They are provided with hopper bottoms and are supported above the yard level on structural steel columns.

The dip pipe which is 24 inches in diameter, enters through the top and extends sufficiently into the wash box to insure a minimum water seal of 10 inches. The lower part of this pipe is equipped with a flange or hood grooved for rotating the water and a suspended disc is provided for closing off the pipe. The gas outlet, which is also at the top, is of the same size and has cast-iron ell and pipe for connecting to the primary scrubbers. Three connections on the top are made for admitting the water. These are arranged with a special shaped casting for spraying the water into the shell. The overflow outlet is of cast iron and is riveted to the side of the shell. It is arranged with movable gate to allow raising the water seal and is provided with outlet pipe 10 inches in diameter. This pipe is sealed in a steel drain tank 4 feet in diameter and 5 feet in height, which is connected by means of a steel flume to an underground pipe line extending to the filters at the briquetting plant. Other connections on the seal tanks include two cast-iron manholes in the sides and 8-inch valve in the center of the bottom for cleaning purposes. As a result of the improved construction the cleaning of wash boxes, scrubbers and seal pots has been entirely eliminated and the separation of lamp-black and tar accomplished in two distinct stages, *i. e.,* lamp-black is entirely removed in the wash boxes and the tar entirely in the scrubbers, thus allowing each constituent to be easily and automatically eliminated.



WASH BOX.



GENERATOR BUILDING.

Primary Tar Scrubbers.

One primary tar scrubber is provided for each generator. These are each 10 feet in diameter and 28 feet in height and are constructed of $^5/_{16}$- and ¼-inch steel plating. They have conical bottoms and are supported on the structural steel columns similar to those of the wash boxes. The inlet and two outlet connections are 24 inches in diameter and the latter are so arranged as to permit the passing of the gas either to the secondary scrubbers or directly to the 36-inch diameter header leading to the relief holder. Water is admitted at the top by means of an "H" shaped spray and the scrubbers are drained at the bottom by a 12-inch diameter pipe, connected to and sealed in the primary tar boxes, without the use of the usual seal pots.

The interior of the scrubbers is equipped with five conical rings, which are riveted to the shell and five small cones, both of which catch the water and form a spray through which the gas passes.

Platforms are provided along the tops of the scrubbers and at the floor level, along the building wall, for access to the valves and for cleaning purposes. Steel stairways lead to all of these platforms and where necessary, hand rails are installed. For the large valves, extension stems are arranged for operating from the ground. Each scrubber is equipped with six cast-iron manholes for access to the cones and water sprays.

Final Cooling Scrubbers.

Three final cooling scrubbers have been installed, one of which is arranged to handle the gas from each pair of generators. The shells and supports are identical to those of the primary scrubbers and also the water inlet and drain connections to the tar boxes. The inlets for each, of which there are two, are 24 inches in diameter and connect to the outlet of the primary scrubbers. The gas outlet is of the same size and connects to the 36-inch diameter header previously described.

There are cones in these scrubbers; the interior is filled with wooden trays, which are supported on steel angle irons riveted to the shells. The platforms, stairways, etc., are the same as those of the primary scrubbers.

The gas passes from final scrubbers to relief holder whence it is drawn through the following apparatus.

Oil Scrubber.

In common with the history of all gas plants, naphthalene troubles had occasionally made themselves felt, with this company, particularly after the introduction of oil gas and high temperature operation. Profiting, however, by the European experience in anthracene oil washing, which was readily understood to be merely a process of physical solution, experiments were instituted by the writer in 1907 and 1908, as a result of which an 8 by 30-foot oil scrubber was installed at the old plant. About the same time a similar development occurred in the plant of the Los Angeles Gas & Electric Company and the technic of the process was worked out by Mr. Wade, chemist, and Mr. D. J. Young, superintendent.

As a result of this experience, crude oil washers 10 feet in diameter by 30 feet high, with automatic oil pumps and receiving tanks, were installed at the new works. Due to oil washing, naphthalene complaints are practically unknown. The four or five calls which are received per month from this source are derived mainly from oil deposits. The process has been well described in an article before the Pacific Coast Gas Association by Mr. Wade, in a paper entitled: "The Naphthalene Problem in Oil Gas Manufacture and Distribution."

The oil scrubber is 10 feet in diameter and 30 feet in height and is constructed of ¼- and $^{5}/_{16}$-inch steel plating. The gas inlet and outlet connections are 24 inches in diameter and the oil inlet, which at the top is 3 inches and the overflow at the bottom 6 inches in diameter. Oil is obtained from the main oil supply from the oil pumps in the pump house and the piping is so arranged as to permit using either cold oil or hot oil heaters for the generators. The 6-inch drain connections overflow into a steel tank 10 feet in diameter and 10 feet in height, which is buried under the ground and which is prevented from overflowing by a 6 by 4 by 6-inch Blake-Knowles duplex steam-driven pump, operated automatically by a float in the tank. This pump returns the oil through a 6-inch pipe line to the oil storage tank.

The oil scrubber is provided with a vertical steel ladder, extending from the ground to the top, where a hand rail is placed. Three cast-iron manholes on the sides give access to the interior, which is filled with wooden trays, supported by steel angle irons riveted to the shell.

The effect of the crude oil washing is to dissolve out the naphthalene present in the gas, which is, however, not lost, since the oil is eventually used for gas making when the naphthalene is made into gas.

About 5 gallons of crude oil is made to circulate through the oil scrubber per 1,000 cubic feet of gas made.

Purification.

The gas, after being subjected to the oil washing, is drawn through the elsewhere described exhausters and passes through a Gas Machinery Company Multiple Gas Washer for final cleansing before purification. The crude oil from which the gas is made contains normally from ¾ to 1¼ per cent. sulphur, which quantity is responsible for about 180 grams of hydrogen sulphide for every 1 per cent. of sulphur in the crude oil. This amount is accompanied by about 15 to 20 grains of carbon bisulphide and other sulphur compounds.

Gas purification is entirely by means of the well known Lamings mixture with selected planning chips, as a coating medium. Purification expense with this material has been materially reduced during the last few years by studies on the preparation of same without losing a great portion of the valuable copperas in the interior of the chips. In other words, means have been found to keep the valuable artificial iron oxide almost entirely in an available state on the surface of the chip.

There is used for the purpose of manufacturing this substance, an apparatus somewhat on the principle of a concrete mixer set up on a high platform and served by a small elevator.

Purifying System.

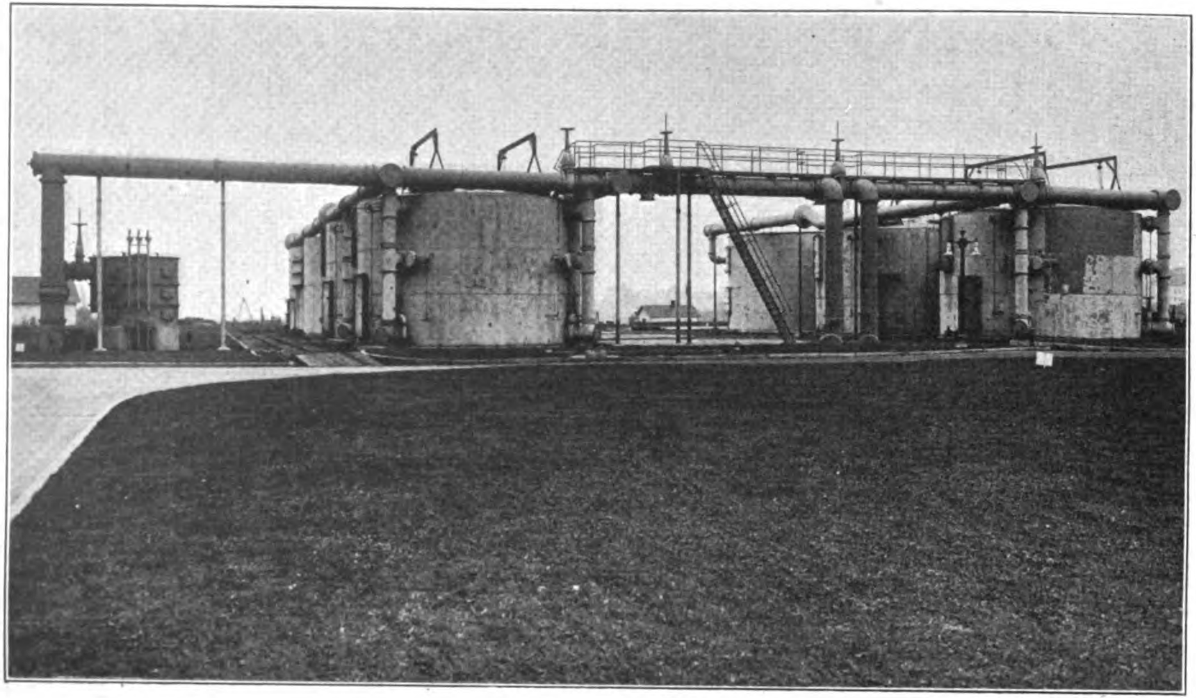
Primary Purifiers.—The primary purifiers, of which there are four, are 32 feet in diameter and 20 feet in height. Two of these were purchased from the Gas Machinery Company at the time the plant was constructed and the other two were moved from the old works on a barge. All are constructed of $^{3}/_{16}$- and ¼-inch steel plating and have spherical-shaped tops, and are designed for either simplex or duplex operation. The three inlet and three outlet connections are 20 inches in diameter and are arranged one above the other with valves so that the gas may be passed through any section or all of the purifiers, as desired.

Steel "I" beams and columns on the inside are installed for supporting four sets of trays, on which the oxide is placed. The trays are of wood and are built in sections, so as to facilitate handling and dumping.

On the top of each purifier two asbestos sealed doors, 6 feet in diameter and constructed of steel plating and angle irons are placed for installing the oxide and are provided with clamps for fastening and with chain blocks and overhead trolley for convenience in handling. On the sides for removing the oxide, are two doors 3 feet, 6 inches by 8 feet, 4 inches high, which are also of steel and are arranged with hinges, clamps and bolts for fastening. A 12-inch diameter blow-off valve is placed on the top of each purifier and on the side a 10-inch connection for air inlet. In the bottom is a 3-inch diameter drain connection, which is equipped with valve, funnel and strainer and piping connection to washer drain tank.

Between each purifier, at the top, a small platform is provided and a steel stairway extends to the ground. Along these and also around the top of the purifier steel pipe hand rails are placed. Most of the large gas valves are equipped with extension stems for operating from the ground and on the sides of the purifiers, where necessary, thermometer wells and test cocks are placed.

Secondary Purifiers.—Two of the secondary purifiers were purchased from the Gas Machinery Company and are identical



PURIFYING PLANT.

