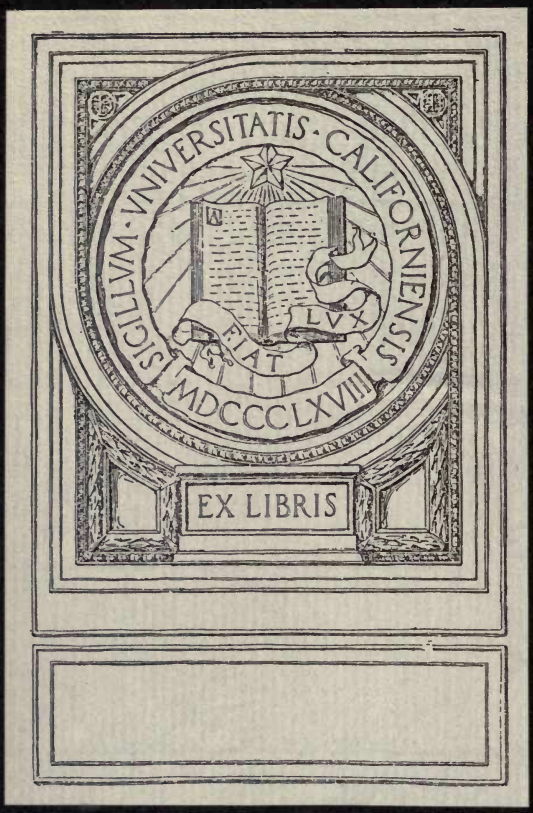

CATECHISM

—ON—

NATURAL GAS

PART OF GAS CONSERVATION PROGRAM OF
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
WASHINGTON, D. C.

REPARED ESPECIALLY FOR HOME ECONOMICS WORKERS TEACHING
CORRECT USE OF NATURAL GAS IN THE HOME

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MAGNITUDE

1. *How many towns in the United States have natural gas?*

   Ans. About 2,000.

2. *Of all the towns in the United States that have gas, what proportion have natural gas?*

   Ans. About one-half.

3. *How many domestic consumers are there in the United States using natural gas?*

   Ans. About 2,500,000.

4. *Of all the gas sold as a public utility service, in the United States, what per cent is natural gas?*

   Ans. About 75%.

5. *What is the geographic distribution of natural gas production?*

   Ans. West Virginia, Oklahoma, Pennsylvania, Ohio, California, Louisiana, Kansas, Texas, New York, Arkansas, Illinois, Kentucky and Indiana produce more than 99% of the entire production in the United States.

NATURAL GAS SITUATION

6. *What is the real crux?*

   Ans. This is aptly stated by the United States Fuel Administration as follows:

   "Natural gas is becoming scarce; the demands for natural gas are now greater than the available supply. When the present supplies are exhausted we must go back to the more expensive and inferior manufactured gas. The use of natural gas is not an inalienable right, but a privilege enjoyed by about 10 per cent of our entire population in the United States, and used in a most extravagant and wasteful manner with no regard for the future, and not appreciated until it is gone.

7. *What will it cost to replace natural gas?*

Ans.

	Amount required to equal 1,000 cubic feet natural gas		Cost of equivalent 1,000 cubic feet natural gas
Kerosene	8½ gal.	@ $0.20	$1.70
Manufactured gas	2,000 cu. ft.	@ 1.25	2.50
Gasoline	9 gal.	@ .30	2.70
Alcohol	15 gal.	@ .40	6.00
Acetylene gas	200 lbs. carbide	@ .04	8.00
Electricity	322 K. W.	@ .06	19.32

8. *Why is the natural gas industry in a transition stage?*

Ans. The total production in the United States has declined 17% in the last two years. There is not enough gas to go around as now used, because the average domestic consumer is creating a demand three times larger than his actual needs, due to the large amount of gas he is wasting in inefficient appliances. The natural gas industry as a whole is now in a transition stage going from a basis of larger volume and extensive use at low prices to a lower volume and intensive use at higher prices per unit.

9. *What does the term "cost" embrace?*

Ans. There is a marked distinction between "cost" and "price." Price is what the seller will take or the buyer will give for a given item of property, and may be more or less than cost. The term "cost" embraces three distinct elements:

a. Expenditures made in operating plant.

b. Liabilities incurred in keeping property value intact. That is, so that the fixed capital entering into the enterprise will be intact, either in the form of tangible property, or a sinking fund when the enterprise stops. The frequent "ostrich attitude" of ignoring this will result in some rude awakenings in the future. Like interest, this is an accumulative factor that is always working and never at rest, thus constantly becoming larger as the inevitable day of reckoning is approached.

c. Rate of return on the property value used for rendering service commensurate with the hazards of the enterprise. The claim has frequently been made that return on capital is not a part of cost, but if the sale price on a particular transaction

does not include this, then the transaction nets no return, and this deficiency must be made up on other transactions, thereby creating discrimination.

10. *What are the dominating service features?*

Ans.

a. Gasoline should be removed.

b. In order to get every foot of gas out of the ground that can be obtained it will be desirable to use more compressing stations and operate existing compressing stations at lower intake pressures.

c. Pooling of field operations is desirable to curtail waste.

d. Gas must be measured into and out of main lines and into distributing plants, so as to get a definite check on leakage conditions.

e. Gas should be distributed at lower and more uniform pressures.

f. Gas must be used more efficiently. The ordinary natural gas cooking stove now in use wastes about 85% of the gas used. The ordinary coal furnace burning gas in the fire pot, wastes about 75% of the gas used. These wastes must obviously be corrected if gas is to be conserved.

g. Gas must be made worth saving. This will automatically result:

First, in taking much more of the gas out of the ground,

Second, in transmitting the gas from the field to the consumer with a minimum of waste, and

Third, in the consumer using the gas in an efficient manner.

