DOMESTIC OIL HEATING

Serial 2590 Edition 1

OIL FUEL AND OIL BURNING

OIL FUEL FOR HEATING

SOURCES OF OIL FUEL

1. Nature of Petroleum.—Liquid fuel is obtained from petroleum, which is a liquid occurring in the earth, and varies greatly in appearance according to the locality in which it is found. Petroleum consists mainly of hydrocarbons, but contains comparatively small quantities of sulphur, oxygen, and nitrogen. Hydrocarbons are liquid and solid compounds of carbon and hydrogen in varying proportions.

2. Classes of Petroleum.—Although petroleums are quite varied in character, they may be divided into three main classes according to the predominating base, or, in other words, in accordance with the kind of residue left after distillation. These classes are:

1. Paraffin-base crude oils, usually the lighter grade oils.
2. Asphaltic-base crude oils, usually the heavier grade oils.
3. Mixed-base crude oils, containing varying proportions of the two foregoing bases and usually forming the intermediate grade oils.

3. Location of Supplies.—Petroleum is found in quantities in almost every part of the world, but at the present time the largest supplies are obtained in the United States, Mexico, and Russia. Considerable quantities are also obtained from the Dutch East Indies, Roumania, India, Persia, Peru, Japan, Egypt, and Trinidad; and small quantities in England, Germany, Canada, and Italy. The largest part of the oil used in the United States comes from the different fields of the United States and from Mexico. At the present time a large amount of the oil used for fuel is obtained from the heavy crude oils from Mexico.

4. **Oil Fields of United States.**—The principal oil fields of the United States are:

1. The Appalachian fields, including Pennsylvania, New York, West Virginia, eastern Ohio, Tennessee, and Kentucky, which produce light-grade crude oil of paraffin base.
2. The Lima, Indiana, Illinois, and northwestern Ohio fields, which for the major part also produce light-grade crude oils of paraffin base.
3. The mid-continental fields, which include the fields of Oklahoma, Kansas, northern and central Texas, and northern Louisiana. These produce medium-grade crude oils mostly of asphaltic base, although some are of paraffin base.
4. The Gulf fields, which include the States along the Gulf of Mexico. These produce somewhat heavier grade crude oils, of asphaltic base, than the mid-continental fields.
5. The California fields, which produce medium-grade oils, mostly of asphaltic and mixed bases.
6. The Rocky Mountain fields, which include Colorado, Wyoming, and Montana, the oils having paraffin bases and asphalt bases.

5. **Mexican Fields.**—Mexico furnishes a large part of the fuel oil used in the United States at the present time. Practically all of this oil is of the heavier grade and asphaltic base. The main fields are in the Tuxpam and the Panuco districts.

6. **Methods of Production.**—Petroleum is obtained almost entirely by means of wells or holes drilled in the earth. These are drilled in one of two ways: either by the cable system or by the rotary system of rock drilling.

The cable system is used principally with hard rock formations, and consists of a derrick supporting a pulley over which a heavy string of tools is suspended at the end of the cable. The cable is given a churning or up-and-down motion by a walking-beam steam engine. The steel tools pulverize the solid rock by falling under their own weight, and practically dig their way to the depth desired. The well is lined, or cased, as the hole progresses, with iron piping inserted in sections to keep out surface and underground water.

The system of drilling in most common use is the rotary one, which is more elaborate, but also more rapid than cable drilling, and is used mainly where the earth presents a softer formation. It employs a series of round, hollow drill rods to which the bit is attached. The rods and bit are rotated and bore their way into the earth. The drillings are continuously washed out by a stream of water flowing through the hollow drill.

7. **Pipe Lines.**—In the United States, crude oil is transported from the fields to refineries mainly by means of pipe lines. All of the main fields are connected with the refineries in this way. Some of these pipe lines are several thousand miles in length; one of the longest is that which connects the Oklahoma fields with refineries along the Atlantic coast. The pipe lines are usually from 6 to 10 inches in diameter, and are made of double extra-heavy steel pipe. The oil is ordinarily pumped under pressures of from 600 to 800 pounds per square inch, and is also heated when necessary, the temperature depending on the viscosity of the oil. There are pumping stations located along the lines at varying intervals to facilitate the handling of the oil along its route.

