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DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
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PROPANE, BUTANE, AND RELATED FUELS

Abstract

The composition, manufacture, properties and methods of distribution of commercial propane and butane are described. There is a brief discussion of methods of storage and utilization, including the cost and uniformity of service, and the selection and adjustment of domestic appliances. Domestic systems using hydrocarbons of higher boiling points are included in the discussion. Leading distributors are listed with the character of the product supplied and the territory within which service is rendered by each.

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1. Purpose and Scope of This Letter Circular

This letter circular has been prepared to take the place of Letter Circular No. 292, entitled "Liquefied Petroleum (Bottled) Gases", dated December 1, 1930. Its purpose is to supply the information most frequently asked for by correspondents of this Bureau regarding the hydrocarbon fuels, principally propane and butane, which are commonly transported as liquids but are used as gases.

Liquid propane and butane are still very commonly referred to as "bottled" gases because of their extensive distribution to domestic users in comparatively small portable cylinders popularly called "bottles". Transportation in tank cars, and local delivery in tank trucks from which consumers' reservoirs are filled, have become as common in recent years as the use of "bottles", and the term "bottled gas" may no longer be generally descriptive, but for the sake of brevity will be used occasionally in this circular.

Although the industrial uses of propane and butane now probably exceed in importance their domestic uses, the circular is devoted mainly to the latter for the following three reasons. The number of inquiries from persons interested in domestic uses of the gases is much greater than from those concerned with their industrial uses; industrial uses are so varied that individual consideration must usually be given to inquiries regarding them; and industrial users usually have enough at stake to justify the purchase of a comprehensive handbook [1] on the subject of the fuels or a study of the original literature to be found in technical journals and other publications.

1. The Handbook of Butane-Propane Gases, of which there are two editions and a supplement, published by Western Business Papers, Inc., 124 W. 4th St., Los Angeles, Calif., is very comprehensive. Much of the information in this letter circular was taken with permission from that source.

Butane, and rarely propane, is sometimes mixed with air or other gas before delivery to the burner. The fuel supplied in this way is not essentially different from that supplied by "gas machines" using gasoline or other relatively high-boiling hydrocarbons, and gas machines still compete with the liquefied gases for domestic use. Brief attention is, accordingly, given to equipment of this type.

2. The Constituents of Petroleum Gases and Some of their Properties

Natural gas and petroleum as they occur in nature consist of mixtures of many substances. These are chiefly compounds of hydrogen and carbon, called "hydrocarbons" by the chemist. The predominent "family" of hydrocarbons is called the "saturated series", and their compositions vary in a regular manner, beginning with methane which has one atom of carbon and four of hydrogen in each molecule and is represented by the symbol CH_4. The first six members of the series and the symbols representing their compositions are as follows: Methane, CH_4; ethane, C_2H_6; propane, C_3H_8; butane, C_4H_{10}; pentane, C_5H_{12}; hexane, C_6H_{14}. In the case of butane and higher members of the series, different arrangements of the atoms in the molecule are possible and cause slightly different properties. There are two butanes and three pentanes. Ordinarily these different "isomers" are not separated, the only common exception being that "isobutane" is frequently separated from "normal butane".

The properties which mainly determine the different methods of transporting and using these fuels are the temperatures and pressures at which their vapors condense to liquids. Methane is the principal constituent of the vast quantities of natural gas distributed from the wells through pipes and is a so-called "permanent" gas, which means that at ordinary temperatures it cannot be liquefied by applying pressure, no matter how great. It is nearly as hard to liquefy, by a combination of great pressure and low temperature, as is air. Hexane, at the other end of the list given, is a liquid which boils at 69°C (156°F) and is one of the important constituents of ordinary gasoline. Gasoline itself is a mixture containing, in the main, still higher members of the methane series of hydrocarbons, but also much hexane and appreciable amounts of pentane. It is with the substances which are intermediate in composition between methane and hexane and especially with propane and butane that this letter circular is primarily concerned.

Ethane can be liquefied by pressure alone at temperatures as high as 32°C (90°F), but if metal containers are to be filled with the liquid they must be of excessively heavy construction to be safe at temperatures to which they would be frequently exposed if made an article of commerce. Ethane is, therefore, seldom distributed alone and is of importance in this discussion only as its presence in solution in propane and butane affects their properties.

Propane is a gas at atmospheric pressure at all temperatures likely to be encountered in the United States, but can be liquefied by moderate pressure and is safe in a container of reasonable strength. Under practically all probable conditions of domestic use, a cylinder of liquid propane will, therefore, deliver a continuous supply of gas at a pressure ample for its effective utilization. Normal butane boils at about the freezing point of water and, since its evaporation cools it somewhat, its liquid cannot be made to supply gas at a satisfactory pressure unless the surroundings of the container are at a temperature considerably above that point. Isobutane is somewhat more volatile than normal butane. Pentane boils at about 36°C (97°F) and is, therefore, a liquid at atmospheric pressure within the usual range of indoor temperatures.

Although the hydrocarbons previously mentioned are the only gases and very low-boiling liquids among the hydrocarbons that usually occur in important quantity in nature, the process of making gasoline and other commercial products from crude oil produces another series of hydrocarbons the individuals of which differ from those of the methane series in having two less atoms of hydrogen per molecule. The first member of this series is ethylene, C_2H_4. It is a familiar anesthetic and has many uses as a raw material in the chemical industry. The next two members of the series, propylene, C_3H_6, and butylene, C_4H_8, are also produced in oil refineries, together with propane and butane, from which they are not easily separated by distillation. They have strong odors and a moderate amount of them is frequently added to propane and butane to make the detection of leaks easier. The properties of propylene and butylene which affect their use as fuels are nearly the same as the corresponding properties of propane and butane; hence, they are not always separated, and the liquefied gases from refineries contain both series of hydrocarbons.

The properties of the hydrocarbons mentioned which are of most importance in connection with their use as fuels are given in Table 1. In this table, heating values in Btu per pound are computed from the heats of combustion per mol observed by F. D. Rossini of this Bureau, and 12.01 as the atomic weight of carbon. The heating values (in Btu per cu.ft.) and specific gravities of the vapors, except those of pentane and butylene, have been corrected for deviations from the ideal gas laws at 60°F and one atmosphere. Pentane is a liquid at 60°, but its concentration in gas mixtures, even those in which it is the only fuel is usually low, and it has been assigned the heating value and specific gravity corresponding to an ideal gas. The vapor pressures given were obtained graphically by plotting various vapor-pressure data, drawing curves to average the best of them,

Table 1
Characteristic Properties of Hydrocarbons which may be present in Liquefied Petroleum Fuels

Substance	Ethane	Propane	Iso-butane	Normal butane	Pentane	Propylene	Butylene
Formula	C_2H_6	C_3H_8	C_4H_{10}	C_4H_{10}	C_5H_{12}	C_3H_6	C_4H_8
Boiling point, °F	-127	-44	14	33	97	-53	20-34
Pounds per gallon of liquid at 60°F	3.11	4.24	4.72	4.85	5.25	4.37	5.0-5.1
Heating value of the gas:							
Btu per pound	22,340	21,680	21,280	21,330	21,110	21,050	20 840
Btu per gallon	69,500	91,900	100,400	103,400	110,800	92,000	105,200
Btu per cu.ft. at 60°, 30 in. Hg	1,790	2,572	3,364	3,393	4,023	2,379	3,190
Specific gravity of gas	1.05	1.55	2.08	2.14	2.49	1.46	1.98
Vapor pressure, lbs. gage							
-44°F	88	0	-9	-12	-14	3	-12
0	206	24	-4	7	-13	32	-6
33	343	54	7	0	-11	69	4
70	553	112	27	16	-6	135	21
100	--	196	55	37	4	218	43
130	--	271	93	64	11	323	74
150	--	346	128	87	21	420	116
Volume of air required to burn one volume of gas	16.7	23.9	31.0	31.0	38.2	21.5	28.6

and adjusting the curves to pass through the boiling points and critical points reported in International Critical Tables. Other data are from various sources.

