BEFORE THE

WASHINGTON UTILITIES & TRANSPORTATION COMMISSION

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GENERAL RATE APPLICATION

OF

NORTHWEST NATURAL GAS COMPANY

December 31, 2018

Direct Exhibit of Andrew C. Middleton

ENVIROMENTAL MITIGATION HISTORY

Exh. ACM-9

THE GAS INDUSTRY IN STATE OF WASHINGTON

By

Bliss G. Sinclair
Assistant Chief Engineer
Department of Public Service
State of Washington

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THE GAS INDUSTRY IN THE STATE OF WASHINGTON

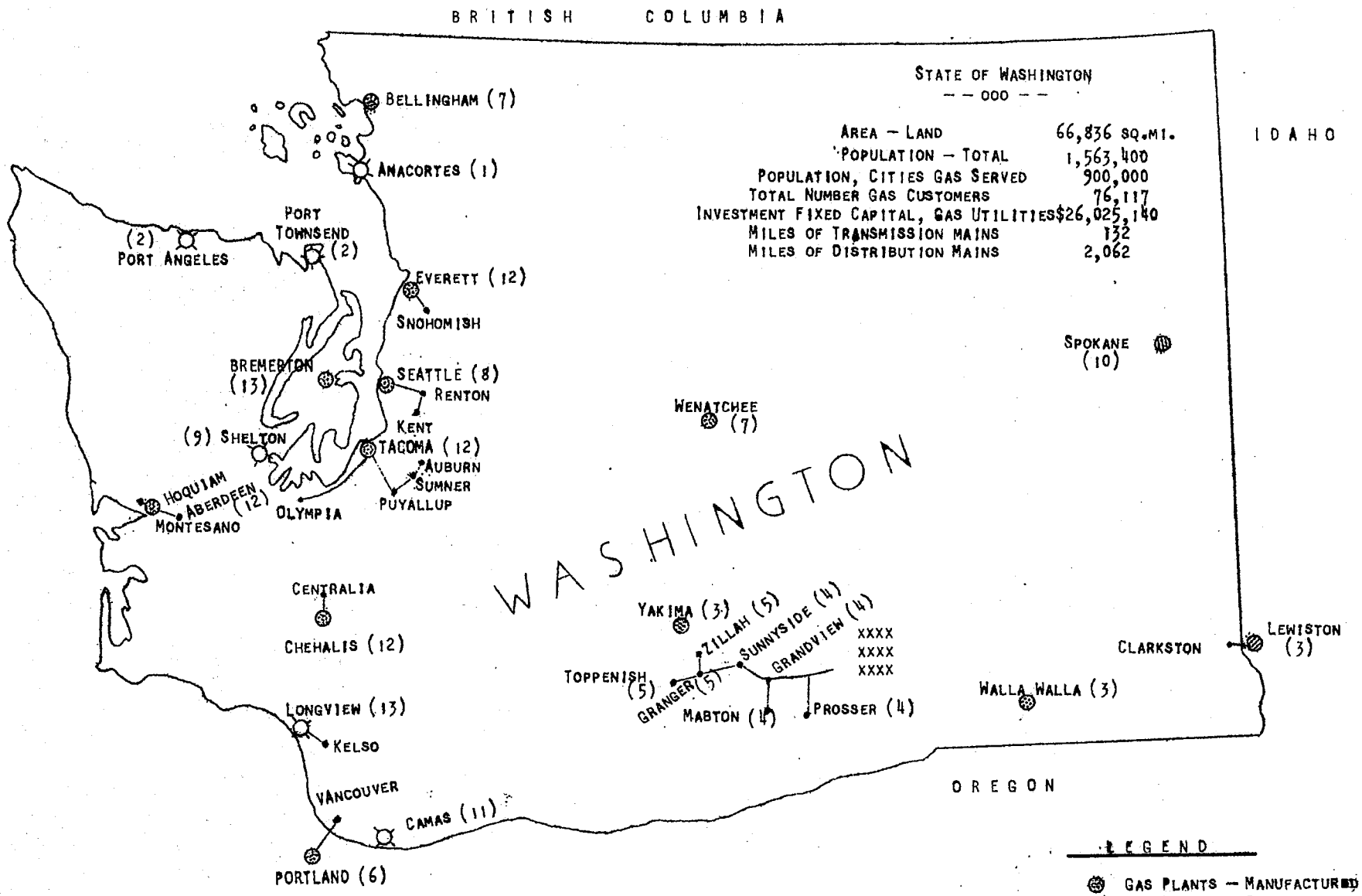
Washington is the 19th State in the Union, having a population according to the 1930 Census of 1,563,400 and having a land area of 66,836 square miles. The cities that are served by gas utilities have a population of over 900,000; in other words, 58% of the population of the State have gas service available. The total number of customers served by the gas utilities at the end of 1938 was 76,117.