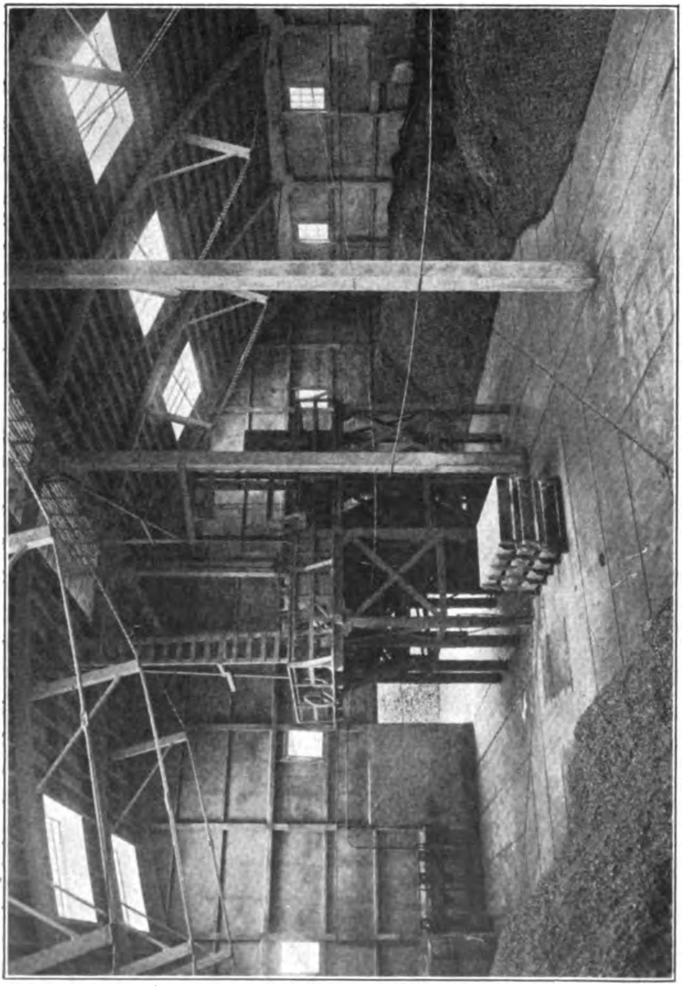
to the primary purifiers. One other secondary purifier, which was moved down from the old plant is 2 feet greater in height, but otherwise practically the same, except in the general construction where much lighter material was used.

In addition to having all of the connections, etc., as described, for the primary purifiers, the secondaries are equipped with steam heating coils located in the bottom. These consist of 2-inch piping spaced about 6 inches on centers and extending entirely across the interior of the shell, and arranged with steam inlet and outlet connections, on the outside.

Air Blower for Purifiers.—For reviving the oxide in the purifiers, a No. 9 Sturtevant steel pressure blower has been installed in one corner of the oxide and shavings storage building. It is direct connected to a 20-horse-power Form K. Type I-8—900 revolutions per mniute induction motor, and has piping connections 16, 14 and 10 inches in diameter, extending to each of the purifiers.

ORGANIC SULPHUR REMOVAL.

It has just been mentioned that the organic sulphur present in the oil gas is about 15 grains per 100 cubic feet. This amount, while noticeable to consumers, has not heretofore been considered poor practice by the fraternity. Such is not the case, however, when the sulphur amounts up in the raw material to 2 or 3 per cent. or even as high as 4 per cent., since the organic sulphur amounts up in proportion and reaches a quantity as high as 60 grains per 100 cubic feet, at which point the gas is unfit for domestic use and many other purposes. This condition was experienced by the Portland Gas & Coke Company soon after changing over to the oil gas and would have barred out that process entirely, if means had not been discovered for eliminating this impurity. The process has been described before the Pacific Gas Association at the 1908 meeting by the writer and again before the American Gas Institute in the year 1910 by Hilmar Papst, general manager, of this company. It is gratifying to the writer to note that the process has since been, with the necessary modifications to



OXIDE SHED.

overcome patent rights, been successfully introduced by the South Metropolitan Gas Company of London, England.

The process consists essentially of purifying the raw gas from hydrogen sulphide and raising same to a temperature from 900 to 1,200° F., thus breaking down the organic sulphur to hydrogen sulphide, cooling the gas and then again passing the same through a set of purifiers, to eliminating the hydrogen sulphide produced.

The reaction is a simple mass action in which the original sulphur distributes itself between hydrogen and carbon combinations reaching an equilibrium at a certain proportion of hydrogen sulphide and carbon bisulphide.

This same equilibrium is destroyed by the removal of the hydrogen sulphide in the primary purifiers so that when the temperature of reaction is again restored and mass action equilibrium is again established, the organic sulphur is re-distributed between hydrogen and carbon radicals in the same proportion as in the primary reaction, thus producing a new amount of hydrogen sulphide, susceptible of a removal by iron-oxide purifiers.

The preheating apparatus at the old plant being new and of the proper size, it was removed to the new plant and installed in the generator house.

Reheating System.

The two reheaters have a combined capacity of 4,600,000 cubic feet of gas per day. They were originally located at the old plant and after being dismantled, were moved to the new plant on railway cars and re-erected.

Each consists of a cylindrical shell 10 feet in diameter and 35 feet in height, and constructed of 5/16- and 3/8-inch steel plating. Near the bottom of each is a 30-inch cast iron nozzle with hot valve for natural draft while heating; and also a 20-inch diameter connection with valve for the gas inlet. At the top is placed a 30-inch steel tee, which is firebrick lined, upon which the 20-inch cast iron stack valve rests. The gas outlet is off the side of this tee and consists of 30-inch steel pipe, also firebrick lined and which reduces to 20-inch diameter cast-iron, with clean-out ell and dip pipe to wash box.

The stack valve of each is operated from the main floor by a hand gear and connecting rod. A steel stack 5 feet in diameter and 20 feet in height is provided for each machine and is supported from the roof trusses, the same as those of the generators. The burners, of which there are four, are on the side near the bottom and each is equipped with control valves, gauges, etc. Several cast-iron doors also on the sides give access below the arches and to the checker brick filling.

The lining is 16½ inches in thickness and consists of 15 inches of firebrick and 1½ inches of asbestos fiber. It extends the entire length of the shell and is corbelled in at the top to form a crown and to support the lining in the 30-inch steel tee. Two sets of arches, with air spaces between and located one near the bottom and the other about half way up the shell, are installed for supporting the checker brick. In bricking on shell a total of 22,000 firebrick are used for the lining and 6,100 for checkering.

The wash box, which is used in connection with both reheaters is 8 feet by 14 feet in plan and 8 feet in height. It is constructed of ⅜-inch steel plating and is elevated on a steel platform, between and near the top and supported from the reheater shells. Water is admitted, through eight sprays distributed on the sides and the overflow consists of a cast-iron box and 10-inch pipe, which is sealed in a drain tank resting on the generator room floor. The two gas inlet connections enter at the top and are provided with 20-inch diameter dip pipes. The gas outlet, which is also at the top, is of the same size and extends to the condenser, which is located just outside of the building.

Gas Condenser for Reheaters.—The gas condenser was moved from the old works on a barge, with the purifiers. It is 12 feet in diameter and 22 feet in height and consists of a steel shell of ⅜- and 5/16-inch plating. It is provided with two ⅜-inch tube sheets and 1,012 2-inch diameter boiler tubes, 18 feet in length. The gas inlet is at the top and the outlet on the side near the bottom, both of which are 20 inches in diameter. The water inlet is 6 inches in diameter and the drain connections to the sewer is 8 inches.

STATION METER AND WORKS HOLDERS.

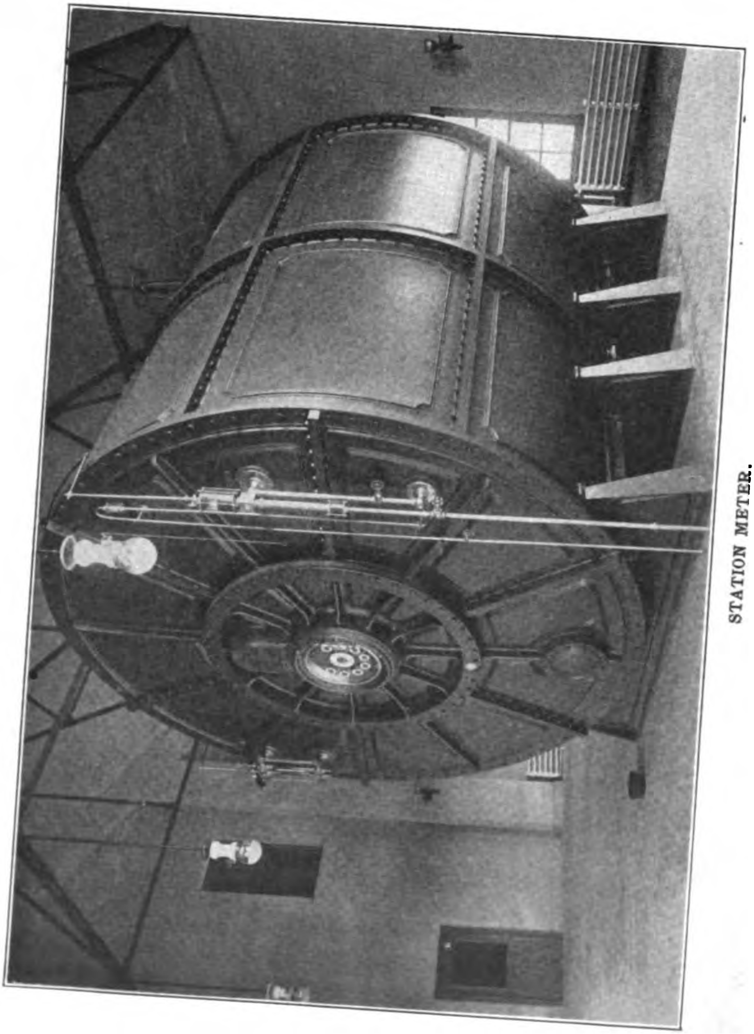
The gas, after purification, is measured in a station meter having a capacity of 4,152,000 cubic feet of gas per day. It is 16 feet in diameter and 16 feet long and has 24-inch diameter piping connections. It is a standard type, manufactured by the Charles H. Dickey & Company of Baltimore, Maryland, and is equipped with a cast iron casing, Hinman Drum and usual accessories.

The foundation consists of four concrete piers, one under each cradle. These piers are 2 feet 6 inches by 13 feet at the base and extend 5 feet below the floor line.

Holders.

Relief Holder.—The relief holder, which has a capacity of 680,000 cubic feet, has two lifts and is provided with new steel tank 113 feet in diameter and 37 feet in height. The holder was originally located at 13th and Couch Streets, and installed in a concrete and brick tank. It was dismantled and re-erected, using practically all of the old steel sheets and guide frames, and provided with new steel tank and stairway, extending to the top of the frame, which is 109 feet in height. The holder is equipped with hand rails on all stairways, along the cups and around upper lift and a Cutler's anti-freezing device is installed for protection in cold weather.

The foundation, consisting of concrete mat 4 inches in thickness at the inside and 12 inches thick around the outside, extends about 4 feet beyond the tank shell, forming a walk entirely around the holder. The outer edge of this walk is shaped into a gutter, which is arranged with sewer drains, the whole of which is similar to that of the storage holder. Concrete pits are provided for the inlet and outlet connections, including large gas valves and drip pots. Around these, hand rails are installed and where necessary steel platforms are placed for operating the valves.



STATION METER.