The fuel "gases" in liquid form in the cylinders are not explosive except as any other confined gas, carbon dioxide or ammonia, for example, is explosive. If a cylinder is heated, the pressure increases. A safety device must be provided which will certainly relieve the pressure before there is danger of rupturing the tank itself; otherwise, a cylinder exposed to fire would explode with the combined effect of a boiler explosion and the sudden release of a great quantity of combustible gas. Actually, no case of the explosion of a liquefied petroleum container has come to the attention of the Bureau of Standards, although many of them, ranging in size from tank cars downward, have been in fires. The safety devices have always released the pressure, and the liquid fuel, cooled by its own evaporation, has boiled evenly and produced flames of moderate size at the relief openings.

Mixtures of the gas with air will burn with explosive force just as will mixtures of air with any other combustible gas, vapor, or dust. The material is not explosive by itself, however, in the sense that acetylene is.

The petroleum gases are not poisonous, but their leakage should be guarded against even more carefully than that of manufactured gas because of fire hazard. They are heavier than air and tend to accumulate at floor level, in contrast to ordinary manufactured or natural gases, which are lighter than air and rise. Ordinarily, convection through a building tends to bring in air at the bottom and force it out at the top of each room. There is, therefore, little chance for a heavy gas to escape from a room until it has become thoroughly mixed with the air by the slow process of diffusion. A flame in the lower part of a room is more hazardous to the occupants than one of equal intensity in the upper part, among other reasons, because of the danger of igniting clothing. These facts combine with its high heating value per unit volume to make the escape of even a little petroleum gas a greater fire hazard than the escape of natural or manufactured gas in much greater volume.

3. Manufacture of Liquefied Petroleum Gases

The natural gases which constitute the principal source of liquefied petroleum gas were used as a source of gasoline for many years before the portion which could be kept liquid under pressure was introduced extensively into commerce. Because the natural gases richest in gasoline were drawn from the top of the casings of oil wells, they were called "casing-head gases" and the gasoline separated both from them and from "dry" natural gas (unaccompanied by oil) was called "casing-head gasoline". Casing-head gasoline, more recently named and now generally called "natural" gasoline as distinguished from the gasoline made in refineries, was separated from the gas (1) by compression and cooling or by compression alone, (2) by dissolving under pressure in an oil somewhat less volatile than kerosene, from which it could subsequently be distilled, or (3) by "adsorbing" in a porous material such as "activated" charcoal, from which it was later driven by steam. In every case the higher hydrocarbons, pentane, hexane, etc., which were wanted as gasoline were accompanied by more or less of the lower hydrocarbons, propane and butane, which were not wanted because they made the gasoline too volatile. Originally the natural gasolines were allowed to "weather", that is, the dissolved propane and the other gases were allowed to escape at ordinary temperature and pressure, accompanied by a large amount of the gasoline vapor, until the gasoline was stable enough for sale. Eventually the process of submitting these escaping gases to "fractional distillation" was introduced, primarily for the purpose of recovering the gasoline they carried with them. Fractional distillation (or rectification) is the general process for separating liquids of somewhat different boiling points which occur together in solution by repeatedly evaporating and condensing portions of the mixtures. It is a process widely applied in the chemical industries; its most familiar examples are the separation of alcohol and water to make "distilled liquors", and the preparation of oxygen by the fractional distillation of liquid air.

At first fractional distillation of natural gasolines appears to have been used only to prevent the loss of gasoline during the removal of propane and butane, which were returned to the natural gas line. Later the mixture of propane and butane with some ethane and pentane, liquefied together, began to find a market; but it was not long before the advantages of a complete separation of the gases, and their marketing as separate products, became apparent. This complete separation, like the partial separation first used, is accomplished by fractional distillation. At the present time both the mixed gases and the substantially pure substances propane, butane, and pentane, are being marketed in large quantities.

4. Sources of and Markets for Liquefied Fuel Gases

Tables 2 and 3, taken from Mineral Market Reports of the U.S.Bureau of Mines, show the rapid development, in recent years, of the sale of the liquefied fuel gases, and the uses for which they are employed.

Much the greater part of the liquefied fuel gases still comes from natural gas, although oil refineries constitute their greatest potential source. The total quantity which could be obtained from these sources is said to be very great. It is much in excess of any possible demand for domestic uses other than househeating. The sale of the fuel for industrial heating and the production of power must meet competition with other fuels at a minor fraction of the usual retail price to domestic users. Oil refineries are able to convert the gases into gasoline and are doing so extensively. It is evident that the liquefied fuel gases must be available in practically unlimited quantities and at a cost, at the point of origin, slightly less than that of gasoline. It is also evident that this condition will continue at least until depletion of the natural sources of gas and petroleum causes radical changes in the present methods of supplying motor fuel.

5. Supplying Liquefied Fuel Gas for Domestic Use

The use of liquefied petroleum gases of greatest importance, considering their relatively small margin of advantage over other fuels used for industrial heating and power, is that of bringing the advantages of gas service for cooking, water heating, and refrigeration to homes beyond the reach of city gas mains. For these domestic uses a supply of propane is as satisfactory in every respect, except cost and the inconvenience of replacing empty cylinders, as the best manufactured or natural gas service. Actually, because of the uniform composition of propane and because of the uniform pressure assured by regulators and an always adequate pressure at the source of supply, it is possible to design and adjust appliances much more accurately to burn propane than is the case with appliances connected to the usually variable city gas supply; and this results not only in more uniform service but, if full advantage is taken of the possibilities by the designer of the appliance, in an improvement in the efficiency with which the gas is used.