Three types of gas are furnished, namely, manufactured, butane-air, and natural. There are seven companies operating thirteen plants that furnish manufactured gas, two of the plants being located outside of the State. There are also seven companies that furnish butane-air gas from seven isolated plants. Two natural gas companies obtain their supply from the same gas fields which are located within the State. Of all the gas sold in Washington in 1938, 94% was manufactured, nearly 2% butane-air, and over 4% natural gas.

The principal source of natural gas is located in south central Washington. The field is of basaltic formation that is more or less porous, permitting the gas which is predominantly methane of about 900 B.T.U., to permeate the lava cap. Thirteen wells have been drilled to a depth of 800 feet. The initial pressure in 1929 was 23 ounces; however, the supply has diminished to where the operating vacuum is approximately 175 ounces. Further development of this field is difficult because of the high cost of drilling in the extremely hard basaltic formation. A deep test well is being drilled and is down to a depth of 3,660 feet but is not yet below the basalt.

There are a number of promotions of natural gas fields in other parts of the State where seepage of both gas and oil has been encountered, but they have not proven commercial producers.

The operating utilities and the location of their plants and transmission mains are shown on the accompanying map, Plate I.



STATE OF WASHINGTON

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AREA — LAND	66,836 SQ.MI.
POPULATION — TOTAL	1,563,400
POPULATION, CITIES GAS SERVED	900,000
TOTAL NUMBER GAS CUSTOMERS	76,117
INVESTMENT FIXED CAPITAL, GAS UTILITIES	$26,025,140
MILES OF TRANSMISSION MAINS	132
MILES OF DISTRIBUTION MAINS	2,062

(1) ANACORTES GAS CO.
(2) NATURAL GAS CORP. OF WASH.
(3) NORTHWEST CITIES GAS CO.
(4) NORTHWESTERN NATURAL GAS CO.
(5) NORTHWESTERN NATURAL GAS CORP.
(6) PORTLAND GAS & COKE CO.
(7) PUGET SOUND POWER & LT. CO.
(8) SEATTLE GAS COMPANY
(9) SHELTON GAS COMPANY
(10) SPOKANE GAS & FUEL CO.
(11) UNITED GAS COMPANY
(12) WASHINGTON GAS & ELEC. CO.
(13) WESTERN GAS CO. OF WASH.

LEGEND

- GAS PLANTS — MANUFACTURED
- GAS PLANTS — BUTANE
- COMMUNITIES SERVED BY TRANSMISSION MAINS.
- × NATURAL GAS FIELD

PLATE Exh. ACM-9
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The development of the gas industry in Washington has been highly competitive. The competition consists of cheap hydro-electric power. In the western part of the State there is an abundance of wood, including not only cord wood, but slab wood, mill ends, sawdust and other by-products of the lumber and wood working industry. There are also a number of coal deposits ranging from the lowest form of lignites through the bituminous to the semi-anthracite classes. All grades of oil are also available at relatively cheap prices from the Pacific Coast fields, principally California. The cheap water transportation to cities on the Coast makes this fuel a strong competitor for domestic and industrial heating purposes.