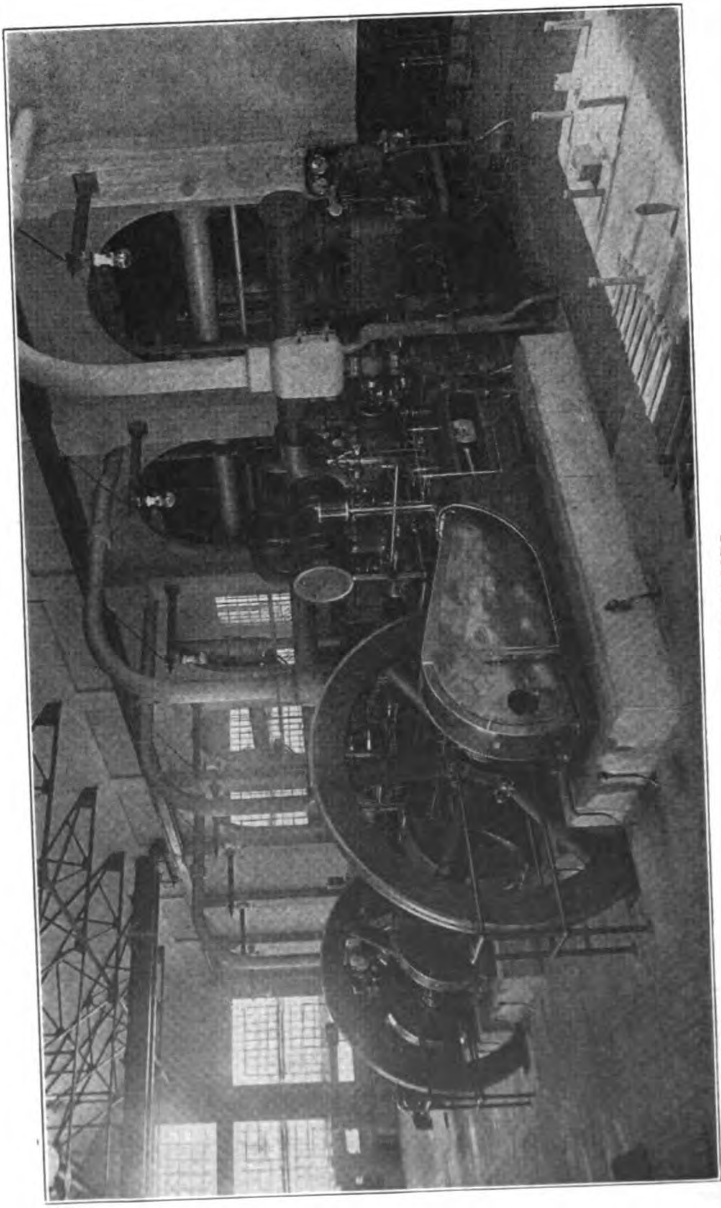
Storage Holder.—The storage holder, having a capacity of 505,000 cubic feet, has three lifts and is provided with a steel tank 94 feet 6 inches in diameter. A steel stairway extends to the top of the guide frames, which are 111 feet in height and hand rails are placed on all stairways, along cups and around upper lift. The holder is equipped with Cutler's anti-freezing device.

The foundation, which is 4 inches thick on the inside and 12 inches thick around the outside, extends about 4 feet beyond the tank shell, forming a complete walk entirely around the holder. At the outer edge of this walk, a concrete gutter is placed and is provided with sewer drains. The inlet and outlet pits are of concrete and are of sufficient size to receive the drip pots and large gas valves. Hand rails are placed around these pits and steel platforms for operating the valves.

Gas-Compressors and Transmission Line.

Since the gas works are located some 7 miles down the Willamette River from the heart of the business district, it is of course not feasible to supply direct to the low pressure systems from the works holders. It is therefore possible and likewise advisable to transmit the gas from the generator station to the outlying storage holders at higher than street pressures.

Calculations as to the growth of the city and the direction of growth furnished the basis for estimating the pumpage for a period of years. The size of pipe line was therefore selected in which the operating costs for pumping together with the fixed charges for investment would reach a minimum, after a period of a few years. The exceedingly low cost of producing power at the works and consequently costs of pumping made it possible to materially increase the pumping pressure and correspondingly decreasing the size of the pipe line. The calculations which were elaborate, indicated an initial pressure of 7 pounds for pumping through a pipe line 16 inches in diameter, to be the most economical. It was further indicated that when the growth of the company should necessitate a

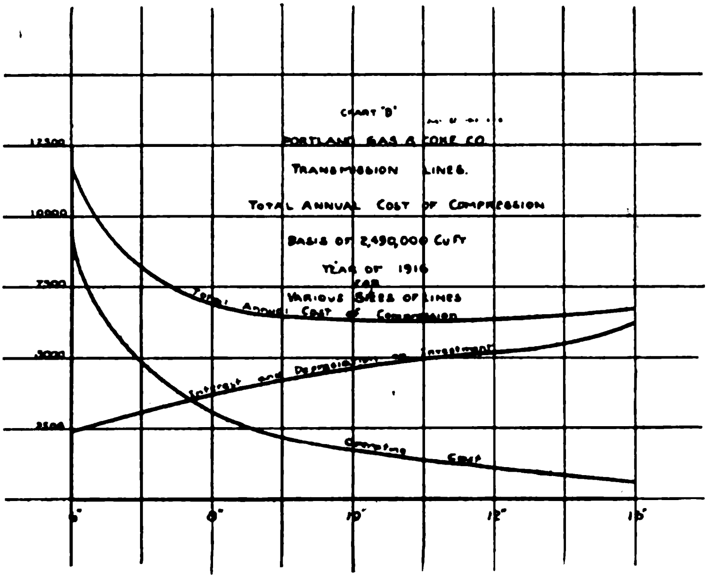


GAS COMPRESSORS.

COST OF PUMPING FROM NEW WORKS.

	1912	1913	1914	1915	1916	1917	1918	1919	1920
Output per hour, maximum	268,000	306,000	354,000	410,000	462,000	520,000	580,000	650,000	750,000
Interest and depreciation on 16-inch pipe line at 15 per cent. $190,000	$13,500	$13,500	$13,500	$13,500	$13,500	$13,500	$13,500	$13,500	$13,500
Cents per 1,000	0.930	0.815	0.705	0.637	0.542	0.480	0.430	0.383	0.383
Pumping pressure, pounds per square inch	4.5	5.75	7.5	9.5	11.5	14.5	16.5	19.0	24.0
Horse-power per 1,000	0.3	0.372	0.467	0.572	0.676	0.813	0.9	1.0	1.2
Cost pumping per 1,000 at 3/4¢ per horse-power	0.225	0.278	0.35	0.43	0.507	0.61	0.675	0.75	0.90
Cost pumping per annum	3,262	4,600	6,700	9,550	12,600	17,150	21,100	26,400	36,500
Total cost per annum one 16-inch line	$16,762	$18,100	$20,200	$23,050	$26,100	$30,650	$34,600	$39,900	$50,000

pumping pressure of 16½ pounds, it would be economical to relay the transmission line. A chart and curve showing the calculations, are given below.



Gas Compressors.

The two compressors are duplex cross compound rolling mills Corliss units, manufactured by the Laidlow, Dunn, Gordon Company of Cincinnati, Ohio, and have a displacement of 5,600 cubic feet per minute, at 106 revolutions per minute, which is equivalent to an actual guaranteed capacity of 5,200 cubic feet at 94 per cent. volumetric efficiency at a mean pressure of 11 pounds. The high pressure steam cylinder is 13 inches in diameter, the low pressure cylinder 25 inches; the gas cylinders 31 inches in diameter and the common stroke is 30 inches. Both compressors are equipped for lubrication, with central glass oil reservoir, which is connected to the various lubricating points by brass piping and furnished with sight feed oilers. A governor is installed on the main steam connections and relief valves on the steam cylinders.

The foundation for each compressor consists of a concrete block 14 feet 6 inches by 24 feet 1 inch, in plan, and which extends below the basement floor.

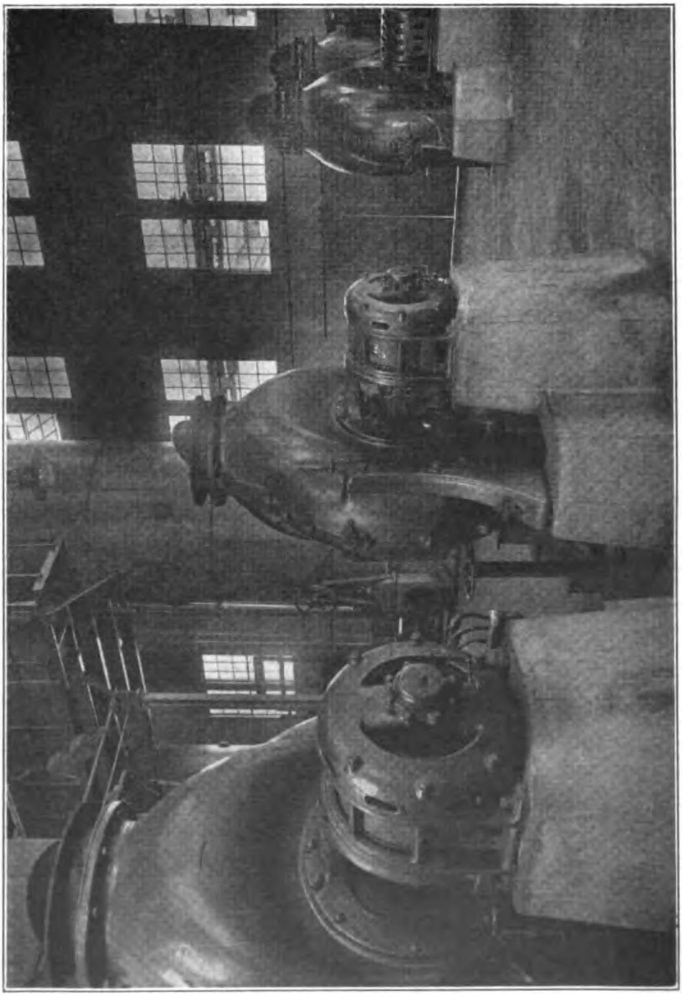
The compressors are arranged to be operated either condensing or non-condensing. Each is equipped with a Worthington cylindrical condenser having 600 square feet of cooling surface and a single horizontal, direct action wet vacuum pump, having cylinders of the following dimensions: 8-inch diameter steam; 12-inch diameter air and 4½-inch diameter water and a common stroke of 12 inches. The condensers have a capacity each of handling a maximum of 7,500 pounds of steam per hour, when provided with 500 gallons of water per minute at 65° F. and the pumps, of displacing 50 cubic feet per minute at 45 strokes, or maintaining a 30-inch mercury vacuum in conjunction with the condensers. Both condensers and pumps are provided with gauges and thermometers; and the pumps with force-feed mechanical lubricating systems and other accessories for convenience in operating.

Auxiliary Equipment.

Blowers.

For furnishing air to the oil-gas generators in connection with the heating process, it was decided to discard the positive-pressure type which had heretofore been in use for that purpose and substitute for the same the fan type. The reasons for this step were numerous. They may be tabulated as follows:

1. Adaptability to the electric drive.
2. Elimination of noise.
3. Ability to shut off air flow at generators suddenly without dangerous results to the machinery or the use of uncertain relief devices.
4. Lower first cost.
5. The realization that a sufficient volume of air for combustion could be delivered in the usual manner and at equal constancy, at a considerably lower pressure than commonly employed and well within the



GENERATOR BLOWERS

limits of efficiency of a fan by the proper designing of air ports on the generators and the necessary air connections.