Propane is usually delivered or stored for domestic use in relatively small cylinders or "bottles" which are placed out-of-doors and above ground, usually in metal cabinets. Three somewhat different systems of supply are in common use. In the first, two cylinders of the fuel gas are installed outside the purchaser's home. Gas is used from one cylinder until it is empty. The other cylinder is then turned on, and

Table 2

Sales of Liquefied Petroleum Gases (in the United States)

in Thousands of Gallons

Year	Propane	Butane	Propane-butane mixtures	Pentane	Total
1926	--	--	--	--	466
1928	--	--	--	--	4,522
1930	11,500	--	6,517 [a]	--	18,017
1932	15,182	14,662	3,417	854	34,115
1934	18,681	25,553	10,271	1,922	56,427
1935	26,814	34,084	13,492	2,465	76,855
1936	36,502	47,455	20,120	2,575	106,652

A. Butane, propane-butane mixtures, and pentane.

Table 3

Marketed Production of Liquefied Petroleum Gases by Uses - 1936

(Thousands of gallons)

	Propane	Butane	Propane-butane mixtures	Pentane	Total	Percent
Domestic	24,423	2,956	2,048	587	30,014	28.1
Gas manufacturing	944	6,227	2,200	--	9,371	8.8
Industrial fuel and chemical manufacturing	11,030	28,553	13,122	1,880	54,585	51.2
Internal-combustion-engine fuel	105	9,622	2,749	--	12,476	11.7
All other uses	--	97	1	108	206	.2
Total	36,502	47,455	20,120	2,575	106,652	100.0
Percent	34.2	44.5	18.9	2.4	100.0	

the empty cylinder is returned to the dealer and a full one put in its place. In the second system, a single cylinder is installed; and this is replaced at regular intervals before it is empty, weighed and returned to the service station for refilling. In the third system, a single container, usually of larger capacity than used in the other systems is filled periodically from a tank truck and weighed in position without interrupting the flow of gas.

The second and third systems are obviously impracticable unless enough customers are grouped near together to justify the maintenance of a regular delivery service. Where customers are closely grouped, the single-cylinder systems should have advantages of convenience and economy. The two-cylinder system is available anywhere.

Butane is little used for domestic service except in the warmest parts of the United States, because temperatures too low to give adequate pressure are frequently encountered elsewhere. Even in the South, butane is usually stored underground in order that the heat for vaporization may be obtained from the ground in the coldest weather. It is extensively used there in sparsely settled areas because its low vapor pressure makes its delivery much less expensive than that of propane. When the liquid is stored underground, tanks large enough to hold several months' supply are commonly employed. At least one company avoids the hazards of underground storage of butane (which will be discussed later) by heating an above-ground storage tank by means of a burner when the weather requires it.

Pentane is used to a considerable extent for supplying individual dwellings by passing air through the pentane container (sometimes bubbling it through the liquid and sometimes passing it over surfaces of the liquid which may be increased by wicks or their equivalent), and using the resultant mixture of air and pentane vapor as the mixtures of butane and air are used from the small city plant. This system, of course, requires a means for mechanically supplying air under pressure. Aside from this requirement, the principal disadvantage of the system is the variability of the mixture with variations of the temperature of the pentane. Usually the pentane tank is buried deeply in the ground to reduce temperature changes, and several systems have devices for adding controlled amounts of air to produce mixtures of greater uniformity than that obtained by vaporization alone.

The pentane systems are essentially the same as the systems for supplying air saturated with gasoline which have been in use in many places for forty years or more. Old plants of this type can be used with pentane with an improvement in constancy of the gas supplied. If the substitution of

pentane is made, appliances will generally have to be readjusted to take more air into the burner because of the greater proportion of fuel in the mixture supplied to the burner.

Fuel gases which have not been completely separated into their constituents, but remain mixtures, are practically as useful for enrichment of manufactured gas supplies as are the pure hydrocarbons, but their use for individual domestic supplies involves considerable difficulty. If such mixtures are allowed to evaporate in the cylinders, the gas first delivered is mainly the lowest-boiling substance present in appreciable quantity; that delivered when the cylinder is nearly discharged is mainly the highest-boiling substance. Such a variation in composition is too great to permit the satisfactory adjustment of appliances, hence liquid mixtures of this character are taken from the bottom of the container and vaporized in the line to the burner, usually in a specially arranged vaporizer which is sometimes heated by the burner itself, sometimes only by indoor air. No appreciable change of composition then results during the discharge of the cylinder. A mixture of this kind may contain enough ethane and propane to give a satisfactory working pressure. Otherwise, the necessary pressure may be supplied by pumping air into the supply tank. Systems for the use of these mixtures were employed several years before pure propane became commercially available, and several clever inventions were made to cope with the manifest difficulties involved in the control of pressure, the danger of leakage of the liquid from the house piping, etc. At the best, a system supplied with a mixture cannot be regarded as being as satisfactory as a supply of commercially pure propane, although lower cost may justify its use.

In some cases different mixtures are supplied for use in summer and winter to more nearly equalize the pressure of the supply at different seasons. When this is done, a considerable change in the conditions of combustion is unavoidable, and readjustments of the appliances may be required for satisfactory service.

Town gas supplies.- The Mineral Market Reports of the Bureau of Mines quote the following information supplied by the American Gas Association.

"At the end of 1936, liquefied petroleum gas was being delivered through mains to consumers in 178 communities in 30 states by 72 companies supplying 31,300 customers.

"Butane-air gas with heating value ranging from 520 to 900 B.t.u. per cu.ft. was supplied to 124 communities in 28 states by 60 companies. A mixture of undiluted butane and propane gas with a heating value of 2,800 to 3,000 B.t.u per cu.ft. was supplied to 14 communities in California and Nevada by 6 companies. Undiluted propane gas with a heating value of 2,550 B.t.u. per cu.ft. was supplied to 40 communities in Maryland, Minnesota, New Jersey, North Dakota, Virginia and Wisconsin by 6 companies."

If the appliances in use are properly designed for burning propane, and if the cost of the raw material is disregarded, it is an ideal gas for a public supply, particularly in a small town. The equipment required at the distributing station is extremely simple and, with the exception of the tank in which the liquid propane is stored, very inexpensive. Practically no labor or attendance is required in connection with production, since the vaporization of the liquid takes place automatically to meet any demand. Distribution is also exceedingly simple and economical. No holder is needed, there is no condensation and no corrosion in the mains, and the high heating value permits the distribution of the same amount of fuel through the same systemwith only about 11 percent of the variation of pressure that would be involved in the distribution of average manufactured gas. The product is always of uniform composition and for the reason just given can be amintained at nearly uniform pressure, which eliminates much of the trouble from the adjustment of appliances.

A plant for sending out a mixture of butane and air is also nearly automatic but requires some power-driven machinery, demands more attention, and possesses more possibilities for trouble than a propane system.

If we consider systems of increasing size, from the domestic unit to that which supplies a large town, it is evident that the advantages of propane are of decreasing importance and the high initial cost of propane is of increasing importance. Small systems can, therefore, use propane the more advantageously; for large systems the cost of the liquid hydrocarbon overbalances the superiority of propane in other respects and makes preferable the supplying of butane. For still larger systems the cost of butane becomes prohibitive in comparison with the cost of a manufacturing plant for the production of ordinary fuel gases, and one of the older manufacturing processes becomes the most practicable.

Propane is usually distributed without dilution. It is necessary to add another gas, usually air, to butane in order to prevent condensation in the distributing system, and to permit the entrainment of enough primary air in appliances. Unfortunately, there has been a tendency to carry this dilution to a heating value of 520 to 550 Btu, which is much too far.