8. **Tank Cars and Tank Steamers.**—Some crude oil is transported to the refineries by means of railroad tank cars and from seaports in the vicinity of the oil fields by means of tank steamers. All the Mexican oil brought to refineries in the United States is transported by means of the latter. Tank cars usually have capacities of 6,000 to 8,000 gallons. Tank steamers vary greatly in capacity, ranging from 4,800 tons to 10,000 tons, and even larger.

9. Refining.—At the present time very little of the crude petroleum, or, in other words, petroleum as it comes from the well, is used for fuel, because the very high value of the gasoline, kerosene, lubricating oils and other products that are obtained from crude oil usually make the crude oil too expensive for fuel. Some of the heavier crude oils are merely treated so as to remove the lighter and more volatile products, the heavy remainder being used for fuel oil. The lighter and more volatile products also often make the crude oil unfit for fuel purposes, because it would be unsafe for storage. In fact, it is safe to state that nearly all of the crude petroleum is refined or distilled and only the residue is available for use as a heating medium, being then known as fuel oil.

10. Oil Suitable for Fuel.—Oil suitable for use as fuel should, as far as possible, have the following general qualities:

1. A maximum heat value.
2. A minimum of water, sediment, sulphur, sand, and other impurities.
3. A viscosity such that it can be pumped without undue heating.
4. A flash point to comply with various city ordinances and insurance rules.

With proper precautions, oils of almost any flash point can be safely handled.

11. Oil Available for Fuel.—Most oil at present available for fuel will fall within the following types:

1. Topped or reduced crudes, that is, crude oils that have had the light oils, such as gasoline, removed.
2. Residuum oils, that is, refuse from distillation of crude oils, but free from water, coke, and other foreign matter.
3. Distillates, such as gas oils that can be mixed with heavy reduced crudes and residuum to make the oil more fluid.
4. Mixtures of the foregoing oils.

12. Distribution of Fuel Oil.—Fuel oil is furnished to the consumer from supply stations, located at various parts of the world, which are maintained by the larger oil companies in all large consuming districts. The oil is brought to these supply stations by means of tank steamers or tank cars and stored in large tanks. Oil is supplied in this way directly from the refineries to large consumers. From the storage tanks the oil is then distributed to the purchasers either by railroad tank cars; or, in case only small local storage capacity is available, by means of automobile and horse-driven tank cars.

13. Classification of Fuel Oils.—Formerly, the various oils used for fuel were known as light kerosene, kerosene, distillate, gas oil, light fuel oil, medium fuel oil, heavy fuel oil, and very heavy fuel oil, these being listed in the order of their specific gravities from the lightest to the heaviest. However, a new standard classification has been adopted, as given in the following tabulation:

Name	Specification Number	A. P. I. Gravity
Furnace oil—light	1	40 to 36
Furnace oil—medium	2	36 to 32
Furnace oil—heavy	3	32 to 28
Fuel oil—light	4	28 to 24
Fuel oil—medium	5	24 to 18
Fuel oil—heavy	6	18 to 12

In general, it would seem that the choice of oil fuel for domestic heating lies between a practically water-white distillate having a gravity of from 38° to 40° and a darker distillate having a gravity of from 28° to 32°. These gravities are based on the readings of a hydrometer graduated according to the A. P. I. scale, or the scale that has been standardized by the American Petroleum Institute.

PROPERTIES OF FUEL OIL

14. Specific Gravity.—In determining the value of an oil for fuel, it is important to know its specific gravity, that is, the ratio of the weight of a given volume of the oil to the weight of an equal volume of water. As a rule, petroleum that has a high specific gravity contains fewer heat units and a smaller amount of the lighter hydrocarbons, such as gasoline and kerosene, than are contained in a petroleum of lower specific gravity. Fuel oil always has a greater specific gravity than the crude oil from which it is derived, because the lighter hydrocarbons have been eliminated from the crude oil. The specific gravities of oils used for fuel purposes range from .82 to .98. Sometimes the term *density* is used to denote the specific gravity of an oil.