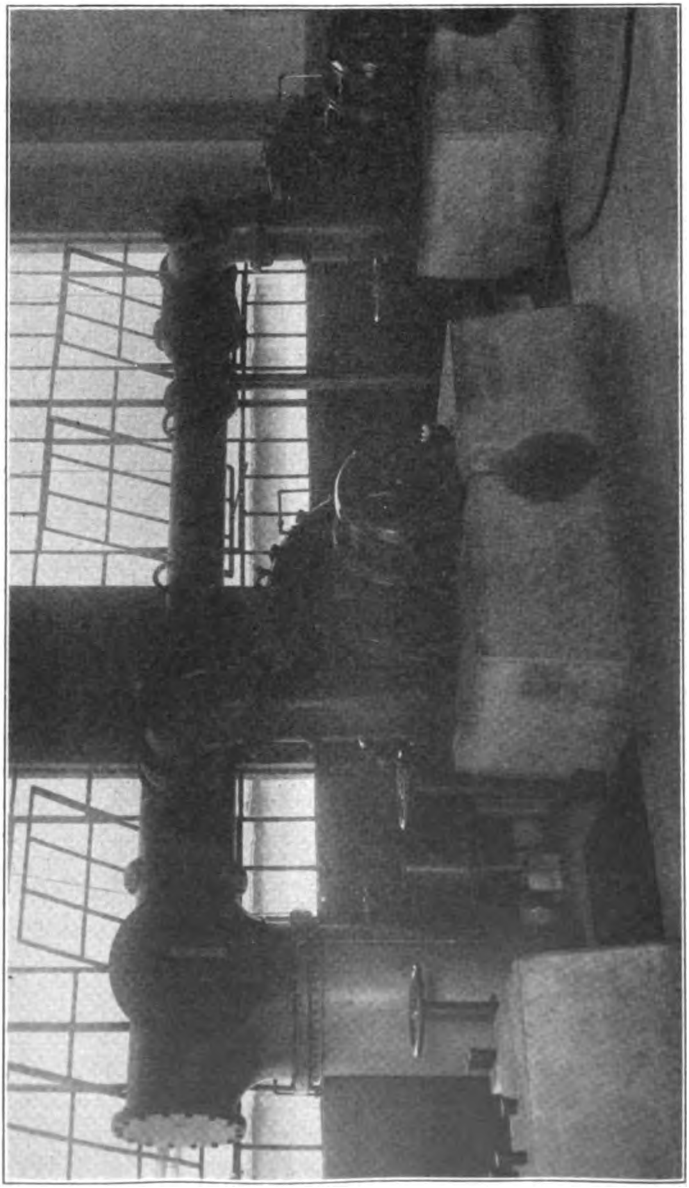
The General Electric Company having produced, about this time, their centrifugal air compressors, it was decided that this unit came nearest to realizing the advisability of compromising between the two types and was for this reason selected.

The four blowers are of the centrifugal type, two of which have a capacity each of delivering 7,200 and two each of 15,000 cubic feet of air per minute. They are manufactured by and direct connected to General Electric Company Type 12, Form K, 3,600 revolutions per minute induction motors, 50 horsepower for small blowers and 120 for large blowers. Each blower is controlled by a secondary switchboard near by and this consists of a pipe frame work, supporting the compensators, oil switches, etc.

Exhausters.

The same general comments, which have been made on the pressure type of air blowers, applies very well for the selection that was made of the exhausters. It was, however, with some misgivings that this type was installed for obvious reasons in connection with machinery of such small clearances and danger of stoppages. Our apprehensions, however, were entirely unfounded. This apparatus has operated with the most gratifying success since its installation, when it is realized that these exhausters have never been apart for cleaning in the three years since their installation. We have, on one occasion, for the purpose of easing our doubting minds, taken them apart, but this would not have been necessary.

In addition to serving the purpose for which it was installed the centrifugal exhauster has likewise achieved a conspicuous and lasting place as a final tar extractor, to the extent of rendering entirely superfluous the multiple gas washer installed as a final cleaner, immediately ahead of the purifier.



EXHAUSTERS

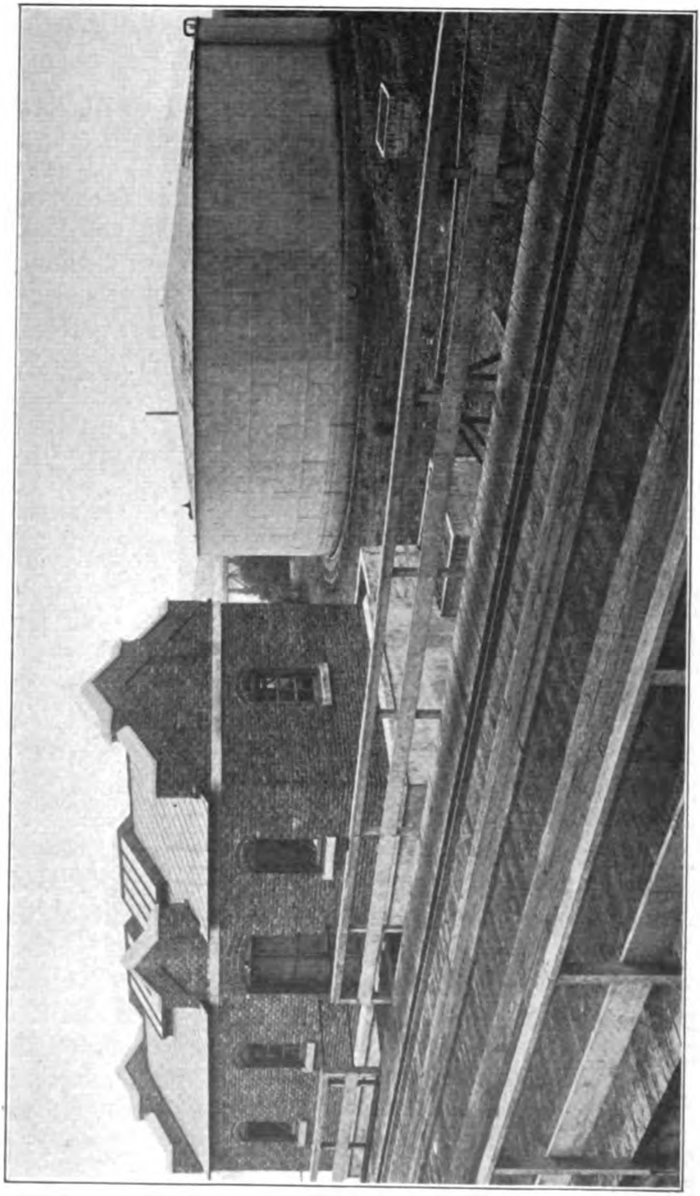
The two exhausters, which are of the General Electric Company's make, are of the centrifugal type and have a capacity each of handling 5,000 cubic feet of free gas per minute, against a normal pressure of 0.625 pound per square inch. Each is direct connected to, and mounted on same base plate with a 75 horse-power Type "I," 2-pole 3,600 revolutions per minute, 440-volt induction motor. The inlet and outlet connections are 14 inches in diameter; for cleaning purposes, while operating, connections for inserting steam for loosening the tar, have been installed, and for further cleaning and for access to the inner parts, one side of the exhauster shell is made removable.

Each exhauster is controlled from secondary switchboard located near by and this consists of a pipe frame work, supporting the compensators, oil switches, etc.

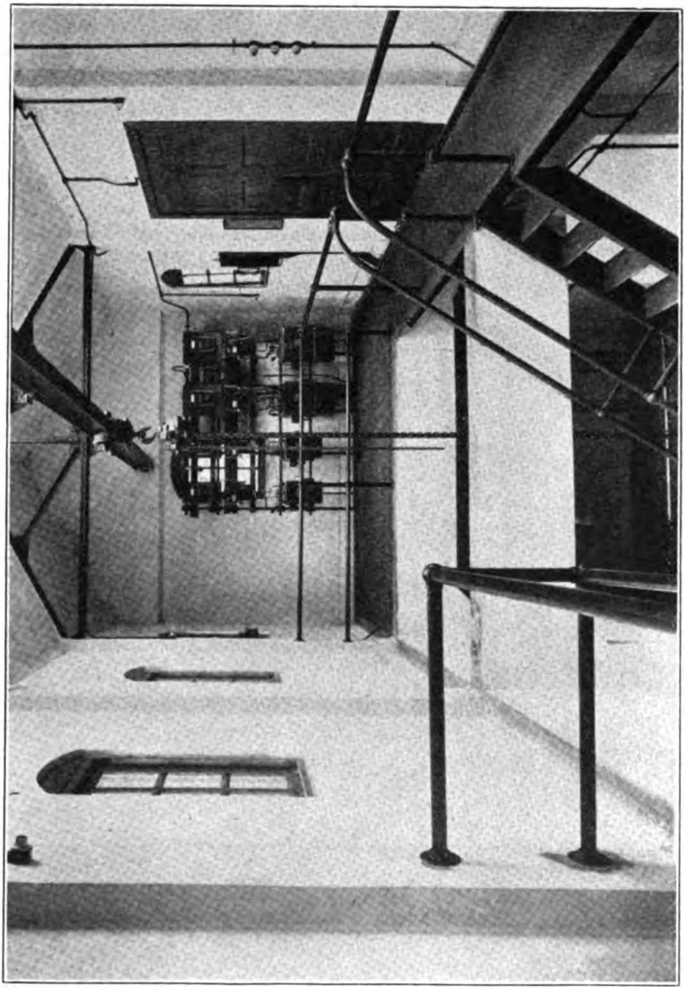
Water Pumps.

It can be easily realized from the remarks made under the description of the oil-gas process, regarding the essential necessity for the separation of carbon from tar pitch, that the water supply for an oil gas plant is the one item most deserving of attention.

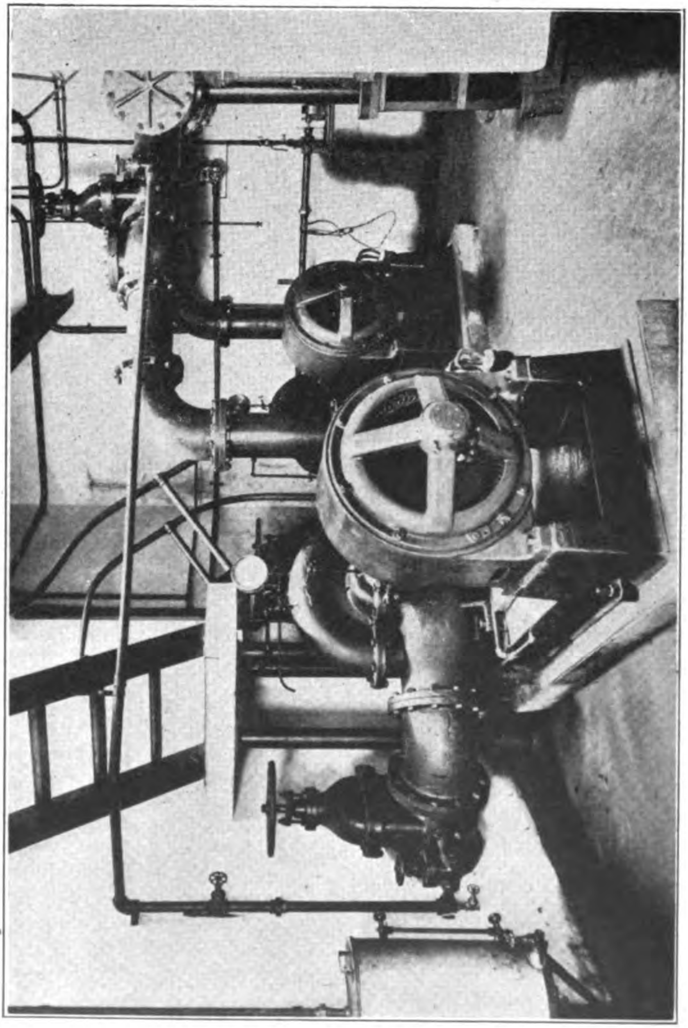
Due to experience at our old plant, located in the heart of the business district, contiguous to the mouth of sewers and subject to the flotsam and jetsam from the wholesale district, an earnest effort was made at the new plant to overcome these conditions. Studies, which were undertaken prior to the designing of the new works apparatus, showed over 75 per cent. of the stoppages in operation to be due to a failure of the water supply. The pump house, which has been elsewhere described, was located as near to the river front as the soil conditions would permit. It was necessary to anchor this building to piling and to weight same down by a heavy mass of concrete to prevent flotation at periods of high water. At the same time it was necessary to thoroughly water-proof the building, since at various seasons of the year the operating units would be at a level considerably under that of the river.