If a mixture of butane and air of 525 Btu per cu.ft. is supplied to an appliance adjusted for a coal gas of the same heating value, at such a pressure as to result in the delivery of the same number of cubic feet (and the same number of heat units) per hour, the total amount of air in the primary mixture will be about twice as much as is desirable. If the 525-Btu mixture is supplied to a burner adjusted for a typical natural gas, the amount of air injected will be about 3.5 times what is wanted. On the other hand, a mixture of butane and air of 1,000 Btu will inject only slightly more air than is needed for best results when supplied to a burner adjusted for 525-Btu coal gas, and 60 percent more than is needed when supplied to a burner adjusted for typical natural gas.

The properties of butane, other than its ability to inject air, are such as to require, for best results, a burner substantially identical with the best burner for natural gas. Most gas appliances are made at the present time to meet the requirements of the American Gas Association when tested with typical natural and typical manufactured gases.

Actually, to use the same appliance without adjustment for average natural gas and a butane-air mixture, the heating value of the latter should be somewhat above 2,000 Btu per cubic foot. However, with the usual adjustments of orifices and air-shutters, our ordinary appliances will serve excellently for the use of butane-air mixtures of 1,000 to 1,500 Btu, but a 525-Btu mixture is far outside the range of usefulness for which they were designed, and appliances to burn such a mixture are built, tested, and sold as a special class under a special set of specifications prepared by the American Gas Association. It has been popularly supposed that the distribution of the 525-Btu mixture paved the way for the subsequent use of manufactured gas of about the same heating value (or made it easier to replace such a manufactured gas with hydrocarbon), but this is not the case. The necessary alteration of appliances is much greater than if a mixture having the heating value of natural gas were delivered.

The large quantity of air delivered with the butane not only results in a troublesome problem in the utilization of the gas with existing appliances, and in the construction and marketing of a special class of new ones, but involves expense for its own transmission. In other words, the prevailing practice incurs expense to transmit air from the plant to the burner and additional expense to prevent air already surrounding the burner from entering it.

The use of liquefied hydrocarbons to supplement manufactured or natural gas during peak demands is of much interest. If either propane or butane is in storage, it can be introduced into the supply of the other gas without delay, at a rate equal to the capacity of an enormous plant for manufacturing the usual gases, and with only a negligible amount of additional labor. The cost of storage may be relatively high, however, because peak loads occur infrequently and this portion of the plant is "idle" most of the time. The enrichment of gas is one of the few important applications for which it makes little difference whether a single hydrocarbon or a mixture is employed.

6. Industrial Uses of Liquefied Fuel Gases

The industrial uses of the liquefied fuel gases are too varied and specialized to be discussed in any detail here. As a matter of interest, several uses will be mentioned. Butane is extensively employed for heating processes in manufacturing plants, usually because it is obtainable, in the large quantity used, at a lower cost per heat unit than must be paid for gas from the local gas company. Butane is used in preference to propane because the lower cost of transportation and storage is added to only inappreciably in an industrial plant by the necessity of pumping and vaporizing with steam in cold weather. Considerations other than cost, which sometimes favor butane over the local gas supply, are greater uniformity, which is particularly important when a heating operation is included in the cycle of an automatic machine, a slightly higher rate of flame propagation than that of natural gas, and the possibility of producing a more radiant and more strongly carbonizing (smoky) flame than with either natural or manufactured gas. In some plants, large quantities of blast furnace gas are available but cannot be effectively used alone because their extreme dilutions with inert gases result in unstable flames or inability to produce sufficiently high temperatures. These gases may be made useful by enriching with butane.

Butane is being used increasingly as a motor fuel, particularly for lines of trucks which pass near a source of origin or wholesale supply and act as their own "distributors". An interesting combination of uses is sometimes made in the case of trucks carrying perishable food products which utilize the cooling effect of vaporization of the motor fuel to refrigerate the food compartment. Butane is also used to produce refrigeration in a wholly different way, as the fuel for a machine of the absorption type - the now familiar "gas refrigerator". This application has been made particularly to railroad cars.

7. Installation of Equipment for Storing and Using Liquefied Fuel Gas

The National Board of Fire Underwriters and the National Fire Protection Association have jointly endorsed regulations and good practice requirements dealing with the storage of liquefied petroleum gas and the installation of liquefied petroleum gas systems. These include:*

Regulations for the Design, Installation and Construction of Containers and Pertinent Equipment for the Storage and Handling of Liquefied Petroleum Gases;

Regulations Covering the Installation of Compressed Gas Systems other than Acetylene for Lighting and Heating;

Requirements for the Construction and Protection of Tank Trucks and Tank Trailers for the Transportation of Liquefied Petroleum Gases;

and a code covering the Construction and Installation of Liquefied Petroleum Gas Systems intended for Enforcement by Fire Marshals or other public safety agencies.

Everyone undertaking the handling or use of these fuels for the first time should secure the pertinent set of rules and assure themselves that they are followed. Those engaged in the transportation of the gases must, of course, comply with the rules of the Interstate Commerce Commission. Local officials should be consulted to learn whether there are any applicable State or municipal regulations. A brief discussion of potential hazards, with a few suggestions which go beyond the formal rules, follows.

The liquefied petroleum gases are under greater pressure in the house piping than is usual for natural or manufactured gas; they form explosive mixtures in much smaller proportions with air; and the fact that they are heavier than air and that the flow of air is normally inward at floor level prevents their ready escape from a room. A leak so small that it could be safely ignored if manufactured gas were used is, therefore, hazardous. For this reason an ordinary job of "gas fitting" will not do. It is preferable to use seamless metal tubing in a single piece from the supply outside the building to the appliance if possible. (Copper is generally used.)

Regulators, and pressure reliefs if used, should be vented to a point from which gas that flows downward will be least likely to enter a building. The storage containers and all connections must be protected from tampering and from danger of breakage by ice sliding from the roof, from settling of the building or the fuel container, from earthquake or storm damage, etc. Connections through which liquid could be discharged if

* Supplied at 10¢ each by National Fire Protection Association, 60 Batterymarch St., Boston, Mass.

they were broken should be avoided if possible. Where this is not possible, excess flow or reverse-flow check valves should be installed inside the storage container.

Storage underground is particularly hazardous unless elaborate precautions are taken. Underground leaks are hard to detect or repair. The density of the gas makes it tend to remain in underground channels instead of coming to the surface, and basement and foundation walls offer no protection against the entry of gas.