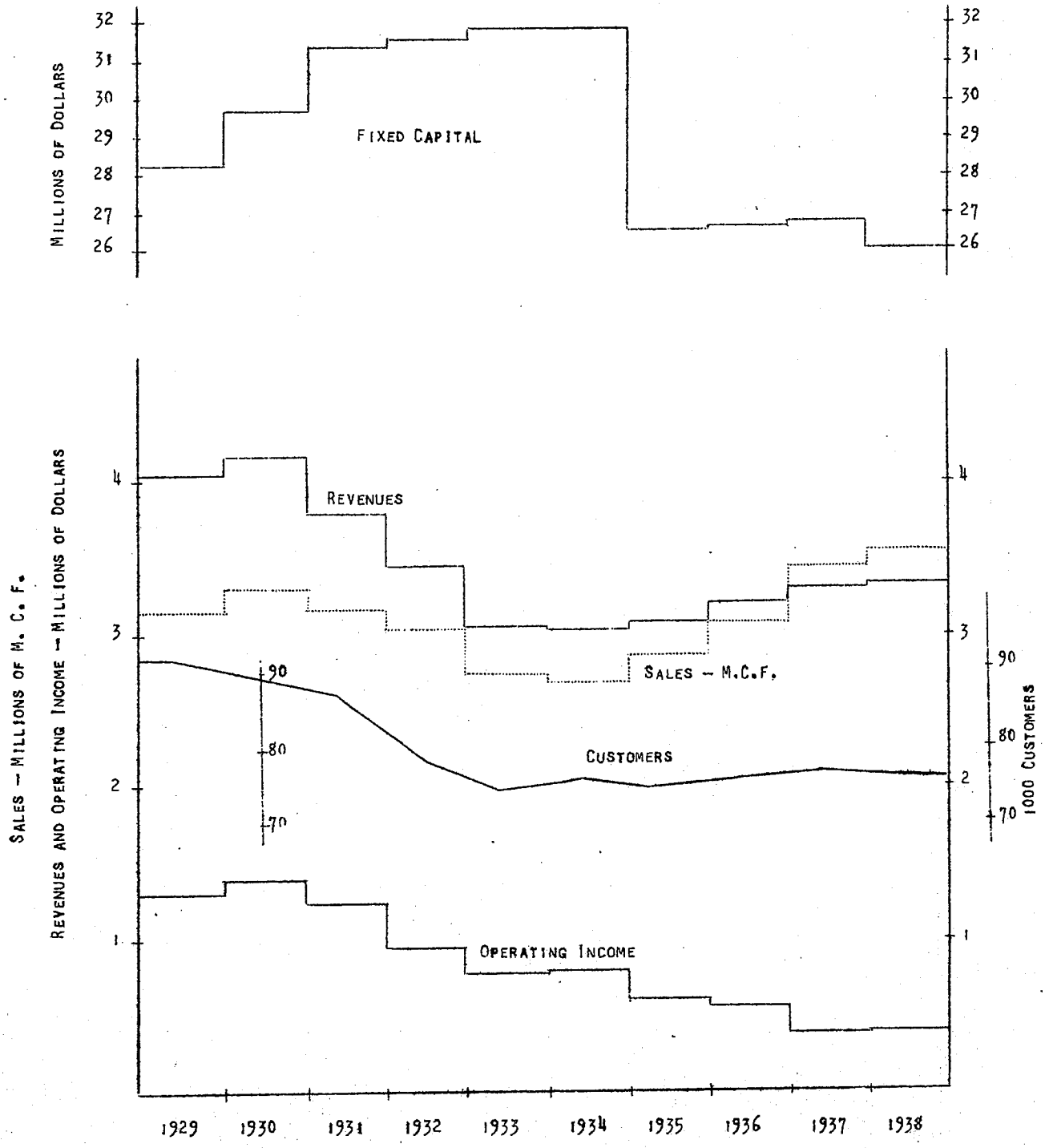
To show the trends of the gas industry in the State of Washington, statistics for ten years of the fixed capital, revenues, operating income, amount of gas sold and the number of customers are listed in Table I below and shown in graphic form on Plate II.

GROWTH OF GAS INDUSTRY - STATE OF WASHINGTON — Table I.

Year	Fixed Capital	Revenues	Operating Income	Sales M.C.F.	Number Customers
1929	$28,323,848	$4,035,045	$1,284,283	$3,149,131	91,614
1930	29,729,087	4,135,608	1,381,034	3,290,883	89,903
1931	31,362,889	3,802,727	1,220,190	3,175,602	87,189
1932	31,599,202	3,434,502	912,631	3,026,631	78,802
1933	31,941,702	3,017,827	756,616	2,722,633	74,445
1934	31,995,724	3,005,912	770,522	2,683,235	75,218
1935	26,658,630	3,063,296	599,389	2,871,789	74,572
1936	26,796,161	3,203,026	535,664	3,143,625	75,431
1937	26,949,547	3,344,870	383,789	3,443,597	76,393
1938	26,025,140	3,366,306	391,368	3,540,810	76,117