PUMPING STATION AND OIL TANK.



PUMPING STATION CONTROLLERS.



WATER PUMPS.

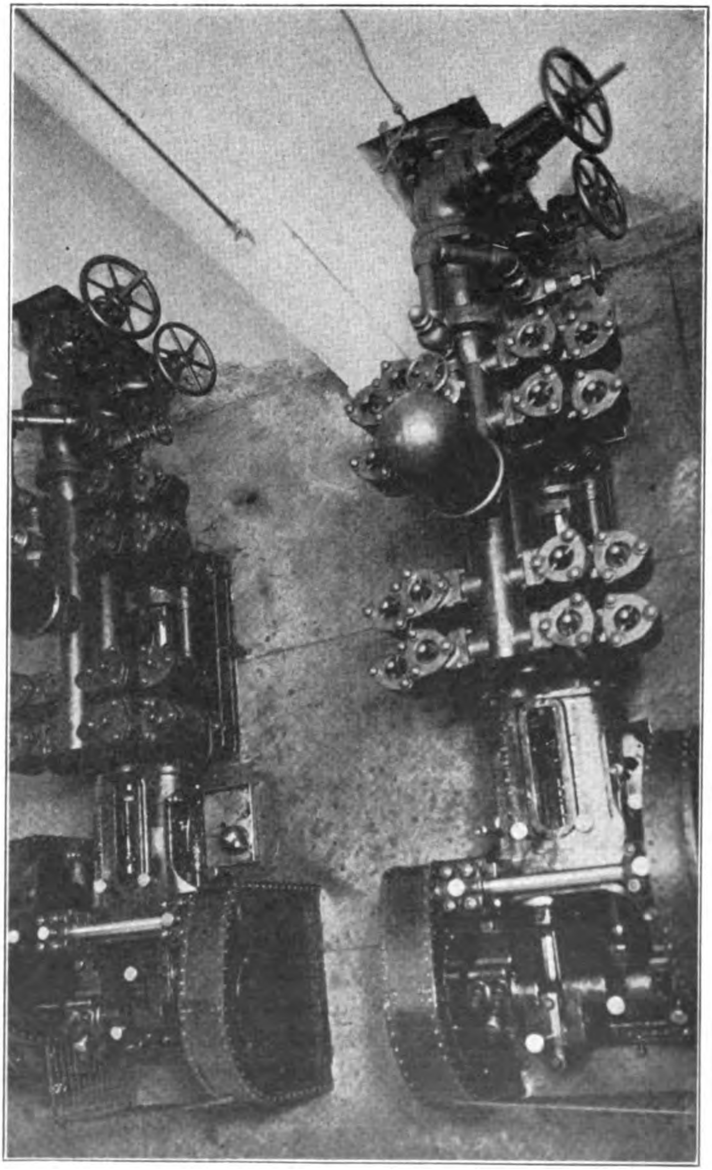
It was at once realized that a structure of this kind would be exceedingly expensive per square foot of floor space. It was, therefore, decided to double deck the machinery and likewise to locate same diagonally with respect to their suctions in order to economize space.

The lower deck was reserved for the water pumps, of which there are two installed, with room for two additional. The upper deck was for the use of the oil pumps, since the pump house is located in close proximity to the 55,000 barrel oil tank, and also because this weight of machinery insured additional stability to the building. Both stories are reached from the ground level by iron stairways and a crane pit. The latter insured easy removal of machinery and parts for repairs and consists of an I-beam at ground level, carrying chain blocks and trolley. Second, of an I-beam on the basement floor with a similar trolley. This second beam is hinged in such a manner that it can be swung to one side after the weight has been taken up by the upper chain blocks, to allow egress of the machinery.

The circulating water required for the condensers, scrubbers and other machinery about the plant is furnished by two 10-inch Jeanesville double suction volute pumps, located in the pump house. They are equipped with bronze impellers and each is direct connected by means of a flexible coupling to a 100 horse-power, Form K, Type "I"-6, 440-volt, 1,200 revolutions per minute, alternating-current electric motor.

Oil Pumps.

For supplying fuel oil for the gas generators and boilers, in the pump house are installed 4-inch by 12-inch duplex oil pumps, as made by the Dean Steam Pump Works. These have cylinders of the plunger valve pattern and parts exposed to pressure are subdivided as much as possible in order to overcome the necessity of replacing the entire parts. The pumps are each gear connected to one 10 horse-power, Type "I"-8, Form K, 900 revolutions per minute, 440-volt, alternating-current motor, and are equipped with gear covers, lubricators and other accessories.



OIL PUMPS.

Sump Pump.

In the pump house for removing the drips, drains, condensation and other leakages, a 1-pound centrifugal pump, as made by the Henry R. Worthington Company, and having a capacity of delivering 50 gallons of water per minute, is installed. It is direct connected to a 1 horse-power, Form "C," Type K. T. 4, 440-volt, 1,800 revolutions per minute electric motor, and is arranged to operate automatically with a float valve and switch.

Oil Storage Tank.

The oil storage tank is 116 feet 6 inches in diameter and 30 feet in height and has a capacity of 55,000 barrels. It is constructed of steel plates ranging from 3/16 inch to 9/16 inch in thickness and is provided with a roof of No. 22 gauge steel, which is supported by wooden columns, rafters and sheathing from the inside. It is equipped with 16-inch diameter swing pipe, which is operated by hand winch for the pump section and a 10-inch pipe line entering through the top, admits the oil from the steamers. A steel ladder gives access to the roof and a gauge consisting of glass tubes, vernier and scale, is installed for measuring the oil.

The foundation consists of a concrete mat 18 inches in thickness at the center and 24 inches around the outside. It extends beyond the steel work a distance of 5 feet 9 inches, entirely around the tank, and provisions, consisting of steel tie rods, extending up around the outer edge, has been made for the future installation of a concrete wall around the tank, as a precaution in case of leakage of the tank shell or piping connections thereto. As the tank rests on the low ground outside of the bulkhead, where it is surrounded by water during the high water season, in order to take care of any settlement or washing out of the sand and in event of installing a concrete wall to prevent the tank wall and foundation from being floated away, 470–40-foot piles were driven and these were securely fastened to the concrete mat by means of steel anchor bolts and tie rods.

One hundred eighty-six 40-foot piles have also been driven for the future installation of a 15,000 barrel oil tank, which is now at the old works, but the concrete for the foundation has not been placed as yet.

Water Tank.

The water tank, which has a capacity of 100,000 gallons, is erected on a steel tower, 50 feet in height. It is 28 feet 8 inches in diameter and 16 feet high, and is arranged with eliptical bottom and 3-foot diameter settling drum, extending to the ground. The tank is constructed of steel plates ¼ and 5/16 inches in thickness and has a conical roof of ⅛-inch plates, supported on steel framing. The tower consists of 12-inch channel columns, securely braced with struts and diagonal tie rods.

A steel spiral stairway, having ornamental iron hand rails and winding around the mud drum, gives access to a balcony with similar hand rail, which extends entirely around the bottom and, to prevent the tank from becoming full to overflowing, a 20-inch diameter overflow pipe has been installed. The water inlet pipe is also 20 inches in diameter and extends up into the mud drum a distance of about 5 feet, thus forming a settling basin around the pipe and for draining off the mud, a 6-inch diameter blow-off valve, with connection to sewer, has been provided.

The foundation consists of five concrete piers, one for each of the four columns and one on which the mud drum rests. These piers extend into the ground a distance of 6 feet and are 13 feet square at the base.

WORKS CONNECTIONS.

The large gas piping connections from the generators to the relief holder are 42 inches in diameter. From there to the exhausters, 36 inches and 30 inches to the purifiers, storage holder and compressors. Overhead piping is made of riveted steel and underground work is hub and spigot cast-iron with lead joints, and all of same has been tested with an air pressure of 50 pounds per square inch.

Oil Piping.

The oil line from the dock to the oil storage tank is 10 inches in diameter, at the dock connections are arranged so that the vessels can unload the oil at any stage of the river. From the tank to the pump house, the line is 16 inches in diameter, made of outside diameter tubing, having welded joints and branches from this consist of standard pipe and fittings. All high pressure oil piping is built for a working pressure of 250 pounds and have been tested to 300 pounds hydrostatic pressure.

All oil pipe lines under ground are covered with burlap and asphaltum and lines for hot oil have two layers of 85 per cent. magnesia pipe covering.

Water Piping.

The water main line from the pump house to the condensers and water tank is 20 inches in diameter. Branches from this extends to all buildings and machinery and also to twelve fire hydrants, distributed about the plant. Water lines outside of the buildings, consist of steel outside diameter tubing connected together with couplings, made by the S. R. Dresser Manufacturing Company. All water lines are built for and tested to a hydrostatic pressure of 125 pounds per square inch.

Tar Piping.

From each primary and secondary tar box a 6-pound pipe connection with gate valve is made and these are connected to an 8-inch main header, which extends to the tar pumps. From there a 6-inch line runs to the tar storage tank and a 4-inch line thence to the briquetting plant. All tar lines are designed for a working pressure of 125 pounds per square inch.

Power Plant.

Under consideration for a prime mover, were the following:

1. Steam.
2. Steam-electric.
3. Gas.
4. Gas-electric.
5. Oil.

Steam.—On account of the small size of the various units, which would not permit the use of high efficiency engines, and would necessitate long and scattered steam mains, no consideration was given to the individual steam drive.

Steam-Electric.—Involved the substitution of motor-drive for steam-drive, around the plant and a generation of current in situ from oil-fired steam boilers. This method was finally selected on account of cheapness of cost of construction and operation and flexibility.

Gas.—The individual gas-drive was not considered for the same reasons as the individual steam-drive.

Gas-Electric.—This form of drive presented the most powerful inducements. It was felt and is still by this company that the gas-electric-drive together with utilization of the exhaust heat for the production of steam, will eventually, by the high combined thermal efficiency, be adopted as the logical source of power for a central station gas plant. Unfortunately at the time this question was being considered and possibly even yet, sufficient practical progress had not yet been made in the utilization of exhaust heat for a plant of this size to be designed on other than experimental lines. Reluctantly, therefore, other prime movers were considered.