More serious, however, is the hazard of corrosion of the storage tanks. The most common size of underground storage tank for domestic supplies, 125 gallons, is required to have only a three-sixteenth inch wall and a protection against corrosion that experience has shown to be of uncertain value for any extended period. Soils exist in which such a tank would be perforated in three or four years, but the corrosive character of the soils is likely to be recognized in such cases and underground storage eliminated from consideration. Many other soils, which are not considered abnormal, will produce corrosion that will perforate the metal in from six to twelve years. Perforation is likely to occur first in the lower part of the tank where it is most dangerous because liquid can escape; it does this without reducing the driving pressure by refrigeration as would occur if the gas escaped. Escaping liquid propane or butane is a hazard not only to the owner but to an entire community, because the rapid liberation of a liquefied gas can result in the formation of a spreading blanket of explosive mixture with air which may drift with the wind and is capable of fearful destruction if it becomes ignited. There is no parallel to this in the underground storage of pentane or gasoline because they are normally under no pressure, and perforation of a container results at the worst in the slow loss of the liquid by capillary filtration through the surroundi soil, which soon tends to become saturated because evaporation can occur only as the heavy vapor is dispersed by diffusion with the immobile atmosphere in the soil.

For the reasons given, it is strongly recommended that no fuel more volatile than pentane be stored below ground, but if it is, the owner should remain constantly aware of the hazard of corrosion and, above all, should promptly attend to the first indication that gas is escaping into the soil. In that case inspection by digging about the reservoir must not be made until all liquid has been removed from the tank. When perforation first occurs, it is possible that the tank is so weakened over considerable areas that it would not withstand the internal pressure except for the support of the surrounding earth. To remove this while liquid is still present is to invite almost certain disaster.

Since the individual cannot possess facilities for pumping out the tank and storing the liquid, any company maintaining delivery service to underground storage should have equipment for the emergency removal of liquid and should keep its customers informed of that fact.

Purchase of gases.- Whenever practicable, liquefied gases should be purchased by weight. If the containers are too large or inaccessible to be weighed, the liquid may be measured. The reading of a pressure gage gives no indication of the amount of fuel in a container until it is practically empty. When gas is distributed from a central point through a system of piping it is, of course, necessary to measure its distribution among the purchasers with gas meters. In this case, the customer should insist on uniform heating value and consider the cost only on the basis of the number of Btu delivered. The installation of a gas meter on a system delivering gas to only one customer is inexcusable. It adds to cost, complication and hazard and has no useful purpose. Purchasers should insist that the vendors state prices per pound, per gallon, or per million Btu (or other convenient, definite unit) not as the "equivalent" of a certain amount of natural or manufactured gas. The latter basis of statement is many times misleading because either the heating value of the gas referred to is indefinite or because the purveyor credits his product with a hypothetically superior efficiency, which it may attain in a superior appliance but which is not inherent in the gas. The purchaser should insist on knowing whether he is to receive propane, butane, or a mixture, and if the latter, what its composition is. He should not credit claims of superiority for a particular brand of the same material, nor for any difference in "efficiency" reduced to the basis of heat units for one of these fuels over another.

The capacity of cylinders in which "bottled gases" are delivered ranges from 25 to 150 pounds; the ones more commonly used contain 50 and 100 pounds. The prices of the fuels depend largely on transportation and distribution cost and vary with the locality. Usually, propane for domestic supply retails between 6 and 10 cents per pound. Pentane and the mixed hydrocarbons are usually cheaper. For purposes of comparison, it may be noted that pure propane at 10 cents per pound costs $4.61 per million Btu. The 600 Btu gas supplied in Washington, D. C., at 90 cents per thousand cubic feet costs $1.50 per million Btu. Kerosene at 10 cents per gallon costs 78 cents per million Btu. Electricity at 3 cents per kilowatt hour costs $8.57 per million Btu.

Relative efficiencies of application of the heat in use are, of course, to be taken into account in judging the cost of service. There will be some improvement in efficiency when using propane for cooking as compared with city gas; probably less than 10 percent. Relative efficiencies of bottled gas and electricity are harder to estimate, largely because of differences in the way in which they are used. As a rough estimate, based on what is believed to be average practice, the cost of bottled gas and electricity will be equal for cooking if the price of fuel per pound is 3.5 times the cost of electricity per kilowatt-hour; for water heating if the ratio is 4.3; and for refrigeration if it is 1.5. It is assumed that appliances of comparable quality will be used in each case.

8. Selection and Adjustment of Appliances for the Use of Liquefied Petroleum Gases

The cost of liquefied petroleum gases is such as to justify considerable care in the selection of the appliances with which they are used. In general, the recommendations of the company supplying the fuel should be followed, but the purchaser should have in mind the fact that an appliance built to burn propane differs from one for manufactured or natural gas only in the change of a few simple dimensions, mainly burner openings and that these differences do not justify any large increase in cost over an appliance of similar quality designed for use with the usual city supplies. The appliance and its accessories including pressure controls should be carefully adjusted by an expert after installation, and should not be changed by the user without consulting the company which supplies the gas.

9. Effect of Impurities in Propane

If the gas is evaporated in the supply tank and drawn from the top, it is essential that the liquid be propane of fairly high purity. Otherwise, a decided change in composition will result during the discharge of the fuel. The presence of a little ethane may cause a great deal of trouble from backfiring (flashing back) or blowing from the ports (burner openings) when a fresh cylinder is first connected. The presence of butane, on the other hand, will result in improperly aerated flames and incomplete combustion, with production of carbon monoxide in possibly harmful amounts, particularly when the fuel is nearly exhausted. Using the American Gas Association's selected values for the permissible limits of the "index of change of performance of appliances" as a criterion, approximately 35 percent of one hydrocarbon in the next hydrocarbon of the series should not make necessary a change of adjustment of the appliance. However, this relationship was derived for the permissible limits with the usually variable city supplies. The close adjustment of propane-burning appliances to the optimum condition is the only thing that makes possible the superior efficiency of propane, hence, no such variation as wide as this is compatible with the claims for superiority of this fuel.

Table 4 shows the variation in the composition of the gas drawn at constant temperature from a cylinder filled originally with propane containing 10 percent of ethane. Table 5 gives similar data for variation in composition of gas drawn from a supply of propane contaminated with a similar amount of butane.

Table 6 is given to show the different extents to which impurities affect the constancy of composition of the gas in the case of a single-cylinder system. If half the fuel is used after each filling, with propane containing 10 percent of butane, the variation in composition during use is only about 10 percent of that which results if the double-cylinder system is employed. Obviously, the smaller the fraction of the supply used between replenishments, the more uniform is the supply.

Table 4

Composition of liquid and vapor during the vaporization of a liquid containing at the start 90 percent of propane and 10 percent of ethane. (Vaporization at 70°F)

Liquid remaining % of original	Ethane in vapor %	Ethane in remaining liquid %
100	32.4	10.0
90	26.7	7.2
80	20.0	5.3
70	15.2	3.9
50	6.4	1.6
30	1.2	0.29
20	0.35	0.08
10	0.04	0.004

Table 5

Composition of liquid and vapor during the vaporization of a liquid containing at the start 90 percent of propane and 10 percent of butane. (Vaporization at 70°F)

Liquid remaining % of original	Propane in vapor %	Propane in remaining liquid %
100	97.4	90
75	96.6	88
50	95.3	83
35	94.0	79
25	91.2	73
15	87	62
10	80	46
5	65	20
2	17	5
1	3	0.8

Table 6

Composition of liquid and gas in a container repeatedly filled with a mixture of 90 percent of propane and 10 percent of butane if one-half of the material is used from the container after each filling

No. of fillings	Composition after filling		Composition when container is half empty	
	% propane liquid	% propane vapor	% propane liquid	% propane vapor
1	90.0	97.4	83.0	95.3
2	86.5	96.4	76.9	93.1
3	83.5	95.5	72.9	91.5
4	81.5	94.8	69.2	90.0
5	79.6	94.2	67.3	89.1
8	77.2	93.2	63.3	87.5
10	76.4	92.9	62.4	87.2
20	76.1	92.8	6[illegible].2	87.0

Table 7 is given to show the effect on the operation of a burner of varying the composition of the mixture from propane to butane. For a burner to remain in perfect adjustment without changes by the operator, the "Btu per hour" (column 4) and the "percent of air required for combustion" (column 5) which is injected as primary air (air which enters the burner with the gas) should remain unchanged.