11. *What is the summary of the present natural gas situation?*

Ans.

a. Rock pressure decline has been general and very marked.

b. Volume of producing wells has declined.

c. Volume of new wells now drilled is much lower than that of earlier wells.

d. Number acres natural gas land reserved per domestic consumer on decline.

e. Number domestic consumers has increased rapidly.

f. Large increase in compressing station capacity has been made necessary by rapidly declining rock pressure.

g. Costs of producing, transmitting and distributing natural gas have greatly increased.

SOURCE OF NATURAL GAS

12. *How do we get natural gas?*

Ans. Natural gas is secured by drilling a hole down from the earth's surface and tapping the underground rock formation in which the gas is stored.

13. *How is natural gas formed?*

Ans. No one knows how natural gas was formed.

14. *What is the meaning of "gas sand" or "gas rock"?*

Ans. In no case is the gas found in rooms, caverns, or large crevices, as popularly supposed. "The oil and gas sands are simply very porous rocks which contain not one great cavity, but millions upon millions of small or microscopic cavities, so that the oil, gas, water, or all three together, it may be, occupy these numerous little spaces, and thus saturate the rock just as water does a piece of cloth or a sponge when dipped into the same. The larger these pores are, and the greater the volume they occupy in proportion to the volume of the rock mass, the greater will be the contained oil or gas supply, and this proportion in fairly good producing sands, usually varies between one-fifth and one-tenth."

15. *Why must rock pressure decline?*

Ans. The rock pressure and volume must decline as gas is removed, because in the removal of the deposit of gas we are confronted with the following:

a. A fixed volume of the reservoir.

b. A fixed amount of gas inclosed in this fixed reservoir.

c. A certain rock pressure resulting from the contraction of the gas volume into the fixed reservoir.

Now, if a part of this fixed volume of gas is removed by tapping the reservoir from the surface of the earth, the remaining gas volume expands and keeps the reservoir completely filled, but at a lower pressure. Rock pressure decline is therefore inevitable whenever any gas is removed.

16. *Is there any regeneration of natural gas?*

Ans. No; when it is used it is gone forever.

PROPERTIES

17. *What is natural gas?*

Ans. Natural gas is a highly combustible gas made by a secret process of nature.

18. *Is natural gas a chemical compound?*

Ans. It is not a chemical compound—as popularly supposed—but a mechanical mixture of several combustible and diluent gases and vapors thoroughly diffused through each other, the number and exact proportion of the various crude natural constituents varying for the different localities and somewhat during the working lives of individual wells.

19. *How much will 1,000 cubic feet of natural gas weigh?*

Ans. About 50 lbs.

20. *Is natural gas heavier or lighter than air?*

Ans. Lighter, weighing about 60% to 70% of the weight of air.

21. *Does natural gas have an odor?*

Ans. Not a distinctive one.

22. *Would there be an advantage in giving natural gas an offensive odor?*

Ans. Yes, so as to make it easier to locate gas leaks.

23. *Is natural gas poisonous?*

Ans. Natural gas does not have any toxic action, and can cause death only by robbing the atmosphere of a room of its oxygen.

24. *Are there any other fuels refined by nature and ready for gaseous use?*

Ans. None.

25. *How do the uses of natural gas compare with the uses of manufactured gas?*

Ans. Natural gas can do everything that manufactured gas need do, and many things that manufactured gas cannot do.

PRESSURE

26. *What is the cause of gas pressure?*

Ans. The gases inherent tendency to expand.

27. *How does the gas come to the surface?*

Ans. By expansion up through the tubing which is placed in the hole.

28. *What makes gas flow through pipe lines?*

Ans. Its universal tendency to expand.

29. *What is the effect of gas pressure on gas volume?*

Ans. An increase in pressure decreases the volume, and a decrease in pressure will allow the volume to increase.

30. *What is barometric pressure?*

Ans. Merely the pressure of the atmosphere as shown by a barometer.

31. *What does the term "gage pressure" mean?*

Ans. Merely the pressure shown by a gage.

32. *What does the term "absolute pressure" mean?*

Ans. This is the sum of barometric pressure and gage pressure.

33. *If 1,000 cubic feet of gas, at an atmospheric pressure of 14.4 lbs. per sq. in. has its pressure increased to 4 ounces (.25 lb.) what is the effect on the volume?*

Ans. The absolute pressure at 4 ounces will be: 14.40 plus .25=14.65.

Then from Boyle's Law 14.65 is to 14.40 as 1,000 is to X.

$$X = \frac{14.40 \times 1{,}000}{14.65} = 983 \text{ cubic feet} = 1.7\% \text{ contraction of volume.}$$

34. *Are uniform pressures in natural gas distributing plants possible?*

Ans. No.

35. *What does the term "rock pressure" mean?*

Ans. When nature generated or deposited the natural gas in the rock reservoir—made up of the microscopic cavities between the sand grains—a fixed amount of gas was placed in a fixed inclosed space. The pressure in the rock—called "rock pressure"—was the result of the pressing into this fixed rock space of a larger volume of gas than the mere free air capacity of this rock reservoir. The degree of compression employed by nature in the formation process determined the intensity of the resulting pressure in the reservoir; that is, a high degree of compression produced a high rock pressure, and a low degree of compression produced a low rock pressure.

TEMPERATURE

36. *What is temperature?*

Ans. The term "temperature" indicates hotness or intensity.