Oil Engines.—Diesel oil engines were given very considerable attention as a source of power, principally as on account of very low operating expense, construction costs were, however, at this time so high as to bar consideration of this type. Investment charges more than offset the operating economy. Moreover, the oil engine had not yet settled down to a standard design or a high degree of operating reliability.

Prime mover	Cost of install.	Annual opr. exp.	Per K. W. Hr.	Fixed Charges @ 15 %	Total apr. cost	Per K. W. Hr.
Steam-electric	62,900	3,066,000 K.W.HR. 22,085	0.72	9,435.00	31,520	1.027
Gas-electric	82,000	24,590	0.80	12,300.00	36,890	1.20
Oil-electric	135,200	11,172	0.38	27,040.00	38,212	1.24

Description of Steam-Electric Plant.—The units as finally selected were of such capacity that a single unit would serve the present and near future requirements for a gas plant of 7,500,000 cubic feet daily capacity and that by the future addition of a third unit, space for which was allowed, the capacity of the plant could be doubled without expensive alterations to buildings and equipment.

The schedule on the next page gives the principal data for the apparatus selected.

	Estimated	Actual
Current generated, kilowatt hours........	3,066,000	3,176,736
Operating expense	$22,085.00	$14,926.00
Per kilowatt hour, mills..................	7.2	4.7
Kilowatt hours per barrel oil.............	180.0	228.0
Load factor, per cent.....................	60	58

The preliminary estimates were considerably exceeded in the final selection of units and auxiliaries.

No expense was spared to make the power plant complete and efficient. The final result was that operating costs were 35 per cent. lower than estimated.

Utilization of Power.—A comparison is possible of the operating efficiencies of the various units by separate house type electric meters. At the present writing not all of the work performed is regularly measured, but this will be done at an early date. This applies particularly to the measurement of air and water.

All of the apparatus operating on gas, oil and steam are metered in such a manner as to afford daily and monthly quantity measurements, which taken together with measurements for electric current afford indications of the working efficiency of the various units which have been of invaluable assistance in the new plant.

The totalization of the individual meters is of great assistance in locating line losses in comparison with switchboard meters.

It is noteworthy that power unaccounted for, habitually amounts to less than 2 per cent.

The total energy consumed in the manufacture of gas, exclusive of that used for briquetting or transmission, is 1.9 kilowatt hours per 100 cubic feet of gas.

Schedule of Power Plant Equipment.

Number	Equipment	Kind	Size	Operating Condition
2	Turbo-Generators	Curtis Horizontal	500 K. W.	480 volts, 3 phase, 60 cycle, 3,600 RPM Gen. Elect. Co.
1	Turbo-Exciter	Type C. C.	35 K. W.	125 " 2 poles, 280 Amp. 3,600 " " " "
1	Motor Gen. Exciter	Motor Type 1	50 H. P.	400 " 3 phase, 60 cycle 1,200 " " " "
		Gen. Type DLC	35 K. W.	125 " 4 poles, 280 Amp. 1,200 " " " "
1	Switchboard		12 Panel	T. A. Regulator " " "
2	Condensers	Surface	1,635 sq. ft.	Utilizing water supply to Gas Gen. H. R. Worthington
2	Pumps	Vacuum	8"x14"x18"	29 1/2" Vacuum " "
2	Pumps	Hot Well Duplex	6"x7 1/2"x6"	" "
2	Pumps	Vertical Duplex Piston	10"x7"x10"	Utilizing superheated steam " "
1	Heater	Vacuum feed water	2,000 H. P.	Utilizing exhaust steam Blake-Knowles
2	Boilers	Horizontal Water Tube	300 H. P.	200 lb., pressure 100 deg. super heat Babcock & Wilcox

Briquetting.

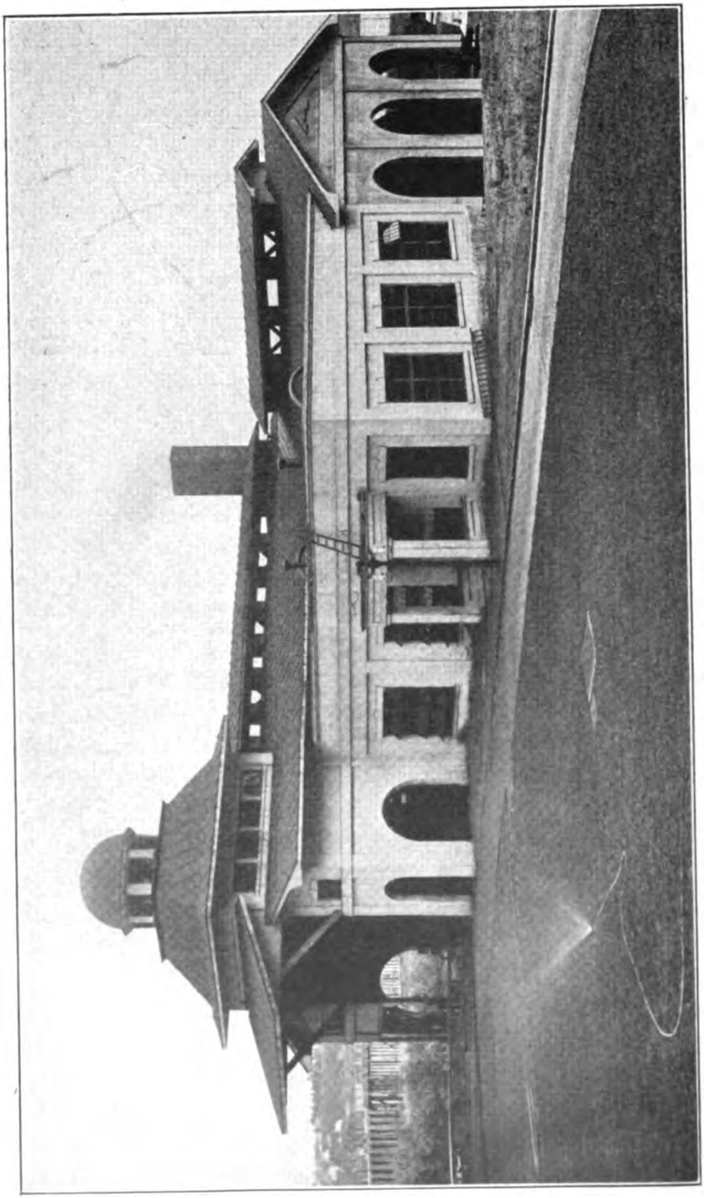
In the manufacture of illuminating gas from crude oils produced on the Pacific Coast, a quantity of very pure carbon is practically the only residue. The amount of the carbon varies from 20 to 30 pounds per 1,000 feet of gas made, or is equivalent to 2 to 3 pounds per gallon of crude oil used.

This carbon is deposited in a partly amorphous and partly graphitic form during the process of cleansing and washing the gas. It can be recovered in the wash water, which contains from 1 to 2 per cent. by weight of lampblack.

In early history of gas making, this carbon was allowed to settle out in large vats, whence it was shoveled out by hand labor. The art was subsequently improved by the use of filters, consisting of a rectangular tank containing the lampblack water, in which revolves a wooden cylinder constructed in various sizes from 10 to 16 feet in diameter, the axis of which is horizontal, and the two ends of which are open. The drum is constructed of fir or redwood staves which are pierced radially by pipes acting as spokes, which are in turn connected with a hollow trunnion.

The exterior of the cylinder is covered with wooden strips dividing the surface into sections, covered with galvanized iron mesh and several layers of burlap and duck canvas, the whole being tightly wound with galvanized wire wound on spirally with the strands about 1 inch apart. The trunnions are fitted with automatic valves, which alternately make contact with compressed air ports and vacuum ports, which communicate to tank receivers. These tanks are connected at the bottom to centrifugal water pumps, and at the top to ordinary vacuum pumps.

The operation of the apparatus is as follows: That portion of the drum which is submerged is in communication with the vacuum ports. The section draws through the canvas large quantities of water, leaving on the exterior of the canvas the suspended lampblack. As the drum emerges from the water, the vacuum connection is continued; but air penetrates through



BRIQUETTE PLANT.

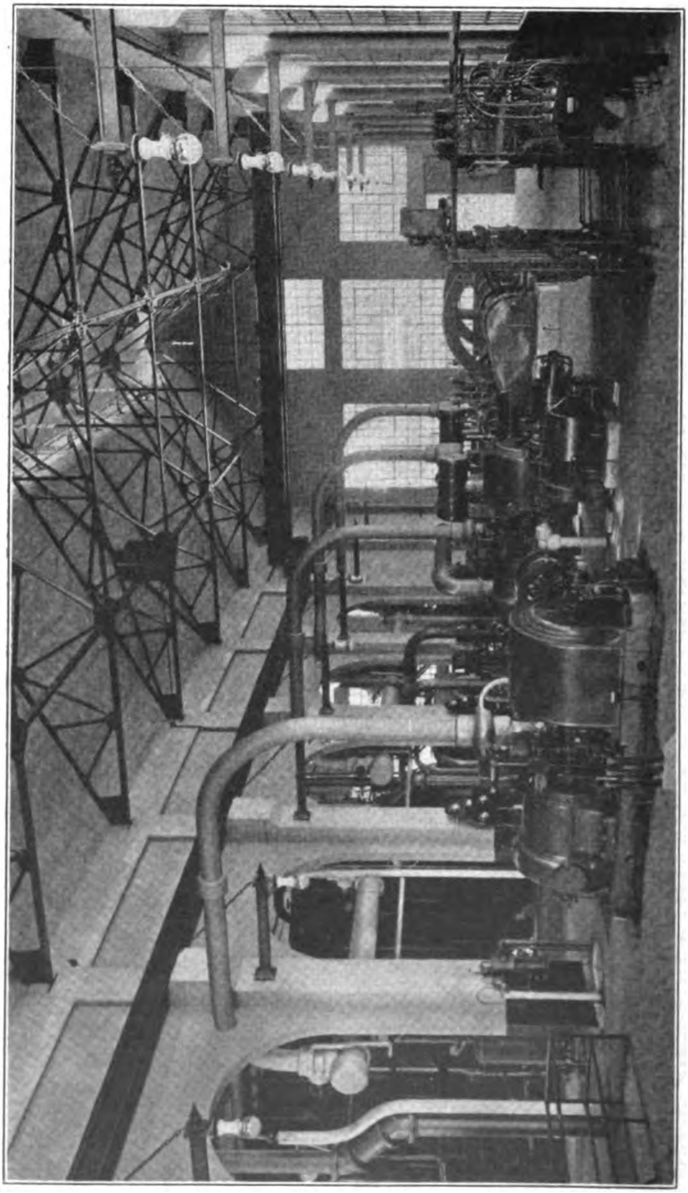
the lampblack and partially dries it. Then a further turning of the wheel breaks the connection with the vacuum ports and makes the connection with the compressed air ports, which happens just before the drum is about to submerge itself again. At this point the drum is in contact with a sheet-iron scraper, resting lightly on the surface of the wires. Through the combined action of the air blast and the scrapers the lampblack is removed from the surface of the drum.

There are four units of the type at the Portland Gas & Coke Company's plant, each 16 feet in diameter, and having a capacity of 1,000 gallons of water per minute. The units are motor driven and placed two on each side of a 36-inch belt conveyor onto which the scrapers discharge. The belt conveyor passes immediately in front of two 50-ton rotary driers provided with worm feed and plow shaped scrapers resting on the conveyor belt. The vats which contain the lampblack water are made of reinforced concrete.