Similar data are given in Table 8 for the gases prepared by saturating air with pentane at different temperatures. The importance of placing the pentane container where the temperature will be as uniform as possible or adopting other means for maintaining a uniform mixture is clearly shown. (At a depth of 6 feet the average ground temperature varies about 20°F between winter and summer, the maximum varying, of course, with latitude.) The extreme variation shown in the table is too great for satisfactory service. Probably the "index of change of performance of appliances" supplied with mixtures of pentane and air should be kept within the same limits as for city gas. This would limit a burner which had been adjusted with air saturated with pentane at 70°F to service (without readjustment) with air saturated between about 65 and 75°F.

Table 7

Properties of mixtures of gaseous propane and n-butane. Under "operation of burner" it is assumed that a burner is adjusted with pure propane to give 10,000 Btu per hour and 60 percent of the air required for combustion is primary air.

% propane in mixture	Heating value Btu/cu.ft.	Specific gravity (Air = 1)	Operation of a burner	
			Btu/hr.	Primary air % required for combustion
100	2572	1.55	10,000	60
90	2654	1.61	10,130	59
75	2777	1.70	10,340	58
50	2982	1.84	10,680	56
25	3188	1.99	10,990	55
0	3393	2.14	11,300	53

Table 8

Composition and other properties of air saturated at different temperatures with pentane vapor. Under "operation of burner" it is assumed that a burner is adjusted for a mixture saturated at 70°F to give 10,000 Btu per hour and to take 60 percent of the air required for combustion as primary air (including the air in the gas supply)

Temp.	% pentane in mixture	Specific gravity (air=1)	Heating value Btu/cu.ft.	Operation of a burner	
				Btu/hr.	Primary air % required for combustion
32°E	24	1.38	985	4600	134
50°	38	1.60	1560	6700	90
70°	62	1.97	2540	10,000	60
97°	100	2.57	4100	14,100	41

10. Trade Names and Leading Distributors

In table 9 is given a list of trade names of liquefied fuel gases and their leading distributors, based primarily on the 1937 supplement to the Handbook of Butane-Propane Gases previously referred to. Unfortunately, a considerable amount of confusion exists. Each of several trade names applies to a whole series of different substances from one producer. The same material from the same producer may be given several trade names by different distributors, and finally the same name has been used at different times and perhaps at the same time by different producers for different products.

Table 9

Trade Names and Leading Distributors

Blaugas - Northwestern Blaugas Co., 791 Hampden Ave., St. Paul, Minn. Commercially pure propane, delivered as gas from top of cylinder. One-drum and two-cylinder systems.

Minnesota, Wisconsin, North and South Dakota.

Blaugas - Omaha Blaugas Co., 4220 No. 27th St., Omaha, Neb. Commercially pure propane. Two-cylinder system.

Wholesale and retail gas in western Iowa, Nebraska, and within three to five hundred miles of Omaha.

Blaugas - Pittsburgh Thermoline Co., 45 So. 20th St., Pittsburgh, Pa. Commercially pure propane, delivered as gas from top of cylinder. Two-cylinder system.

Pittsburgh and vicinity and Philadelphia and vicinity by way of local trucking service. Isolated districts in Ohio, Kentucky, Indiana, and New York via freight.

Bluflame - Bluflame Gas Corp., Toledo, Ohio. Commercially pure propane. Two-cylinder system, 60 and 100 lb.

Northwestern Ohio and southeastern Michigan. Salesmen and dealers.

Blu-Spot - Universal Bottled Gas Corp., 138 Mt. Hope Ave., Rochester, N. Y. 3000 Btu iso-butane, Two-cylinder system.

New York State, Northern Pennsylvania, and New England, through dealers.

7-70
Bradford/- Bradford Gasoline Co., Bradford, Pa. 3000 Btu wet type gas. Two drum.

Connecticut, New York, and Pennsylvania.

Bupane - Bupane Gas Co., Cedar Rapids, Ia. Distributes three products as follows:

Super Bupane - Commercially pure (95%) propane. In part of the territory makes routine periodic deliveries with exchange of cylinders.

Regular Bupane - 15% iso-butane, 50% normal butane, 30% butylene, 5% pentane.

Demand Bupane - 10% butane, 90% pentane. Replenish containers on customers premises. Sold by liquid measurement.

Iowa, Illinois, Wisconsin, Minnesota, South Dakota, Nebraska, Kansas, Missouri, Colorado, Indiana. Sales are made through a dealer organization.

City Gas - Wisconsin Rapids Gas Co., Wisconsin Rapids, Wis. Commercially pure propane. One- and two-cylinder systems.

Wood, Waushara, Portage and Admond Counties.

Coleman Bottled Gas - The Coleman Lamp and Stove Co., Wichita, Kan. Commercially pure propane, delivered as gas from top of cylinder. Two-cylinder system.

Midwestern part of United States.

Dri-Gas - Illinois Bottled Gas Co., 35 W. Jackson Blvd., Chicago, Ill. Commercially pure propane. Two 2-cylinder systems and one single cylinder system.

Indiana, Illinois, Wisconsin, eastern Minnesota, eastern Iowa, southern Michigan, and western Ohio.

Drigas - Miami Bottled Gas, Inc., Miami, Fla. 2550 to 3200 Btu propane and butane and butane-propane mixtures. Two-drum system and underground liquefied gas systems.

Miami, Hollywood*, Fort Lauderdale*, Delray*, Vero Beach*, Homestead, Tavenier, all Florida Keys, Key West, Nassau, and Havana*, Cuba. All territories marked with * are serviced through specially selected dealers.

Engco - Engco Natural Gas & Electric Co., Chatham and Newark, N. J. Commercially pure propane, delivered as gas from top of cylinder. Two-cylinder and monthly service.

New Jersey, Delaware, Maryland and eastern Pennsylvania.

Engco - Eastern Natural Gas Corp., Chatham and Newark, N. J. Commercially pure propane, delivered as gas from top of cylinder. Two-cylinder and monthly service.

New Jersey, Delaware, Maryland and eastern Pennsylvania.

Essotane - The Protane Corporation, Erie, Pa. Commercially pure propane, delivered as gas from top of cylinder. Two-cylinder system.