37. *How is temperature measured?*

Ans. By means of a thermometer.

38. *What is the effect of temperature on gas volume?*

Ans. Each 5 degrees increase in temperature makes an increase of about 1% in volume, and each 5 degrees decrease in temperature makes a decrease of about 1% in volume.

39. *What is the effect of temperature on gas volume?*

Ans. Temperature changes will neither destroy nor create any heat units and these will neither increase nor decrease the total number of heat units contained in gas. However, the volumetric changes resulting from changes in temperature will always alter the distribution of the total number of heat units.

40. *Why do atmospheric temperature changes have more effect on the heating value of gas than changes of gas pressure?*

Ans. The variation in temperature of natural gas in the underground mains makes more difference in heating value than the variation in gage pressure. The

maximum fluctuation in temperature produces a difference in heating value of about 5%, while the maximum fluctuation in gage pressure on the domestic consumer's premises produces a difference in heating value of less than 4%.

41. *Why is the heating value of natural gas higher in winter than in summer?*

Ans. The variations referred to in the preceding answer work in opposite directions. That is, in winter time when the pressure is low, therefore tending to decrease the heating value, the temperature is lower and therefore thus tending to increase the heating value. This increase, due to low temperature will always be more than the decrease due to low pressure.

STANDARD CONDITION

42. *What does the expression "standard condition" mean?*

Ans. Since the volume of gas is affected by both temperature and pressure, it is necessary to specify some definite basis of standard condition for both of these, in comparing one gas with another.

43. *What reference bases are usually used for temperature and pressure?*

Ans. In giving the heating value or any other determination relating to a given gas, it is usually given as if the temperature of the gas were 32° F. and the pressure the same as atmospheric pressure at sea level, namely, 30 inches, or what is the same thing, 760 millimeters, abbreviated mm. of mercury. 60° F. is also frequently used.

STORAGE

44. *Is the storage of gas feasible in the field?*

Ans. No.

45. *Is the storage of natural gas feasible in transit between the field and the cities?*

Ans. No.

46. *Is any storage feasible in the distributing plant?*

Ans. The only plan that can be used would be to allow the gas to expand in a gas holder, similar to that used for storing manufactured gas. Ordinarily it would not be expedient to build new holders for this purpose.

NATURAL GAS COMPRESSORS

47. *How is the natural pressure of the gas increased?*

Ans. By means of a device known as a gas compressor.

48. *What is a gas compressor?*

Ans. A gas compressor is merely a stationary cylinder which has a moving piston within that contracts the volume of the gas and thereby increases the pressure.

49. *Why is natural gas compressed?*

Ans. Merely to expedite transmission, for the same reason that makes it necessary to compress cotton, hay, or straw for shipment.

50. *How long have gas compressors been used?*

Ans. More than 30 years.

51. *Could gas be delivered to consumers without compressors?*

Ans. No.

52. *Could the residue supplies of natural gas in the field be removed without compressors?*

Ans. No.

53. *Why could the gas not be delivered without compressors?*

Ans. If compressors were not used to supplement the declining natural pressures, then the size and number of lines that would be necessary to transmit the gas under the lower natural pressure would be so large as to make it impossible to operate.

54. *Does compressing gas lower its heating value?*

Ans. No.

55. *To what pressure is the gas ordinarily raised at the intake of transmission lines?*

Ans. From 200 to 400 lbs.

56. *What pressure will you have at the end of a transmission line?*

Ans. This varies largely with the distance, quantity of gas handled, and size of line. However, it is a very common occurrence to have a pressure drop between the intake and discharge end of a line of more than 200 lbs.

57. *What causes the pressure drop?*

Ans. The friction of the line.

NATURAL GAS SERVICE PROBLEMS

58. *What is the relation between the demand of the average domestic consumer in winter and in summer time?*

Ans. The demand in winter is frequently 15 times greater than in summer.

59. *What is the effect of atmospheric temperature on natural gas loads?*

Ans. The temperature of the atmosphere has a direct bearing on the demands for natural gas for heating service. However, the quantity of cooking, incidental hot water heating, and lighting is independent of the temperature of the atmosphere and would be practically constant for the year. The humidity of the atmosphere, direction and velocity of wind, and hours of sunshine, also affect gas consumption, as far as heating service is concerned. In general a high wind causes more of an increase than merely a low temperature. The mean monthly temperature curve plotted upside down will always show a close relationship between volume of gas used and temperature of atmosphere.

60. *What is the peak load condition of the average natural gas plant?*

Ans. Abnormal peaks of very short duration are characteristic of all natural gas loads for domestic consumers. It is because the domestic consumer creates a demand larger than the gas company can supply that the service is frequently so inadequate during extremely cold weather.

61. *Why do peak loads increase the cost of service?*

Ans. An increase of volume of business can decrease the cost of production only when the increment of increase is distributed so as to make possible the more efficient use of existing equipment. When the increment of increase is concentrated so as to require more equipment, as is the case in all peak loads, the cost of production to the unit of service is increased. Therefore, the cost of peak load natural gas service is greater than the cost of normal service.

62. *Why should consumers that create the peak load pay a higher rate for their larger consumption, that is, a sliding scale upward rate?*

Ans. A rate schedule to be equitable to all consumers must make the consumers who need and create the peak load service pay a price that will be commensurate with the extra cost of the service they are receiving.