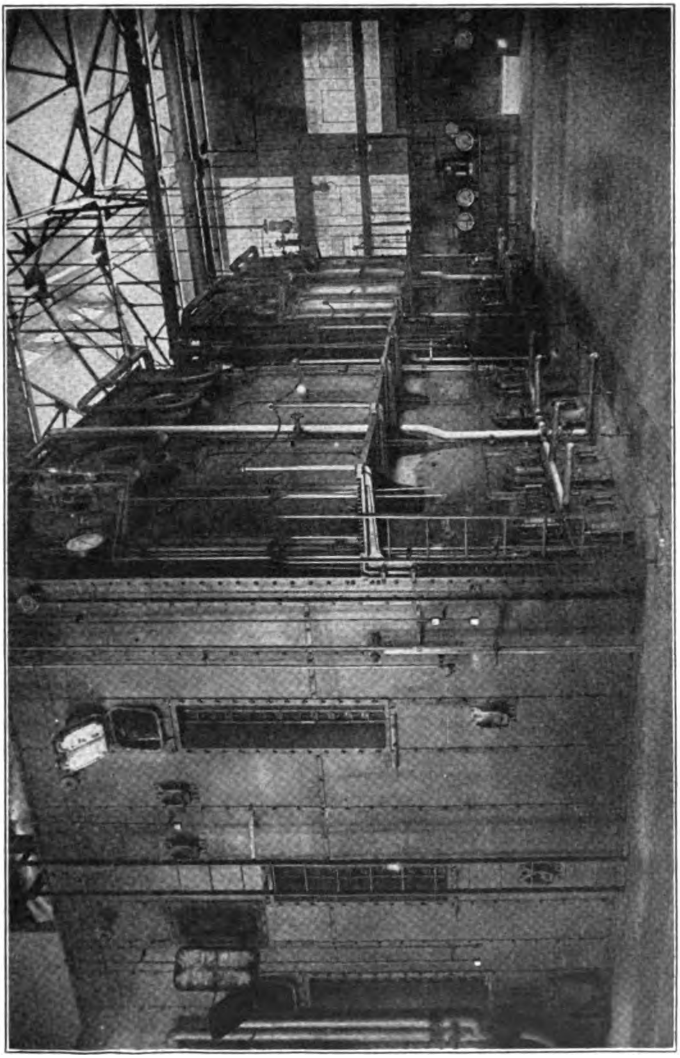
The driers are similar to rotary cement kilns. They are provided at the front, immediately under the feeds with Dutch-oven furnaces for firing with wood, and with 60-inch exhaust fans running at 900 revolutions per minute, handling about 12,000 feet of air per minute, and connected likewise at the front of the drier, the front plate of which makes a sliding contact with the drum. The drum is set on a slight incline, and the progress of the lampblack is from front to rear, where it is discharged by gravity. The path of the fuel gas is under and around the drums, entering at the rear and passing through the drum into the fan duct at the front.

Both driers feed into a single bucket elevator, discharging into an overhead hopper, which is supported directly on the frame work of a 50-mould briquette press, designed especially for the briquetting of lampblack. The press operates at about 7 revolutions per minute, producing about 50 briquettes per revolution.

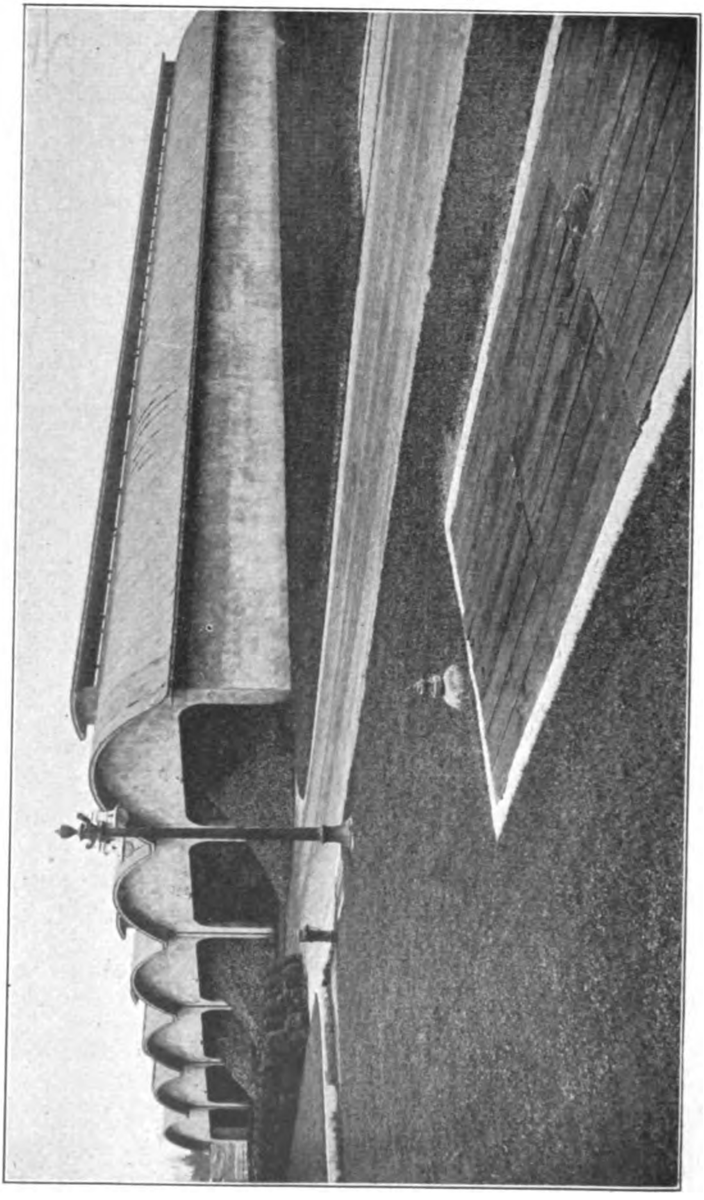
The press consists of a bronze mould board containing 50 moulds, 2¼ inches in diameter, which is fitted to receive top and bottom plungers actuated by cams and connected by means



POWER PLANT.



BOILER ROOM.



BRIQUETTE STORAGE SHEDS.

of a set of gears and clutch to a 35 horse-power motor. Compression of briquettes is by means of simultaneous action of top and bottom plungers. The filling and discharge of the moulds is accomplished by means of a reciprocating horizontal mould board, continuously fed with lampblack from the overhead hopper.

The briquettes as produced are discharged immediately onto a short rubber belt conveyor, gear driven from the press itself, and discharging onto a system of unit conveyors for the purpose of storage.

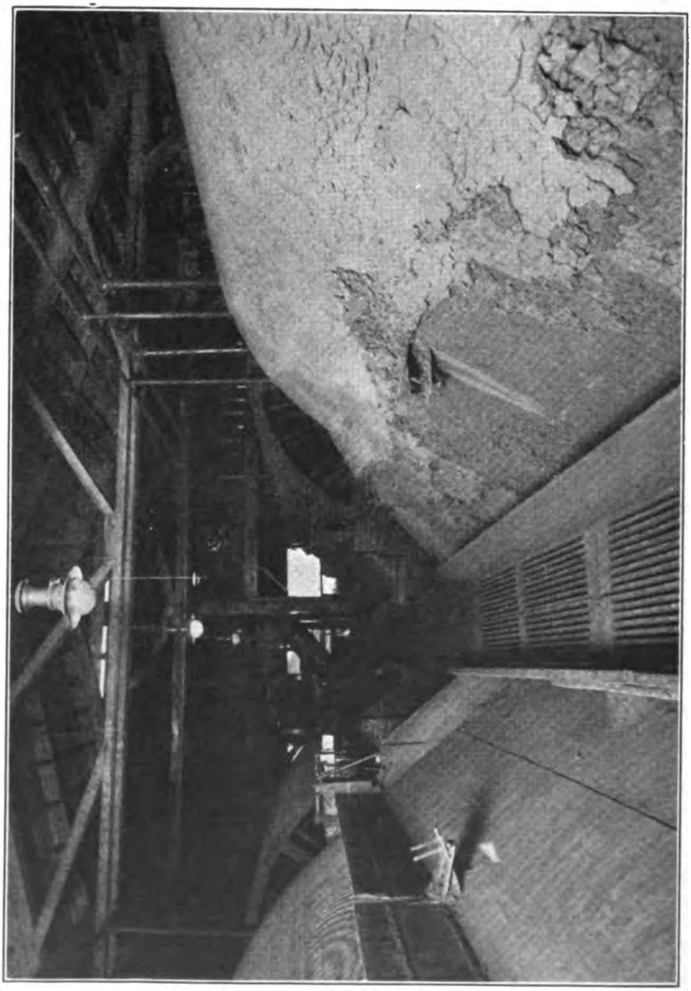
They consist of 12 sectional conveyors, each equipped with its individual motor, and overlapping end to end. The last one in series is known as a stacker, and consists of a belt conveyor operated at a steep angle, and which may be lowered or raised or moved from side to side as desired.

The process of briquetting is as follows: The lampblack as recovered on the wheel is dried to a percentage varying from 45 to 52 per cent. of moisture. The material is continuously recovered on the wheel is dried to a percentage varying from gas plant, there being no storage provided for the carbon water; in other words, the carbon water is treated as fast as the gas is made.

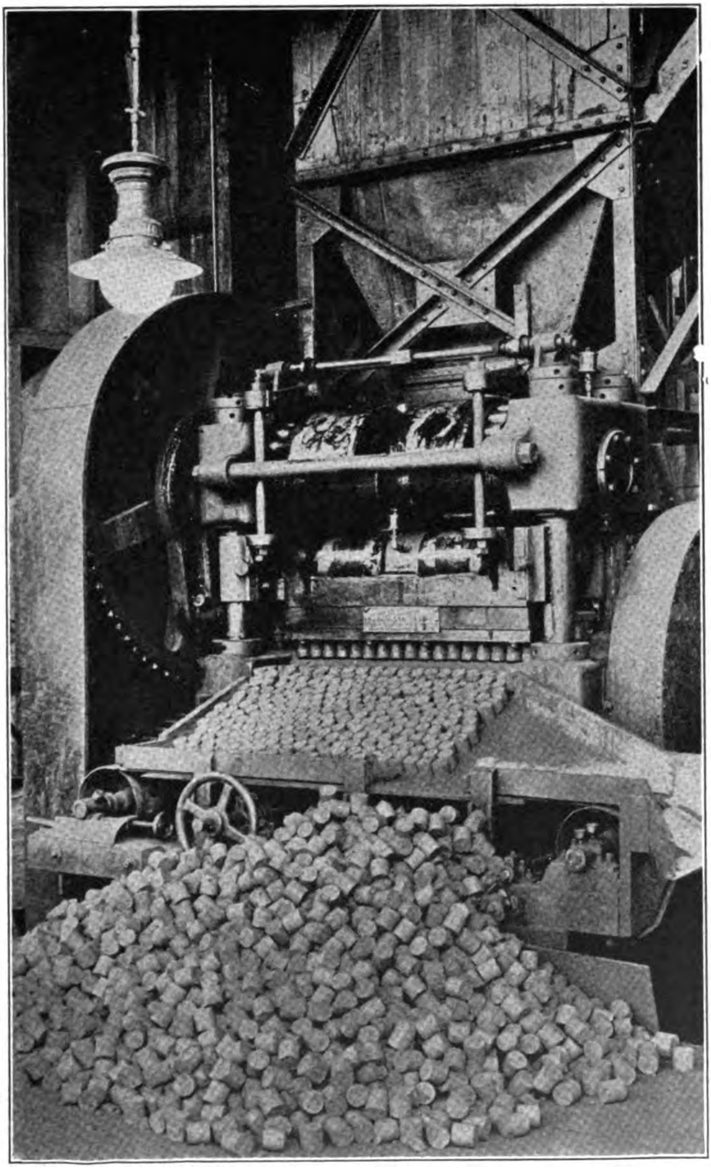
The gas works has a present capacity of 50 to 75 tons of carbon per day. This quantity is continuously discharged onto either one or two driers and dried to a moisture content of from 12 to 15 per cent. No binder is used, since the volatile matter naturally present in lampblack, which is of a tarry nature, is sufficient for this purpose.