PLATE II

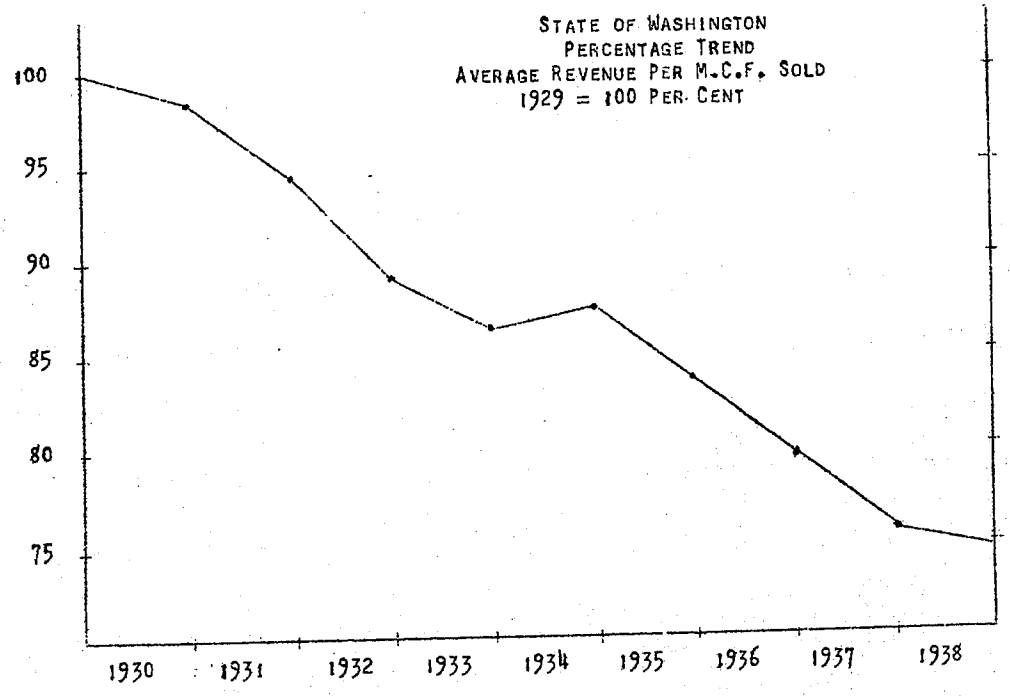
GAS INDUSTRY IN THE STATE OF WASHINGTON



The basic data for these statistics have been obtained from the Annual Reports submitted by the companies. All except the 1938 data has been audited by the Department; however, it has not been feasible to make field checks of these reports.

The average cost of gas for all residential service cannot be shown for the reason that no such segregation is reported to the Department. However, according to the American Gas Association Reports, five of the manufactured gas companies in the State of Washington, have shown a marked increase in 1938 over 1937 in house heating. House heating revenues were increased 13.4% and the amount of gas sold for this service 12.6%. It also shows that the State of Washington has had a much larger gain in the total gas business than any other State on the Pacific Coast region, including Arizona, Nevada and British Columbia.

In compiling the data submitted to the Department, it is apparent from the following chart that the public continues to receive gas at constantly decreasing average cost inasmuch as the revenue per thousand cubic feet has decreased from $1.28 in 1929 to $ .95 in 1938. The following chart shows the percentage trend relative to 1929.



Seattle, the largest city in the State, is supplied by the Seattle Gas Company which also served the surrounding territory. Gas service was first started in Seattle in 1873, and the first plant consisted of coal gas retorts which were later supplemented by water gas sets. In 1914, horizontal coke ovens with a capacity of 1,500,000 cubic feet per day were installed, and for the last fifteen years about one third of the gas was made in coke ovens and two-thirds by water gas process. Early in 1937, the coke ovens reached the end of their useful life having been in service about twenty-three years and the company was faced with the necessity of either rebuilding them completely or resorting to some other form of gas making apparatus. The coke produced in the ovens was used as generator fuel in the water gas process. Although Washington produced considerable quantities of coal, there are only two or three deposits of coking coal and these are comparatively high in ash - running from 12% to 15% and producing coke containing approximately 20% of ash, which is not economically adaptable to the production of coke oven gas. Consequently, the Seattle Gas Company decided to install an oil gas unit similar to the one used in Portland, which permits the recovery of a number of valuable by-products. This interesting process will be described later in detail.