63. *Why must standards for service be lower for natural gas than for manufactured gas?*

Ans. The operating conditions in a natural gas plant are so different from those prevailing in a manufactured gas plant that the standards of service that would reasonably be applicable to the latter would not be feasible or expedient with natural gas, because:

a. The volume of natural gas business for each domestic consumer is generally about five times as large as for manufactured gas.

b. The peak load difficulties in a natural gas load are much more troublesome than in manufactured gas, due primarily to the heating load, which fluctuates with the atmospheric temperature.

c. The service standards can not be limited to merely the distributing plant limits, but would be closely related to the main pipe lines, back into the field to the compressing stations, and general field operating conditions.

d. The natural gas company can not create the basic feature of the service it is selling to the public, but must depend entirely on the caprice of nature for this.

e. Every foot of gas sold represents in effect the sale of a part of the company's property.

f. Since there is no regeneration, the supply can be kept continuous only by constant and persistent hunting for new supplies.

g. Although the distributing end is a public utility service, the field or producing end is a mining propostion, and the continuous connection of the two by the transmission line has the imme-

diate effect of also connecting the mining hazards to the distributing end of the business.

h. The migratory tendencies and fugitive nature of natural gas under the ground make its reduction to possession much more difficult than for solid minerals.

i. In general, the prices for natural gas service have not been adequate, and have not been made on the basis of rendering as uniform a condition of service, especially with regard to pressure, as can be maintained in a manufactured gas plant.

j. Both the quality and quantity are entirely controlled by nature.

64. *Would making natural gas transmission lines common carriers improve or injure the service of the domestic consumer?*

Ans. No.

65. *Is a discount for pressures lower than 4 ounces desirable from a public viewpoint?*

Ans. No.

66. *What is the real practical effect of a penalty discount?*

Ans. Stimulates waste and tends to make a bad condition worse.

67. *Why has industrial gas been sold?*

Ans. The average load on a natural gas plant is only about one-third of the total capacity necessary to meet the winter demand. This emphasizes the many opportunities for rendering service which the domestic consumer can not utilize. In order to sell gas cheaper to the domestic consumer and use the plant for a larger number of hours, the companies began selling gas to industrial users during the summer months, when the domestic consumption was very low. Since in most fields there is unrestricted competition between various companies, this had the immediate effect to make it impossible for any one company to conserve the gas for future use without co-operation with its competitors. The public has frowned upon any arrangements for co-operation on the theory that competition was desirable. This has resulted in a wild race between the various companies, each trying to get the gas out

of the field, with the result that the supplies were drained very heavily and are, therefore, not available for further use.

AIR IN NATURAL GAS

68. *Do natural gas companies mix air with the gas?*

Ans. No.

69. *How would you test natural gas to determine whether air had been mixed?*

Ans. By making a heating value determination, or chemical analysis.

70. *How may high pressure gas in a domestic appliance behave so as to lead the consumer to believe that air instead of gas is coming through the appliance?*

Ans. If the full pressure of gas is turned on it may be so high as to actually blow out the flame and give an erroneous impression that the gas will not burn.

GASOLINE REMOVAL

71. *In what forms does petroleum exist under ground?*

Ans. Solid, liquid, vapor and gas.

72. *What forms of petroleum can the domestic consumer use?*

Ans. Gaseous only.

73. *What do the terms "wet gas" and "dry gas" mean?*

Ans. Natural gases coming from the ground may be classed—according to their gasoline vapor content—into two main groups, namely:

1. *Wet gas.*—This is gas intimately associated with oil, usually produced with oil, and is ordinarily known as casing head natural gas.

2. *Dry gas.*—This is gas not intimately associated with oil, but may nevertheless contain gasoline vapors. The term "dry" does not refer to water vapor that may be carried by the gas, but rather to the gasoline vapor, and, furthermore, this is a relative term since a strictly dry gas would be one containing no gasoline vapors.

74. *How much does the removal of gasoline lower the heating value of natural gas?*

Ans. It does not affect the gas proper, but the removal of the gasoline vapor lowers the combined heating value of the gas and vapor less than 3%.

75. *Why is gasoline removal desirable from a service viewpoint?*

Ans. If the gasoline is not removed the condensed vapors will injure the joints in the line and increase the leakage. The condensed vapor may also freeze, causing interruption of service and disturbed pressure conditions. Gasoline vapor always exists in such form that practically none of it can ever be delivered to the ultimate consumer, and the heating value is little disturbed because the removal of gasoline from natural gas lowers the heating value only about 2%.*

76. *Is gasoline removal from natural gas a separation or an alteration?*

Ans. Merely a separation of two natural substances.

77. *How do temperature and pressure determine the form assumed by petroleum constituents?*

Ans. The various compounds and elements mixed together in petroleum will exist in the different forms of the solid, liquid, vaporous or gaseous state, depending on temperature and pressure. At low temperatures or high pressures the vapors and gases may be changed to liquids. At extremely low temperatures all are solids. At high temperatures the vapors may become gases.

78. *Are constituents other than gasoline vapor separated from natural gas?*

Ans. Yes, water vapor and the element helium.

GAS MEASUREMENT

79. *How does the accuracy of the average domestic natural gas consumer's meter compare with its general reputation?*

Ans. The accuracy of the meter is very much better than its popular reputation. The percentage of inaccurate meters will be very much lower than the percentage of inaccurate measuring devices for selling ordinary household commodities.

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* Bureau of Mines Technical Paper 253 on "Effects of Gasoline Removal on the Heating Value of Natural Gas."

80. *How are gas meters tested?*

Ans. By checking them against a device known as a meter prover, which is merely a tank that can be made to discharge a known volume of gas through the meter.

81. *Have gas meters any power within themselves to register?*

Ans. No.

82. *Is the gas consumption increased by the use of a large meter?*

Ans. No.

83. *Can the gas consumption be decreased by the use of a small meter?*

Ans. No.

