grade, and the freight rate low, making the price of raw material correspondingly low. Oil can be had, but as it must come from the California oil fields, the freight rates are high; it has to be transhipped from steamer to cars and the source of supply could not be guaranteed as constant without installing immense storage tanks. Hence, the cost of both oil and water gas would be excessive.

At Portland, Oregon, however, the gas plant installed is of the oil gas type. Oil can be brought from California to the plant in tank steamers and unloaded directly from the steamer into the storage tanks at the plant. Hence oil is comparatively cheap and under the conditions the oil gas type of plant resulted in the lowest cost of manufacture.

At Paris, Texas, however, coke can be procured at a reasonable cost, while oil is also procured at a fair price, and it has been found least expensive to use water gas in the plants in this district than any other. Hence most of the plants in Northern Texas are either water gas or a combination of water and coal gas.

Cost to Manufacture.—The cost to manufacture the various kinds of gas varies in different localities. The following table gives the cost to manufacture coal and oil gas in various localities on the Pacific Coast for October, 1910. These are all medium and small sized plants and, of course, this cost can be somewhat reduced in plants of larger capacity.

Cost of Gas Manufacture per M. Feet, October, 1910.

Town.	Walla Walla.	Pendleton.	Lewiston.	North Yakima.	*Astoria.	Salem.
Production cost	.62	.38	.70	.54	.54	.70
Transmission and distribution	.09	.08	.05	.12	.06	.35
Commercial expenses	.09	.14	.11	.07	.01	.06
New business expenses	.16	.11	.32	.13	.08	.03
General expenses	.15	.50	.36	.25	.18	.20
Total	1.11	1.21	1.54	1.11	.87	1.34
Average daily output, in cubic feet	82,000	12,500	38,300	24,800	80,000	41,400
Population of town	22,500	5,000	7,000	16,000	10,000	.....
Rate per M.	$1.75	$2.00	$2.00	$1.50	$1.75	$1.70
Cost of coal per ton at plant	$5.10	$5.25	$5.10	$3.60	....	$5.89
Oil per bbl.	....	....	....	....	$1.05	.....

*Oil gas plants.

Physical and Chemical Properties of Gas Desired.—The principal characteristics of a gas, which are of interest to the consumer, are as follows:—

1. Candle-power.
2. Heat units or B.t.u.'s per cu. ft.
3. Amount of injurious or objectionable constituents in the gas.

The lighting customer is interested, of course, in getting as much light from his burner as possible, and hence in some franchises granted gas companies by the municipality a certain candle-power is stipulated, and to meet this requires care in the manufacture and it may also be a deciding point in the choice of the type of gas plant to be used. The standard for measuring candle-power is a flame burning at the rate of 5 c.f. per hour, the gas being measured at 60 degrees Fahr. and 30″ barometer, or corrected to this. This flame is compared with a standard sperm candle which weighs six to the pound and burns at the rate of from 114 to 126 grains per hour.

The heating customer is much more interested in the number of B.t.u.'s per 1,000 cu. ft. than he is in the candle-power of his gas, and hence franchises are sometimes drawn up stating the limiting heat value of the gas in B.t.u.'s, below which the gas company must not allow it to fall. This also is of very great importance in deciding what type of gas plant will be used. The average heating quality per cu. ft. of various gases is given in the following table:

Pennsylvania natural gas	1,145
Ohio and Indiana natural gas	1,095
Kansas natural gas	1,100
Average coal gas	755
Texas (Petrolia Field) natural gas	630
Average water gas	350
Average bituminous producer gas	155

The presence of injurious and objectionable constituents in the gas is usually entirely the fault of the gas company, as by means of the proper condensing, purifying or reheating apparatus, all objectionable impurities may be removed. Among the more important impurities in crude gas may be mentioned, ammonia, hydrogen-sulphide, carbon-dioxide, carbon-bisulphide, cyanogen, tar, carbon, and naphthalene. The market for residuals has considerable influence on the net cost of manufacture of the gas. Coal gas produces:—

1. Ammonia liquor—and if the plant is large enough to warrant the installation of a still to concentrate the liquor it is a source of considerable revenue.

2. Coal tar—a coal gas plant produces a considerable amount of heavy, dense tar which is in great demand for roofing and as an ingredient in preservative paints and a gas plant can usually dispose of their entire output very readily.

3. Coke—a coal gas plant produces a large amount of coke, the quality, of course, depending on the time that the coal has been in the retorts. The kind of coal used also influences the quality of the coke to a large extent. While some coke can be used in the benches and boilers as fuel, yet only a small proportion can be used up in that way, and the remainder has to be sold or it will accumulate very fast. Usually the breeze and smaller pieces can be used as plant fuel, leaving the best of the coke for sale, and the market is generally very good. It sometimes happens that a company operating several coal gas plants can erect a water gas plant at some convenient point in order to utilize the coke from the coal gas plants.

Water gas produces a very light and watery tar, which is not in such demand as coal tar. It is, however, usually possible to find a market for same, and failing in that it can be sprayed under the boilers and used as fuel, although even then it makes a very indifferent fuel.

Oil gas produces large quantities of lamp black, a finely divided and almost pure carbon. In small plants