The next largest gas utility in the State is operated by the Washington Gas & Electric Company, which serves the cities of Tacoma, Olympia, Centralia, Chehalis, Everett, Aberdeen and Hoquiam. Olympia, the Capitol of the State is served by a high pressure pipe line from the plant at Tacoma.

The Northwest Cities Gas Company serves three towns in eastern Washington, namely Walla Walla, Yakima and Clarkston. The plant serving Clarkston is located in Idaho. All three of the plants are of the coal gas type.

Spokane is served by the Spokane Gas & Fuel Company, which furnishes a combination of coal gas and water gas. It is a very difficult city to serve on account of the fact that it is underlayed with solid rock and the extension of distribution mains is very expensive. Most of the coal used in Spokane is shipped from British Columbia, where a very good grade of coking coal is mined.

There are small isolated gas plants located in Bellingham and Wenatchee. These plants are owned by the Puget Sound Power & Light Company which also serves a good share of the State with electric service. The Western Gas Company furnishes water gas to the city of Bremerton and has recently converted its plant at Longview to butane-air.

The companies furnishing butane obtain their supply from California, the liquid gas being shipped in tank cars. The rail freight charges are more than 50% of the charges of the gas laid down in Washington. There is an effort being made to increase the use of butane gas in the Pacific Northwest to a point where the installation of a large storage and distribution unit can be proven out. The liquid gas could then be shipped by water at a very much lower rate.

A BRIEF DESCRIPTION OF THE OIL GAS PLANT OF THE PORTLAND GAS & COKE COMPANY

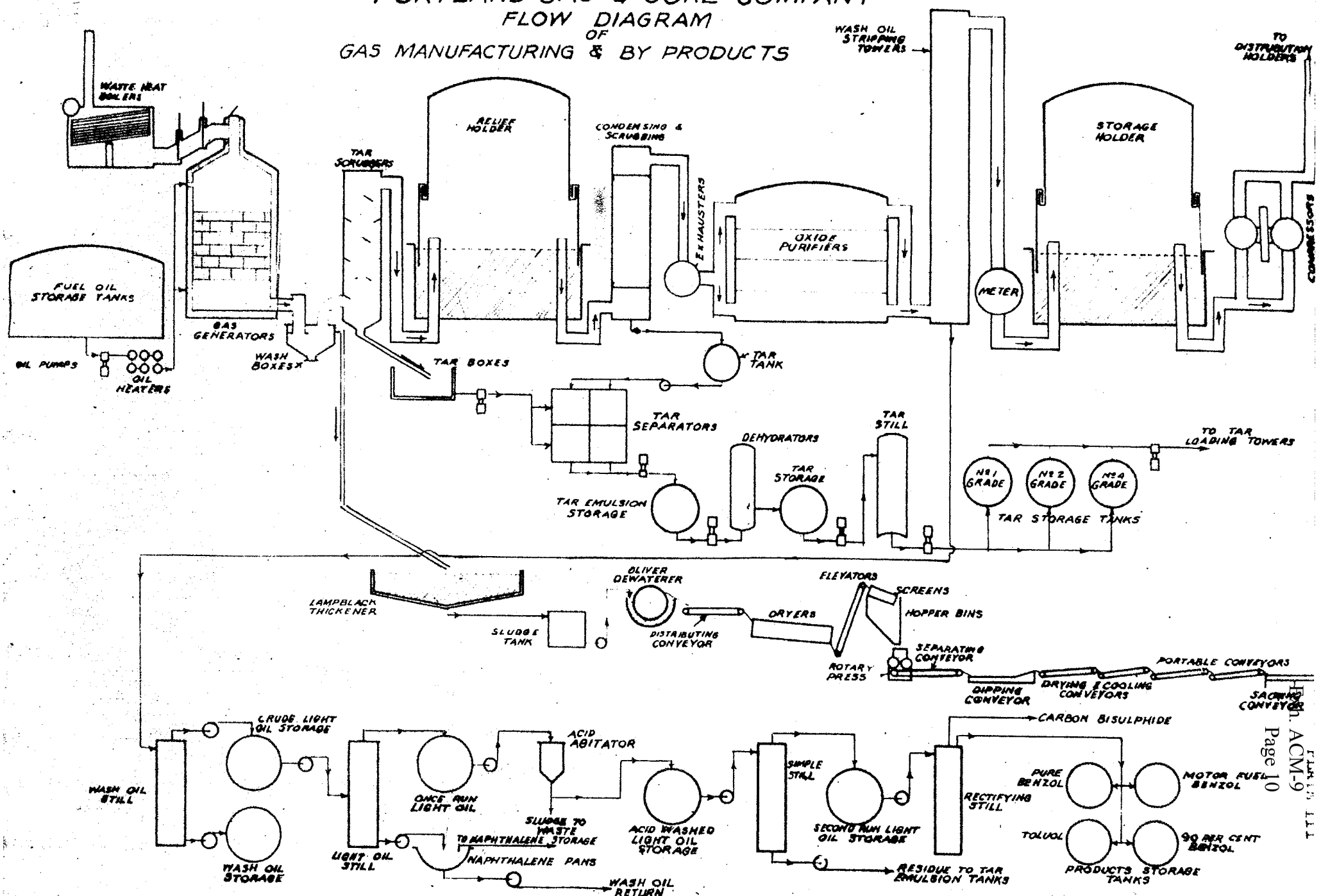
The Portland Gas & Coke Company's plant is the only one of its kind in the country. A unit somewhat similar is being placed into operation in Seattle at the present time. The interesting part of this method is the use of an oil residuum from raw materials and also the yield of a large number of by-products.