84. *Does high gas pressure increase or decrease the rate of registration of a meter?*

Ans. No.

85. *Does low gas pressure increase or decrease the rate of registration of a meter?*

Ans. No.

86. *Is it possible for a gas meter to register twice?*

Ans. No.

87. *Are meters generally fast?*

Ans. No.

88. *What is the present state of the gas measuring art, as relating to large volume measurement?*

Ans. Large volume meters are available, and will give accurate results if properly installed and correctly operated.

89. *Is there any excuse for a gas company not measuring the gas into its main lines and into its distributing plants?*

Ans. No.

DOMESTIC CONSUMPTION

90. *What is the average amount of natural gas consumed per domestic consumer per annum in West Virginia, Pennsylvania, New York, Ohio, Maryland, Indiana, Kentucky and the entire United States?*

Ans. For the respective states the average annual consumption per domestic consumer is as follows:

West Virginia	158	"M"	cu. ft.
Pennsylvania	120	"	"
New York	120	"	"
Ohio	100	"	"
Maryland	79	"	"
Indiana	76	"	"
Kentucky	68	"	"
Average for entire United States	102	"	"

91. *What is the average amount of money spent per annum by each domestic consumer in the United States for natural gas service?*

Ans. $31.00.

92. *What is the average family monthly consumption for cooking, lighting, hot water heating and incidental heating like bath room heater or bed room, and laundry stove, etc.?*

Ans. With proper use this will average less than 4 "M" (4,000) cubic feet per month.

HEATING VALUE

93. *How is the heating value of gas determined?*

Ans. By means of an apparatus known as a calorimeter.

94. *What is a B. t. u.?*

Ans. This is merely a unit or yard stick for measuring the quantity of heat produced by burning a given amount of fuel, and is represented by the amount of heat required to heat one pound of water one degree Fahrenheit.

95. *What is the relation of a B. t. u. and a Calorie?*

Ans. One Calorie equals 3.96 B. t. u.

96. *What is meant by the heating value of gas?*

Ans. This simply means the number of heat units that are produced by burning a given amount of gas.

97. *What is the average heating value of natural gas?*

Ans. About 1,000 B. t. u. per cubic foot.

98. *What is the average heating value of manufactured gas?*

Ans. About 575 B. t. u. per cubic foot.

99. *Does the wind have any effect on the heating value of gas?*

Ans. No.

COMBUSTION

100. *Why must air be mixed with gas before it is burned?*

Ans. To furnish oxygen for combustion.

101. *How much air must be mixed with natural gas?*

Ans. About 9½ cubic feet of air per cubic foot of natural gas.

102. *What is the average B. t. u. content of the gas and air mixture as it is burned at the burner?*

Ans. About 100 B. t. u. per cubic foot. The lower the heating value the smaller will be the air necessary so that the B. t. u. content of the mixture ready for combustion will be approximately the same for 125 B. t. u. producer gas or 1,200 B. t. u. natural gas.

103. *Where is the air necessary for combustion mixed with the gas?*

Ans. At the consumer's burning appliances.

104. *Does any of the air necessary for combustion go through the meter?*

Ans. No.

105. *What results when not enough air is mixed with the gas?*

Ans. Incomplete combustion.

106. *What is a Bunsen flame burner?*

Ans. One in which a part of the air for combustion is mixed with the gas in the burner before reaching the flame.

107. *What is a yellow flame burner?*

Ans. If natural gas is forced out through a small hole about the diameter of a pin, enough air can be mixed with the issuing gas to insure perfect combustion. This is the principle of the yellow or luminous flame burner.

108. *What is the fundamental distinction between a yellow flame and a Bunsen flame burner?*

Ans. The Bunsen burner, when properly adjusted, will burn with a clean blue flame, which will not deposit carbon when striking a cooler surface. If a yellow flame strikes a cold surface not only carbon will be deposited but the combustion will be imperfect.

109. *What is meant by the term "combustion products"?*

Ans. When anything is burned a chemical change results from the uniting of the oxygen of the air with whatever is burned, forming new substances which are the combustion products of the material that has been burned.

110. *Can anything be burned without forming combustion products?*

Ans. No.

111. *What is meant by the term "perfect combustion"?*

Ans. A fuel is said to undergo perfect combustion when it is completely burned leaving no residue of unburned fuel.

112. *Are combustion products formed with perfect combustion?*

Ans. Yes, for the reasons given in the answer to Question 109.

113. *What does the term "smoke" mean?*

Ans. When the combustion products carry minute visible particles of carbon these small particles of carbon are called smoke; smoke is, therefore, the result of incomplete combustion.

114. *What is smokeless combustion?*

Ans. This is merely combustion which produces combustion products which do not carry small particles of visible carbon.

115. *Is smokeless combustion necessarily perfect combustion?*

Ans. No.

116. *Why is it that smokeless combustion is not necessarily perfect combustion?*

Ans. Because carbon monoxide may be formed, which, while it is smokeless, yet represents a waste of fuel.

GAS UTILIZATION

117. *How is natural gas used for illumination?*

Ans. By burning it in an incandescent mantle.

118. *Is the candle power requirement in manufactured gas desirable?*

Ans. No.

119. *Why is the candle power requirement no longer desirable even with manufactured gas for illumination?*

Ans. Because the illumination art has advanced so far that it is no longer desirable to use even manufactured gas in open flame burners. The candle power requirement is therefore of no particular value, since manufactured gas should be used only in incandescent mantles.

120. *What makes the illumination in an incandescent mantle?*

Ans. The illumination is produced by the heat in the gas heating the mantle to a white heat. Since natural gas has a higher heating value than manufactured gas, it is, of course, a larger carrier of heat energy to the mantle for this service.