Continuous Process.

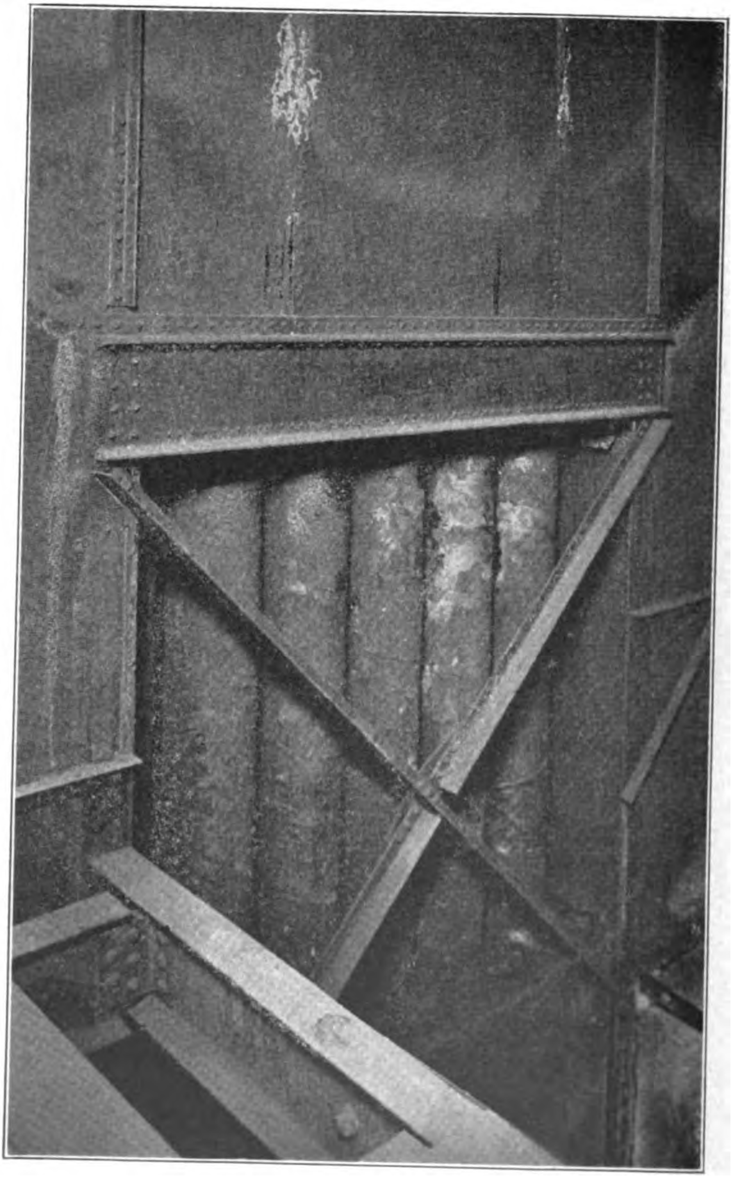
The drying, unfortunately, is accompanied by a certain amount of yellow smoke, consisting mainly of hydrocarbons of a tarry nature. This smoke is of a very persistent nature, and at one time brought complaints from adjoining property owners. The smoke is not susceptible to being treated or washed in a similar manner as chemical fumes, since it is not



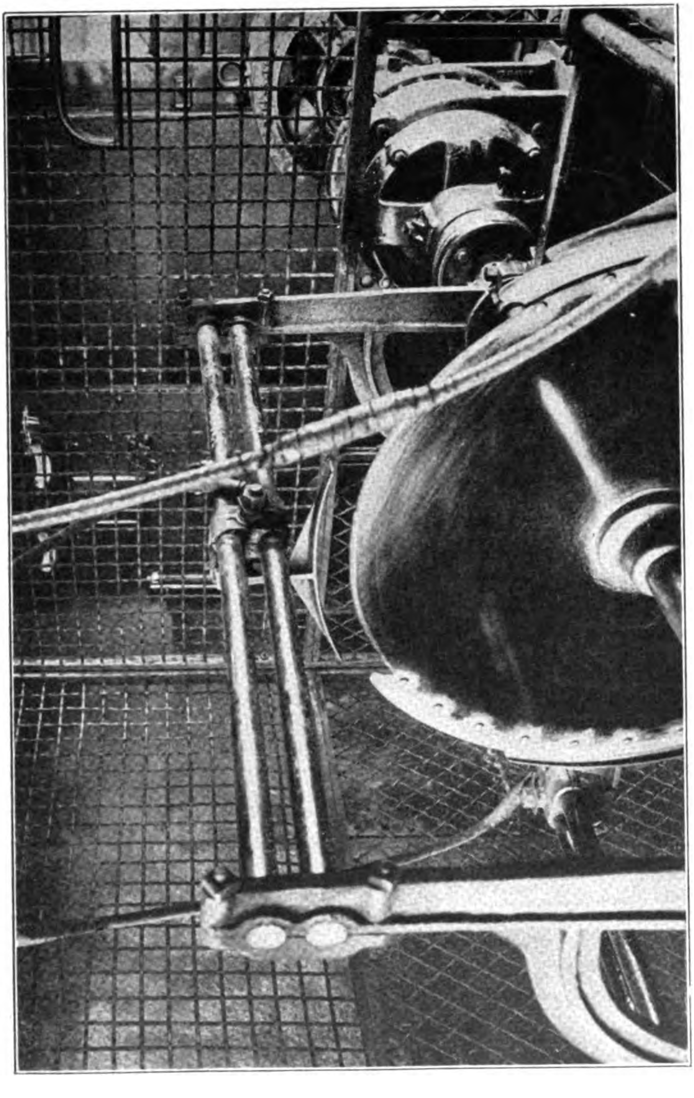
FILTER WHEELS.



BRIQUETTE PRESS.



SMOKE TREATER.



APPARATUS FOR RECTIFYING HIGH TENSION CURRENT.

soluble and is present in a vesicular or fog form. After considerable experimentation, the problem of obviating this nuisance was accomplished by treating the smoke by high potential electric discharges, in a similar manner as the Cottrell process used in treating smelter fumes. But little power is required for this purpose, and the results are remarkable.

The dried lampblack is continuously discharged from the conveyors and continuously briquetted. The hopper over the press has a storage capacity equal to about 1 hour's run, which is sufficient for the ordinary attention to the press. The briquettes produced are cylindrical in form and 2¼ inches high. They are quite hard and will bear considerable handling. Owing to the irregularities of operation, etc., there is at times considerable dust produced, and for this reason, all briquettes are screened before selling. Inasmuch as the briquettes are pressed with a very low percentage of moisture, extensive drying or curing is not needed before selling, a couple of weeks being ample time for this purpose, at which time the moisture content has been reduced by evaporation to 5 or 8 per cent.

Same Price as Coal.

Briquettes are at present delivered by trucks to all parts of Portland, and, inasmuch as the gas plant is located about 7 miles down the Willamette River from the center of the city, the expense for transportation is quite an item. The briquettes are sold on a sliding scale, ranging from $7.00 to $9.50 per ton, with a 50 cent reduction in the summer months. They are used for all purposes that coal is utilized, including domestic use and steam raising in apartment houses.

Operating Efficiencies.

The new plant effects a saving over the old plant approximating $45,000.00 per annum, or practically 15 per cent., accounted for principally in fuel and labor.

THE CHAIRMAN: The paper is now open for discussion. Unfortunately this paper did not reach the Secretary far enough in advance of the annual meeting, to enable us to send out advance copies and in that way secure discussion. We have one written discussion which will now be read.

MR. C. O. BOND (Philadelphia): (Written discussion communicated.) On page 361 there are given the two points kept steadily in mind in designing the Portland works, and it is to the second of these that I wish to draw attention, particularly as Mr. Hall has been so modest in statements as to his success in achieving his second aim; namely, "to eliminate what had heretofore been the principal source of complaints against the operation of a gas works, namely, soot, dirt, smoke, cinders, etc., together with the untidy appearance of things and the gloomy, grimy and ugly buildings."

The photographs give some impression of the architecture, and natural setting of the buildings, and the plans give an accurate idea of the arrangement and relation of the buildings and apparatus one to the other; but these cannot adequately voice the impression that a visitor gets who has come with the idea of seeing the usual gas plant.

The telltale trail of smoke is missing as one approaches; the idea occurs that possibly the plant is shut down, but if so the coke or rather briquette business is moving briskly, for truck after truck of these motor by on the way to Portland. A nearer approach brings a high singing sound; this is found to come from the high speed fans and motors. Every expenditure of energy is applied as needed and for a specific purpose, and a separate meter records it. The results come in every morning and the energy rquired for each operation is known. No wonder less than 2 per cent. is unaccounted for!

I do not remember seeing another plant where the power room could use its ceiling for indirect gas lighting as is partially done here.

The sense of cleanliness and orderliness gets into the blood and temperament. There is a constant challenge whenever a new piece of work is to do, that it also shall be done not in *a* way but in *the* way which has become habitual in the environment. If a machine can do it then develop or obtain the machine, and get as much as possible of the operation automatic. The small number of men about is noted

After a trip over the entire plant with increasing elation over the fact that "*it can be done in a cleanly way*" your faith wavers and one more question forced by habit comes to the surface, "Won't you now show me the dump?" The host looks at you queerly with something of commiseration in his face and says, "Yes, but can you not understand, there *is no* dump!" And it is a fact. You cannot find it underground nor on the surface, nor in the air. *It is a clean plant.*

In the effect which it has wrought on the morale of a plant do I find a chief benefit flowing from this particular attention paid to design and operation. I take off my hat to the medicine man of Portland whose treatment does one good.

Upon motion, a vote of thanks was adopted for Mr. Hall's paper.

The Chairman: We will go to the next paper, the report of the Committee on Standard Tests, presented by Dr Wing.

Dr. J. F. Wing (Everett, Mass.): Mr. Chairman, remarks made here yesterday would well serve as a preface of this report.

(Dr. Wing abstracted the printed report of Committee on Standard Tests.)

REPORT OF THE COMMITTEE ON STANDARD TESTS.

It has been the task of this Committee to comply with an insistent demand for comparable or uniform methods of stating the results of testing or, more broadly, the results of operating a manufacturing unit or plant. The object of this standardization is to facilitate the study of the efficiency of