The city of Portland, Oregon, and the surrounding territory have enjoyed the use of manufactured gas for a period of 79 years. This utility is, therefore, one of the oldest on the Pacific Coast. The company is justly proud of the progress made. A real estate census taken in Portland in 1933 shows that of all the homes using fuel for cooking, well over 50% use gas. This has been accomplished in the face of the low cost of wood and electric service in the vicinity.

The construction of the first plant was started in 1860, and after enlarging and making many changes the company moved to its present site in 1912. In 1936 a change was made in the gas generators, which for the first time in the history of the gas industry made it possible to use for raw material a very low gravity residuum obtained from gasoline refineries. The use of such material for gas making had never before been attempted because excessive carbon deposits would accumulate in the generators. By cross connecting the generators in pairs this excess carbon could be burned out during the heating cycle, the carbon itself serving as fuel for heating instead of oil as formerly. The gas making cycle continues as before, but at the beginning of the heating cycle air is forced in at the top of one generator down and through the cross connection and up the other generator and out to waste heat boilers. The hot carbon deposits burn away in the presence of air and in burning reheat the brick checkerwork.

A flow diagram is shown on Plate III and a brief description of the method follows:

PORTLAND GAS & COKE COMPANY
FLOW DIAGRAM OF GAS MANUFACTURING & BY PRODUCTS



The gas coming from the generators requires purification before being suitable for public consumption. It is first washed with water in wash-boxes to remove the lampblack. It then flows up through scrubbers in which baffles are so placed that the gas passes through curtains of water several times which removes the most of the tar. The gas is then stored in a temporary relief holder, whence it flows through another set of washers to remove the remaining tar, then through the exhausters to the purifiers.

The purifiers are large steel tanks in which are placed trays loosely covered with oxide bearing material made by soaking wood shavings with a solution of lime and copperas. The gas passing through this material is purified of small quantities of objectionable material such as sulphur. This method of oxide purification is known as the dry process and is of the same type as used in the coal gas and water gas.

The gas then passes through tall absorption towers where the benzol and other hydro-carbons, which are in the gas in the vapor state, are absorbed by a light oil. The gas now purified and free of by-products enters into the works storage holder and is pumped through the holders to the transmission lines feeding the various communities.

The flow diagram also shows some of the by-products. The tar is collected from the two types of scrubbers, is dehydrated and distilled, producing three grades, namely, No. 1, No. 2, and No. 4. Virtually all of the tar now finds a ready market in the construction of non-skid surfacing for roads. Last year the sales of tar amounted to over 1,600,000 gallons.

The second kind of by-product that is recovered is carbon or lampblack. As shown on the flow sheet, the water carrying the lampblack is run into a large tank which is a special application of the Dorr Thickner. The lampblack that floats on the surface is skimmed to the center and the lampblack that sinks is scraped to the center well from whence it is pumped by diaphragm

pumps to the Oliver filters where the moisture content is reduced to 30%. The carbon cake is then fed by a conveyor belt to rotating driers similar to the burners used in the cement industry. These driers are oil fired. Due to the selection of equipment in this process and the careful control, the company has been able to reduce the fuel requirements for drying the carbon to 18.63 gallons of fuel oil per ton of briquettes made. The company has calculated that the saving over the former method in fuel oil alone for drying purposes was $15,600 for the year 1933.