East of the Mississippi from Maine to Florida. Sales and gas service through own dealers.

Essotane - Standard Oil Co. of New Jersey, 26 Broadway, New York, N. Y. Commercially pure propane, delivered as gas from top of cylinder. One and two-cylinder system.

New York, New England states (Colonial Beacon Oil Co.), New Jersey, Virginia, West Virginia, Delaware, Maryland, District of Columbia, North Carolina, South Carolina (Standard Oil Co. of New Jersey), Arkansas, Louisiana, Tennessee (Standard Oil Co., Louisiana).

Flamo - Standard Oil Co. of California, 225 Bush St., San Francisco, Calif. Commercially pure propane. Two-cylinder installation.

California, Oregon, Washington, Nevada, Arizona, parts of Idaho and Utah, and the territories of Hawaii and Alaska.

Fuelite - Fuelite Natural Gas Corp., 315-319 Marrett Road, Lexington, Mass. Commercially pure propane, delivered as gas from top of cylinder. Two-drum and one-drum systems.

New England states and part of New York State.

Heatwave - Imperial Gas Co., Los Angeles, Cal. Approximately 3000 Btu propane-butane mixture, for use in gasoline type appliances in liquid form. Single and two-cylinder systems.

California and Arizona.

Hi-heat Gas - Hi-Heat Gas Co., 2 E. 40th St., New York City. Mixture of about 70% butane, 30% propane. Delivered as a liquid through a special vaporizer.

New England, New York, New Jersey, and Pennsylvania.

Home-Gas - Home Gas Division, C. I. Tenney Engrg. Co., 316 Frontenac Bldg., Minneapolis, Minn. Commercially pure propane, delivered as gas from top of cylinder. Two-cylinder system.

Central Minnesota.

Insto-Gas - Insto Gas Corp., 1900 E. Jefferson Ave., Detroit, Mich. Commercially pure propane, delivered as gas from top of of cylinder. Portable cylinders for torches and melting furnaces.

Liquo or 7-70 - Bluflame Gas Corp., Toledo, Ohio. Butane-propane mixture. Two-cylinder-vaporizer.

Northwestern Ohio. Salesmen and dealers.

Meter Gas - Bluflame Gas Corporation, 1801 Adams St., Toledo, Ohio. Commercial butane.

Mobilane - General Petroleum Corp. of California, 106 West Second St., Los Angeles, Cal. Commercially pure propane. Also sells propane-butane mixtures.

Delivery within 250 miles of Los Angeles in tank-truck lots on individual order only.

Nat Gas - Natural Gas Co. of New Jersey, Hammonton, N.J. Commercially pure propane, delivered as gas from top of cylinder. Two-cylinder systems, also a monthly one-cylinder system.

Southern New Jersey, eastern Pennsylvania, and Delaware.

Natrogas - Natrogas, Inc., 310 First St. No., Minneapolis, Minn. Commercially pure propane, delivered as gas from top of cylinder. Delivered in cylinders to dealers.

Minneapolis and St. Paul trade area, Minnesota, and border states.

Nugas - Bradford Gasoline Co., Bradford, Pa. Commercially pure propane, delivered as dry gas from top of cylinder. Two-cylinder system.

Pennsylvania, New York, New Jersey, Maryland, Delaware, and the New England states.

Oxalene - Oxalene Gas & Equipment Corp. of New England, 424A Broadway, Lynn, Mass. Commercially pure propane, delivered as gas from top of cylinder. Single-cylinder (industrial only).

New England. Serves cutting and welding shops, garages, factories, etc., doing cutting and welding work.

Philgas - Modern Gas Co., Woodbine, N. J. Propane, delivered as gas from top of cylinder. Two-cylinder system. Southern New Jersey.

Philgas - Philgas Dept., Phillips Petroleum Co., General Motors Bldg., Detroit, Mich. Commercially pure propane, batch vaporization in cylinder. One-cylinder; tank truck delivery, monthly billing system.

New York, Connecticut, Wisconsin, Rhode Island, Massachusetts, Maryland, District of Columbia, Ohio, Michigan, and Indiana.

Philgas - Southeastern Natural Gas Corp., Miami, Tampa, and West Palm Beach, Fla. Commercially pure propane. Two-cylinder and Phillips round cabinet one-cylinder systems.

Florida from Orlando south, east and west coast.

Philgas - Utilities Distributors, Inc. Portland, Maine. Commercially pure propane, delivered as gas from top of cylinder. Two-cylinder system.

Maine, New Hampshire, and Vermont. Subdivided into two zones with reference to price only. Sales made through specially selected dealers.

Philgas - The Verkamp Corp., Losantiville Ave., Cincinnati, Ohio. Commercially pure propane. Two-drum system.

Approximately 100 mile radius of Cincinnati. Fifty miles direct service, balance through distributors. Appliance sales through dealers.

Philgas - Polver's Gas Service, Bridgehampton, N. Y. Commercially pure propane. Two-tank system.

Eastern Long Island.

Propane - Union Oil Co. of California, Union Oil Bldg., Los Angeles, Cal. Commercially pure propane. Two-cylinder system. Delivered on order only.

Protane - Illinois Bottled Gas Co., 35 W. Jackson Blvd., Chicago, Ill. Wet gas. Two-cylinder system.

Illinois, northern Indiana, and eastern Wisconsin.

Protane - The Protane Corp., Erie, Pa. 3400 Btu butane, used as a liquid. Two-cylinder system.

East of Mississippi River from Maine to Florida. Sales and service through own dealers.

Protane "A" - The Protane Corp., Erie, Pa. Commercially pure propane, delivered as gas from top of cylinder. Two-cylinder system.

East of Mississippi River from Maine to Florida. Sales and gas service through own dealers.

Pyrofax - Carbide and Carbon Chemicals Corp., 30 East 42nd St., New York City. Commercially pure propane. Two-cylinder system.

Minnesota, Iowa, Missouri, and all states east of Mississippi River except Mississippi and Alabama.

Pyrofax - Chas. F. Smith Co., Greensboro, N. C. Commercially pure propane. Two-cylinder system.

16 central counties in North Carolina, and 2 counties in Virginia.

Pyrolane - Western Gas Distributors, 815 Broadway Arcade Bldg., Los Angeles, Cal. A mixed liquid fuel gas distributed in northern New Mexico and Arizona to gas companies and large consumers.

Pyroline - Burdett Oxygen Co. Inc., Cleveland, Ohio. Commercially pure propane, delivered as gas from top of cylinder.

Ohio and eastern Pennsylvania.

Redie Gas - Lima Suburban Gas and Stove Co., 326 N. West St., Lima, Ohio. Commercially pure propane, delivered as gas from top of cylinder. Two-cylinder system.

Distributed out of Lima to dealers and consumers in 17 counties.

Redigas - The New Gas Co., Verona, N. J. Commercially pure propane, delivered as gas from top of cylinder. Two-cylinder system.

New York, New Jersey, and Pennsylvania. Sales are made through appointed distributors or dealers.