121. *How does the consumer's method of gas utilization determine the quality of service produced?*

Ans. The results obtained will depend primarily on the appliances and the consumer's adjustment of the appliances.

122. *Why have low set burners been used in natural gas cooking stoves?*

Ans. Because the gas was considered so cheap as not to be worth saving, coupled with a mistaken idea that solid tops were necessary

123. *Why should low set burners not be used in natural gas cooking stoves?*

Ans. Because they are wasteful under all conditions, and ineffective at low pressures.

124. *How can low set burners in natural gas cooking stoves be raised to proper height?*

Ans. By raising the manifold (nickel plated pipe holding burner cocks) and supports for burners on stove top.

125. *Why were solid tops used with natural gas cooking stoves?*

Ans. Because of the mistaken idea that natural gas produced some mysterious poisonous fume.

126. *Why should skeleton lids or grid tops be used with natural gas stoves?*

Ans. Because more effective results can be obtained than with solid tops.

127. *How can low pressure gas be used for cooking?*

Ans. If the vessel is brought down so that the tip of the short flame can strike the vessel, satisfactory results can be obtained.

128. *Is there any particular advantage in slotted or drilled burners?*

Ans. Drilled burners are easier to keep clean and will give better combustion conditions.

129. *What is the correct burner position in a cook stove?*

Ans. About 1¼ inches below the vessel.

130. *How can you cook efficiently with high pressures?*

Ans. First raise the burners so that the vessel will be about 1¼ inches above the burner openings, then efficient short-flame combustion conditions may be obtained by partly opening the gas cock.

131. *Why is more gas used for cooking in winter than in summer?*

Ans. The food is colder and requires more heating and the radiating loss is also much greater.

132. *What is the difference between cooking and heating?*

Ans. In a heating operation it is merely necessary to secure perfect combustion in the heating device, because in so doing all of the available heat in the gas can be utilized. In cooking it is not only desirable to secure a perfect combustion, but absolutely necessary to direct the heat to a particular place, in a particular manner, and sometimes at a particular time. It is for this reason that gas-cooking operations are more susceptible to changed pressure conditions than heating operations.

It may not be amiss to emphasize that the time element in many cooking operations is of much more importance than intensity.

133. *What are the steps necessary in correct house heating?*

Ans. First correctly burn the gas, then get the heat, with a minimum of loss, into the room.

134. *Why are flueless heating stoves objectionable?*

Ans. Because the combustion conditions may be very dangerous to life.

135. *Why are flueless heating stoves more dangerous than flueless cooking stoves?*

Ans. Flueless heating stoves are usually used in bed rooms and bath rooms, where the ventilation is inadequate, the stoves are used frequently 24 hours a day and where the room occupant will have the head close to the floor and may be asleep for a long period of time.

In kitchens the room is much better ventilated, the gas is used a relatively short time, the person walking around with head farther from the floor, and the danger here is negligible.

136. *How may gas combustion products injure a chimney?*

Ans. The water vapor may disintegrate the mortar.

137. *Why may the heating value of natural gas seem lower on windy days than on equally cold still days?*

Ans. Because it takes much more gas to heat on a windy day owing to the large amount of cold air driven into the room.

138. *How much gas is wasted by leakage on the average consumer's premises?*

Ans. One-sixth the total amount used.

139. *How is gas wasted by high pressure?*

Ans. By blowing of burners.

140. *How is gas wasted by imperfect combustion?*

Ans. The unburned gas will cause smoke and also not utilize all of the heating value.

141. *How is gas wasted by low-set burners on cooking stoves?*

Ans. When the flame cannot reach the burner a longer time is required for cooking, thus using more gas, and the radiating loss is much greater.

142. *How is gas wasted by improperly directed flames on cooking stoves?*

Ans. Even with proper length of flame, if the flame is deflected by a strong draft the amount of gas needed will be materially increased.

143. *How is gas wasted by using gas before and after cooking?*

Ans. Because the only heat that does any good is the heat that goes into the food cells.

144. *Why is the use of gas in coal stoves or coal furnaces wasteful?*

Ans. Because the path traveled by the flame is short and the radiating surface is relatively small.

145. *What is the relative fire travel—that is distance that combustion products travel in contact wih radiating surface —in a coal furnace and a gas furnace?*

Ans. The fire travel in a properly built gas furnace will usually be five times as long as in the ordinary coal furnace.

146. *What is the relative radiating surface in a coal furnace and a gas furnace?*

Ans. A correctly built natural gas furnace will have about 2½ times as much radiating surface as the ordinary coal furnace.

147. *What is the relative efficiency of a coal furnace and a gas furnace?*

Ans. The efficiency of a correctly built natural gas furnace will be about three times as large as that of the ordinary coal furnace.

148. *How is gas wasted by excessive heating?*

Ans. Most rooms are kept at too high a temperature.

149. *How is gas wasted by daylight burning of lamps?*

Ans. Three lamps burning 24 hours a day waste enough gas to supply one domestic consumer.

150. *How is gas wasted by improper lamp adjustment?*

Ans. By using much more gas than necessary.

151. *How is gas wasted by dirty appliances?*

Ans. By improper application of heat, imperfect combustion, and using more gas than necessary.

152. *How is gas wasted in hot water heaters?*

Ans. Water frequently produces a scale inside the heater that greatly increases the heat used, and the radiating surface under most heaters is so small as not to adequately absorb the heat generated.