The dry carbon is then elevated to storage hoppers, whence it passes to a rotary press that makes pillow shaped briquettes. These are conveyed to a tank of hot starch which adheres to the outside, the coating being dried by running the conveyor through a drying oven. This coating keeps the briquettes from shedding fine particles in handling, resulting in a clean fuel and also reducing the napthalene odor.

The company has designed and constructed an ingenious combination of a portable conveying, weighing, and sacking machine. It is so arranged that it can be moved to any part of the warehouse for sacking, which has resulted in a minimum of labor in packaging. The briquettes are immediately weighed in sacks as they are taken from the conveyor, 108 pounds being put in each sack. The use of sacks facilitates the loading of trucks and the unloading at the customer's premises. Last year the briquette sales were nearly 52,000 tons.

The third by-product is the recovery of light oil which is treated by distillation where it is broken up into its several constituents, namely, naphthalene, benzol, toluol, xylol. The benzol blended with gasoline was first put on the market in 1923 as motor fuel, the annual output recently being over 2,000,000 gallons.

In addition to the by-products just described and shown on the flow diagram there are other by-products, one of which is sulphur. A small plant was

constructed in 1936 to recover the sulphur from the oxide used in the purifier. Sales of this chemical sulphur amounted to 150 tons in 1938. Because of the exceeding fineness of the sulphur particles so recovered, this chemical sulphur is superior to commercial ground sulphur for use as an insecticide and fungacide. The particles are 5 times as fine as ground commercial sulphur and will pass through a 1666 mesh screen. The recovery of sulphur is by the process of bleaching, washing, lime treating and evaporation.

There has been a great deal of original engineering and chemical research in order to develop such a plant as this. In 1937 the company constructed a "pilot plant" which is a miniature gas plant complete in all essential details. This makes it possible for research to be carried on and special tests to be made without disturbing the regular plant production schedule in any way, and without using large quantities of raw materials.

To obtain 1,000 cubic feet of gas of 570 B.T.U., it requires from 9 to 10 gallons of oil, depending upon the grade. From every 1,000 feet of gas manufactured, there are the following by-products:

22 to 30 pounds of lampblack
$\frac{1}{4}$ to $\frac{1}{2}$ gallons of tar
.4 gallons of motor benzol, pure benzol and coluol.

During the year 1938 the totals of these by-products were:

Lampblack - 51,536 tons
Tar (water free basis) 1,635,589 gallons
Crude light oil 1,745,517 gallons.

The company has made some comparisons and claims that they are able to place gas in the holder at a net production cost less than any other manufactured gas company in the country and lower than many natural gas companies.

Economics of Oil Gas Manufacture

In the early history of oil refining, the lighter grades of oil were used for gas making largely because the residuum from the manufacture of gasoline was of this quality. As time went on the oil refiner has dug down more deeply into a barrel of oil in the effort to produce a maximum yield of gasoline and the resulting residuum has been of increasingly heavy quality. During the period from 1906 to 1930 the quality of oil available to Portland Gas & Coke Company at a reasonable price went down from 22° A.P.I. to 8° A.P.I., accompanied, nevertheless, by a moderate increase in price. However, the development of by-products by this company has more than kept pace with the decreasing quality and increasing cost of oil, so that manufacturing costs have not tended to rise appreciably, if one neglects the flurries in oil prices during the war-time period.