15. Hydrometer.—It is customary to determine the specific gravity of an oil by using a hydrometer, as shown in Fig. 1.

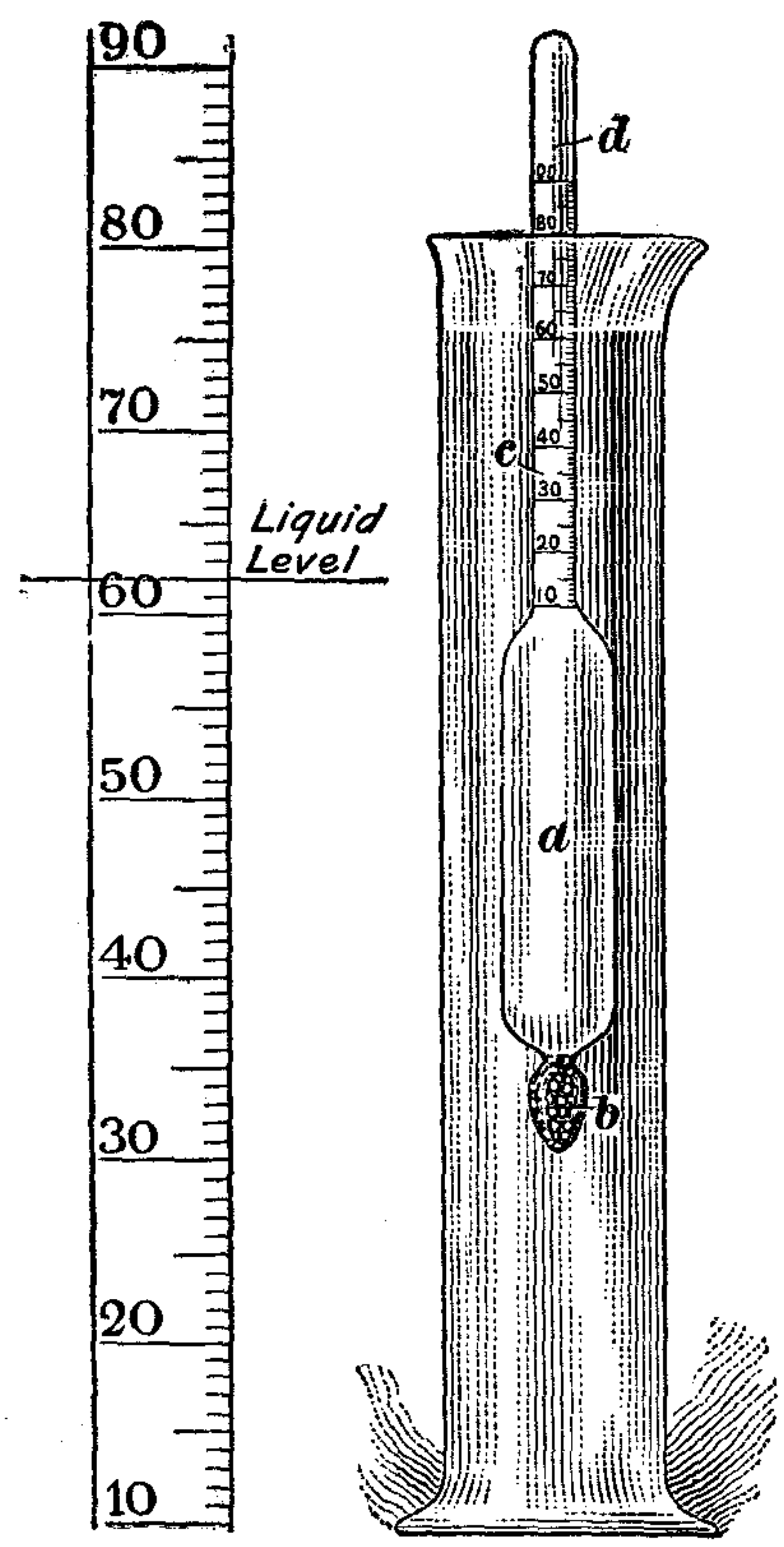

FIG. 1

The hydrometer consists of a glass bulb *a* filled with air, with a teat *b* at the lower end filled with shot or mercury. The upper end forms a slender stem *c* that is graduated with a scale having equal divisions called degrees. This scale is shown in the enlarged view. When the hydrometer is placed in pure water at a temperature of 60° F., it floats in an upright position and the point *10* of the scale is just even with the surface of the water. When the hydrometer is placed in a liquid that is lighter than water, such as fuel oil, it sinks farther, and the point on the scale to which it sinks is observed. This value is the gravity of the oil in degrees. For example, if the instrument sinks to 62, the oil is said to have a gravity of 62.