153. *What are some of the wastes of natural gas in a home that could easily be corrected and ought, therefore, to be prohibited?*

Ans.

a. Improper adjustment of appliances, resulting in imperfect combustion.

b. Low burners — that is, burners more than 1¼ inches away from the cooking vessel on cook stoves.

c. Solid tops on cook stoves. Grid tops or skeleton lids only should be used.

d. Use of gas in coal furnaces and stoves. Especially built gas-heating appliances, giving an efficiency of at least 75 per cent should be used.

e. No hot-water heater should be used that gives an efficiency of less than 75 per cent.

f. No tank heater, that is, tank with burner underneath, should be used without an outer jacket and flue connection.

g. All daylight burning of lamps ought to be prohibited.

The prohibition of the foregoing wasteful uses of natural gas would—

a. Greatly improve the quality of the service.

b. Immediately convert low-pressure conditions into usable service for cooking.

c. Cut down the needed consumption during the cold-weather period — where the demand is now greater than the available supply—so as in effect to make more gas available for all.

d. Add 15 to 20 years to the period that natural gas will be available for domestic use.

e. Because of the greatly increased efficiencies obtained—even with decidedly higher prices per 1,000 cubic feet—would permit the domestic consumer to get the same service without a greater annual outlay of money.

f. Permit the many small towns that are too small for the introduction of manufactured gas to have gas service for a much longer period.

154. *Why are manufactured gas cooking stoves better than natural gas cooking stoves?*

Ans. Because they are more efficient at all pressures and more effective at low pressures.

155. *What is the difference between a manufactured gas cooking stove and a natural gas cooking stove?*

Ans. Only in burner distance and type of top—manufactured gas stoves have the burners about 1¼ inches from the vessel bottom and are always fitted with grid or open tops. Natural gas stoves have the burner distance from 2½ to 3 inches below the vessel bottom, and are nearly always erroneously fitted with solid tops.

156. *Why is cooking during low pressure period more important than heating?*

Ans. Because if the consumer can use the low pressure gas effectively and cook a meal without serious difficulty he is in a much better frame of mind to forego the inadequate heating service during the peak load period in extremely cold weather.

157. *If calcium carbide, for making acetylene gas, costs 4c per lb., what is natural gas worth per "M" cubic feet for the same number of heat units received?*

Ans. $7.00 per "M" cubic feet.

158. *If denatured alcohol costs 40c per gallon, what is natural gas worth per "M" cubic feet for the same number of heat units received?*

Ans. $5.40 per "M" cubic feet.

159. *If gasoline costs 25c per gallon, what is natural gas worth per "M" cubic feet for the same number of heat units received?*

Ans. $2.00 per "M" cubic feet.

160. *If manufactured gas costs $1.25 per "M" cubic feet, what is natural gas worth per "M" cubic feet for the same number of heat units received?*

Ans. $2.50 per "M" cubic feet.

161. *If electricity costs 3c per k .w. hour and is used for heating with 100% efficiency, and natural gas is used in a furnace giving 80% efficiency, what is natural gas worth, per "M" cubic feet for the same number of available heat units?*

Ans. $7.00 per "M" cubic feet.

162. *With electricity at 3c per k. w. hour, for cooking, what do the Home Economics Department tests,* of The Ohio State University, show would be the worth of natural gas per "M" cubic feet, for cooking, using properly directed short flames?*

Ans. $4.60 per "M" cubic feet.

163. *With soft coal at $6.50 per ton, for cooking, what do the Home Economics Department tests,* of The Ohio State University, show would be the worth of natural gas per "M" cubic feet, for cooking, using properly directed short flames?*

Ans. $2.50 per "M" cubic feet.

* Kitchen Tests of Relative Cost of Natural Gas, Soft Coal, Coal Oil, Gasoline and Electricity for cooking. Department of Home Economics. Ohio State University, Columbus, Ohio.

164. *With gasoline at 27c per gallon, for cooknig, what do the Home Economics Department tests,* of The Ohio State University, show would be the worth of natural gas per "M" cubic feet, for cooking, using properly directed short flames?*

Ans. $4.00 per "M" cubic feet.

165. *With coal oil at 15c per gallon, for cooking, what do the Home Economics Department tests,* of The Ohio State University, show would be the worth of natural gas per "M" cubic feet, for cooking, using properly directed short flames?*

Ans. $5.00 per "M" cubic feet.

166. *With electricity at 5c per k. w. hour, used in a Tungsten lamp, what is natural gas, burned in an incandescent mantle lamp, worth per "M" cubic feet to give the same amount of illumination?*

Ans. $1.60 per "M" cubic feet.

167. *With coal oil at 12c per gallon, burned in an oil lamp, what is natural gas, burned in an incandescent mantle lamp, worth per "M" cubic feet to give the same amount of illumination?*

Ans. $5.00 per "M" cubic feet.

168. *With gasoline at 18c per gallon, burned in a gasoline lamp, what is natural gas, burned in an incandescent mantle lamp, worth per "M" cubic feet to give the same amount of illumination?*

Ans. $2.00 per "M" cubic feet.

169. *With calcium carbide at 4c per lb. to make acetylene gas, what is natural gas burned in an incandescent mantle lamp, worth per "M" cubic feet to give the same amount of illumination?*

Ans. $5.00 per "M" cubic feet.

170. *How many B. t. u. in a k. w. of electric energy?*

Ans. 3,412.

171. *How many B. t. u. in 1,000 cubic feet of natural gas?*

Ans. An average of about 1,000,000.

* Kitchen Tests of Relative Cost of Natural Gas, Soft Coal, Coal Oil, Gasoline and Electricity for cooking. Department of Home Economics. Ohio State University, Columbus, Ohio.