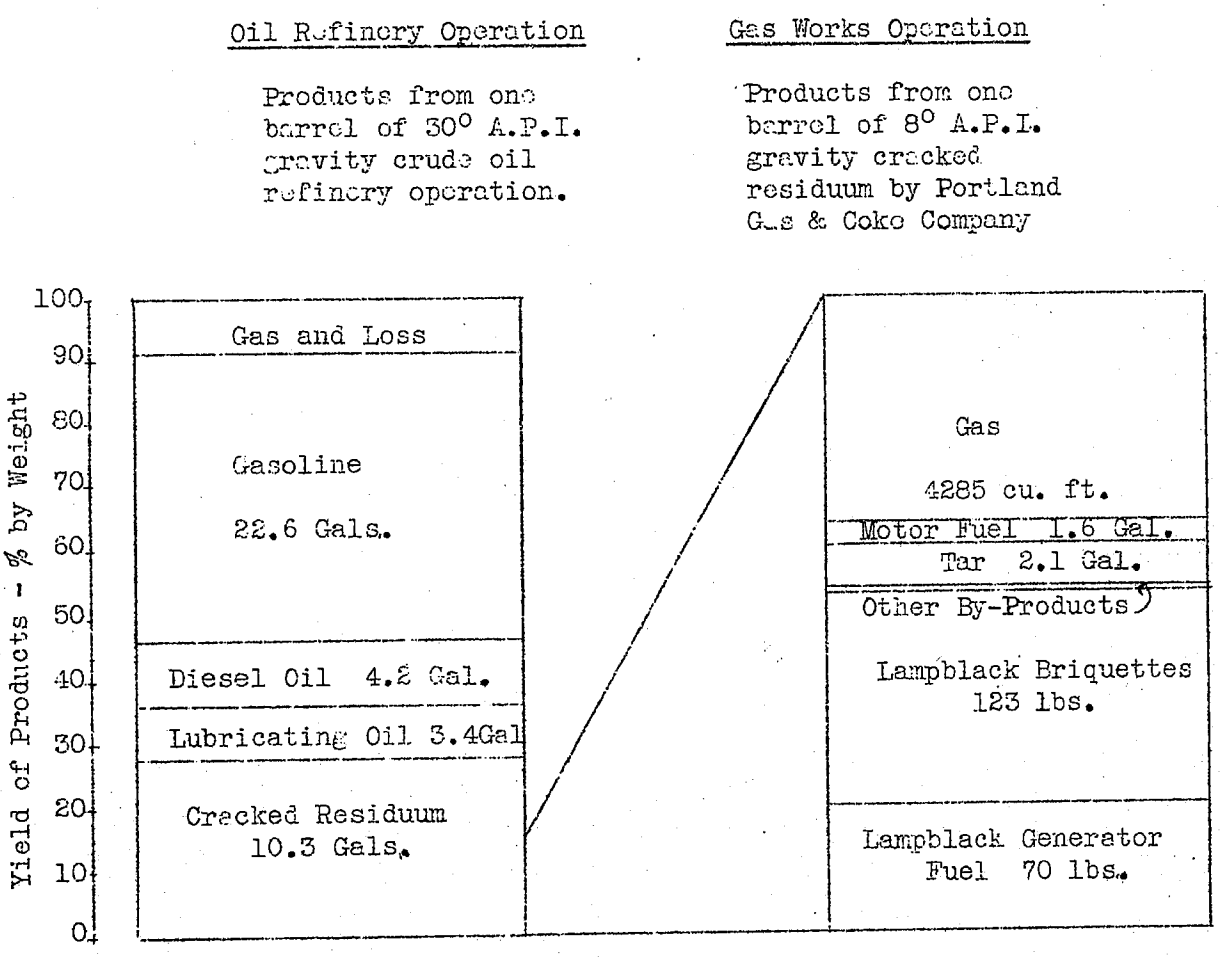
It must be realized, however, that there is a limit to how far the oil refiner can continue to degrade the character of the residuum produced in the manufacture of gasoline. A point has already been reached where the residuum is so heavy that it must be heated before pumping.

While it is feasilbe for the refiner to run this residuum down to coke, the quantities of coke produced would be very greatly in excess of the amounts that could be marketed in the neighborhood of the refiner. On the other hand, the coke cannot be transported, because of freight limitations, for any considerable distance. When the residuum, therefore, reaches from 6° to 8° A.P.I. gravity, the practical limit has been attained in the refining of a barrel of oil.

The heavier residuums are, however, a preferred source for oil gas manufacture when it is desired to produce maximum amounts of carbon for the production of briquettes. By reason of the local market for solid fuel, the

Gas Company can carry on the processing oil from where the oil refiner leaves off, to produce gas with a maximum yield of by-products. This condition is illustrated in the attached chart which shows the processing of a barrel of oil by the oil refiner to a residuum still permitting transportation, and the processing of such residuum by the gas manufacturer and the by-product yields in connection therewith.

GRAPHIC COMPARISON OF GAS WORKS OPERATION
WITH OIL REFINERY OPERATION



The data used in this paper that specifically refers to the various utilities was furnished by the several operating companies.