Redigas - C. Wade-Dalton, Manassas, Va. Commercially pure propane, delivered at top of cylinders. Two-cylinder system.

Virginia, outside of Philgas territory.

Rockgas or Rockgas Propane - Imperial Gas Co., Los Angeles, Cal. 2550 to 2897 Btu iso-butane and propane mixture, depending upon product desired. Either single or two-cylinder system; customers' option.

California, Arizona, New Mexico, portion of Nevada, Hawaiian Islands, portion of Mexico, and British Columbia, Canada.

Rulane - Rulane Gas Co., Cherryville, N. C. 2550 Btu. Delivered as gas. Two-cylinder system.

North and South Carolina, part of Georgia, and eastern Tennessee.

Shellane - Shell Oil Co., 100 Bush St., San Francisco, Cal. Commercially pure propane, delivered as gas from top of cylinder. Two-cylinder and multiple cylinder systems.

Six western states, through company operated depots and selling agencies.

Shellane - Shell Oil Co., Shell Bldg., St. Louis, Mo. Commercially pure propane delivered in winter; 70% propane, 30% butane in summer. Two-cylinder system.

Missouri, Iowa, Minnesota, Wisconsin, Illinois, Michigan, Indiana, and Northwestern Ohio.

Shellane - Shell Petroleum Corp., Shell Bldg., St. Louis, Mo. Commercially pure propane, delivered as gas from top of cylinder. Two-cylinder system.

Southern Michigan, northern Indiana, Illinois, southern two-thirds of Wisconsin, southern half of Minnesota, Iowa, and Missouri.

Shorgas - Eastern Shore Gas Corp., Pocomoke City, Md. Commercially pure propane. Single-cylinder.

Del-Marva Penninsula. Sales of appliances made through merchandising dealers. Company delivers gas monthly by tank truck to customers.

Skelgas - Skelgas Co., 2534 Madison Ave., Kansas City, Mo. Commercially pure propane, delivered as gas from top of cylinder. Two-cylinder system.

The Mississippi Valley north of the Texas line, from Colorado to Michigan and Indiana. Has fully equipped bottling plants at all key points through the Middle West to service Skelgas distributors, dealers, and consumers.

Star gas - Lone Star Gas Co., Dallas, Texas. Commercially pure propane, delivered as gas from top of drum. Two-drum system.

Texas.

Suburban - Suburban Gas Co., Verona and Belvidere, N. J. Commercially pure propane, delivered as gas from top of cylinder. Monthly service system, also conventional two-cylinder system.

All counties in New Jersey north of Burlington County, and the adjacent counties of New York and Pennsylvania except New York City and Long Island.

Sungas - Sungas Co., 1100 W. Flagler St., Miami, Fla.
2550 Btu, top gas. Two-cylinder system.

Greater Miami area.

Thermogas - Pentane Natural Gas Co. Inc., 614 Corning St. Desmoines, Iowa. Commercially pure propane, delivered as gas from top of cylinder. Two-cylinder system.

Iowa, by truck route and through dealer organization; North Dakota, Minnesota, Missour, Illinois, and Nebraska, by distributor wholesale accounts.

Thermoline - Pittsburgh Thermoline Co., 45 S. 20th St., Pittsburgh.

Pennsylvania, Indiana, Ohio, Kentucky, and Connecticut. Maintains a delivery service in Pittsburgh and Philadelphia areas.

Trugas - Viking Distributing Co., Charleston, W.Va.
97,700 Btu per gal. propane and butane mixture, also butane made to dealers' requirements. Two-cylinder system. Also sells propane-butane mixtures and pentane wholesale.

500 mile radius of Charleston, W. Va. Sells entirely through subdistributors.

Liquefied Petroleum Fuel Systems and Industrial Uses

Atlantic States Gas Co., Inc., 50 Broadway, New York City. 2750 Btu butane-propane mixture. Underground tank system.

New York and Pennsylvania.

Berry-Gas - Berry Gas System Co., Wewoka, Okla. 3273 Btu butane, delivered as gas from top underground tank. One underground tank, sizes 120 to 500 gal.

Oklahoma.

Calol Industrial Gas No. 2 - Standard Oil Co. of California, San Francisco, Cal. Commercially pure propane, delivered as gas from top of cylinder. Customer supplies all service equipment for industrial gas uses.

California, Oregon, Washington, Idaho, Nevada, Utah, Arizona, New Mexico, and territories of Alaska and Hawaii.

Gas-O-Lite - Bluflame Gas Corp., Toledo, Ohio. Stabilized casing-head. Cold process machines.

National, in 54-gal. drums, direct.

Gasair - Utility Development Co., 5815 Third St., San Francisco, Cal. A system for producing butane-air mixtures for pipe-line distribution.

Hydro-Gas - Hydro-Gas Co., San Antonio, Texas. 3200 Btu. Underground system.

Southern states, including California, Arizona, and New Mexico.

Hydro-Gas - Hydro-Gas Co. of California, Inc., 1451 4th St., Santa Monica, Cal. 3200 Btu butane. Hydro-gas plant. Calif. Sales made through specially selected dealers.

Liquefied - Liquefied Gas Co. Inc., Aransas Pass, Texas. 3274 Btu normal butane. Distributed in tank trucks to underground tanks.

Houston and San Antonio, and south to the Mexican border.

Metergas - Bluflame Gas Corp., Toledo, Ohio. Butane. Buried tank-metered.

Northwestern Ohio and southeastern Michigan. Salesmen and dealers.

New Stargas - Lone Star Gas Co., Dallas, Texas. 3250 Btu butane, utilized as gas from top of tank. Bulk tanks.

Dallas and Tarrant Counties, Texas.

Ovox Fuel Gas - The Verkamp Corp., Losantiville Ave., Cincinnati, Ohio. 2550 Btu (commercial propane). Sold for industrial and commercial purposes for preheating and as a fuel gas for cutting. Priced and billed on a cu.ft. basis.

Cincinnati, Ohio (within industrial radius).

Petro Gas - Petro Gas System, Dilley, Texas. Butane. Underground tank system.

Winter Garden District of Texas.

Southern Liquid Gas Co. - Dothan, Ala. Commercially pure propane. Dry gas from top of cylinder. One and two-cylinder systems. Monthly delivery to the one-tank customers.

South Alabama, west Florida, and southwest Georgia.

The following is a partial list of manufacturers of systems for pentane air mixtures or similar fuels.

American Heating & Lighting Co., Morenci, Mich.
"Clark Gas Producer."

Delco Appliance Div., General Motors Co., 391 Lyell Ave., Rochester, N. Y. No longer makes the Delcogas generators but does supply "Delcogas fuel" for machines of this type.

Freeport Gas Machine Co., Freeport, Ill.

C. M. Kemp Mfg. Co., 405 E. Oliver St., Baltimore, Md.
National Lighting Co., Arkansas City, Kansas.

Presto Gas Manufacturing Co., 2439-2451 Northwestern Ave., Chicago, Ill. "Gloria Gas Producing Equipment".

Tirrill Gas Machine Corp., 19 Rector St., New York City.