172. *What per cent of the B. t. u. in coal used in creating electric energy is available in electric energy at the consumer's premises?*

Ans. About 5%.

GOING BACK TO MANUFACTURED GAS

173. *What is meant by the term "manufactured gas"?*

Ans. The term "artificial gas" has been used synonymously for manufactured gas, both meaning a gas that has been made by mechanical and not by natural means.

174. *How much lower is the heating value of manufactured gas than natural gas?*

Ans. About one-half.

175. *Could manufactured gas be used in the present natural gas stoves?*

Ans. Not without raising burners, adjusting mixers, and substituting grid for solid tops.

176. *What is the average annual gas consumption of the domestic manufactured gas consumers in the United States?*

Ans. 22 "M" cubic feet.

177. *What is the average annual gas consumption of the domestic natural gas consumers in the United States?*

Ans. 100 "M" cubic feet.

178. *What would be the probable average annual consumption of natural gas per domestic consumer if natural gas were used as efficiently as manufactured gas and sold on a manufactured gas basis?*

Ans. 40 "M" cubic feet.

179. *Would it be generally feasible to build large central plants to make manufactured gas, and pipe it long distances through existing natural gas transmission lines?*

Ans. No.

180. *Is mixing of manufactured and natural gas possible?*

Ans. Yes.

181. *Why will it not be possible to serve many of the smaller towns along the present natural gas lines with gas, if the large towns go back to manufactured gas?*

Ans. Because manufactured gas plants cannot be advantageously operated in small towns.

CONSERVATION

182. *What does the term "conservation" mean?*

Ans. A wise use and equitable exhaustion with a maximum efficiency and minimum waste.

183. *What is the difference between conserving and hoarding?*

Ans. Hoarding is merely saving for the future; conservation is proper use at the present.

184. *What publications has the United States Government published on gas conservation?*

Ans. The United States Bureau of Mines, Washington, D. C., on gas field situations has published Technical Papers 38, 42, 45, 53, 66, 68, 130, and Bulletins 65, 134 and 163, and on Waste and Correct Use of Natural Gas in the Home, Technical Paper 257.

The Smithsonian Institution, Washington, D. C., Bulletin 102, Part 7, on Natural Gas: Its Production, Service and Conservation.

185. *How many years would be added to possible natural gas service by the immediate adoption of a comprehensive conservation program?*

Ans. From 15 to 20 years.

186. *Why has industrial gas been sold?*

Ans. Because under existing operating conditions in the past it could not be conserved, and the income from the low-priced gas sold to the domestic consumers is not enough.

PRICE

187. *What is the effect of price of gas on gas consumption?*

Ans. An increase in price will in general always lower the consumption. In fact the average consumer's annual bill will remain the same whether the price is 10c or $1.00 per "M" cubic feet.

188. *What is the average price of domestic natural gas in the United States?*

Ans. About 32c per "M" cubic feet.

189. *What is the average price of manufactured gas in the United States?*

Ans. For the newer rates the average is in excess of $1.25 per "M" cubic feet.

190. *What is the average natural gas bill of domestic natural gas consumers in the United States?*

Ans. The average annual bill of 2½ million (2,500,000) domestic consumers in the United States is slightly less than $31.00 per year.

191. *Why have consumers found that $1.00 manufactured gas cost them no more for the same service than 30c natural gas?*

Ans. The manufactured gas was used carefully, in efficient appliances, whereas the natural gas was used carelessly in grossly inefficient appliances.

192. *What effect has a change in price on gross income of a natural gas company?*

Ans. An increase in price per "M" will generally make no material difference in the gross income received, because the average domestic consumer by substituting efficient equipment for the usual inefficient equipment can get the same service with one-third of the volume of gas consumption. In fact trebling the price per "M" cubic feet of gas not only will not increase the income of a gas company, but will probably decrease it because of the smaller sales.

193. *Why is natural gas merely a by-product of the oil industry?*

Ans. Because most gas pools have been discovered by prospectors in search of oil.

194. *What is the effect of retail price on field conditions?*

Ans. Because natural gas has generally been merely a by-product of oil prospecting and low prices have prevailed, the gas has not been worth saving. However, an increased retail price will immediately raise the price level in the field, and will have the practical effect of making the gas worth saving and, therefore, available for the public.

195. *How can the retail price of natural gas make the resid supplies of natural gas in the field, which now go waste, available?*

Ans. If the retail price is made high enough so as raise the field price to a level where the gas will worth saving, much residue gas — now left in t ground because the cost of removal would be grea than the low field price obtained—can be pumped o of the underground formations and be made ava able.

196. *What percentage of the average family income is spent natural gas service?*

Ans. As the average family natural gas bill is less th $31.00 per annum, it is obvious that this represents insignificantly small part of the average family come.

197. *What is the only thing that will adequately conserve tural gas and insure continuity of gas service for t future?*

Ans. Making the gas worth saving.

198. *What are some of the conveniences of natural gas not or narily considered in price comparisons?*

Ans.

a. Cost of having solid fuel placed in house. M coal or oil prices do not include delivery in ba ment.

b. Labor in shoveling or handling solid or liquid fue

c. Labor and annoyance in handling ashes.

d. Elimination of dirt from soot and ashes.

e. Much better fire control than is possible with c or oil.

f. No odor.

g. No preliminary preparation of fire necessary give service.

h. Coal is paid for in advance, frequently long befo it is used. Natural gas service is paid for lo after it has been used; incidentally the consum frequently forgetting the unusual weather con tions that prevailed during the preceding consum tion period, which weather conditions were respo sible for the higher bill.