16. The scale now used principally in determining the gravity of petroleum oils by the hydrometer is the A. P. I. scale. For every reading of the hydrometer scale, there is a corresponding specific gravity, and Table I gives the relation between values of A. P. I. degrees and specific gravities. The table also shows the weight, in pounds per gallon, and the number of gallons per pound of oil, corresponding to each hydrometer reading.

TABLE I

DEGREES A. P. I. AND CORRESPONDING SPECIFIC GRAVITIES

Degrees A. P. I.	Specific Gravity at 60° F.	Pounds per Gallon	Gallons per Pound	Degrees A. P. I.	Specific Gravity at 60° F.	Pounds per Gallon	Gallons per Pound
10.0	1.0000	8.328	.1201	32.5	.8628	7.184	.1392
10.5	.9965	8.299	.1205	33.0	.8602	7.163	.1396
11.0	.9930	8.270	.1209	33.5	.8576	7.141	.1400
11.5	.9895	8.241	.1213	34.0	.8550	7.119	.1405
12.0	.9861	8.212	.1218	34.5	.8524	7.098	.1409
12.5	.9826	8.183	.1222	35.0	.8498	7.076	.1413
13.0	.9792	8.155	.1226	35.5	.8473	7.055	.1417
13.5	.9759	8.127	.1230	36.0	.8448	7.034	.1422
14.0	.9725	8.099	.1235	36.5	.8423	7.013	.1426
14.5	.9692	8.071	.1239	37.0	.8398	6.993	.1430
15.0	.9659	8.044	.1243	37.5	.8373	6.972	.1434
15.5	.9626	8.016	.1248	38.0	.8348	6.951	.1439
16.0	.9593	7.989	.1252	38.5	.8324	6.930	.1443
16.5	.9561	7.962	.1256	39.0	.8299	6.910	.1447
17.0	.9529	7.935	.1260	39.5	.8275	6.890	.1451
17.5	.9497	7.909	.1264	40.0	.8251	6.870	.1456
18.0	.9465	7.882	.1269	40.5	.8227	6.850	.1460
18.5	.9433	7.856	.1273	41.0	.8203	6.830	.1464
19.0	.9402	7.830	.1277	41.5	.8179	6.810	.1468
19.5	.9371	7.804	.1281	42.0	.8155	6.790	.1473
20.0	.9340	7.778	.1286	42.5	.8132	6.771	.1477
20.5	.9309	7.752	.1290	43.0	.8109	6.752	.1481
21.0	.9279	7.727	.1294	43.5	.8086	6.732	.1485
21.5	.9248	7.701	.1299	44.0	.8063	6.713	.1490
22.0	.9218	7.676	.1303	44.5	.8040	6.694	.1494
22.5	.9188	7.651	.1307	45.0	.8017	6.675	.1498
23.0	.9159	7.627	.1311	45.5	.7994	6.656	.1502
23.5	.9129	7.602	.1315	46.0	.7972	6.637	.1507
24.0	.9100	7.578	.1320	46.5	.7949	6.618	.1511
24.5	.9071	7.554	.1324	47.0	.7927	6.600	.1515
25.0	.9042	7.529	.1328	47.5	.7905	6.582	.1519
25.5	.9013	7.505	.1332	48.0	.7883	6.563	.1524
26.0	.8984	7.481	.1337	48.5	.7861	6.545	.1528
26.5	.8956	7.458	.1341	49.0	.7839	6.526	.1532
27.0	.8927	7.434	.1345	49.5	.7818	6.509	.1536
27.5	.8899	7.410	.1350	50.0	.7796	6.490	.1541
28.0	.8871	7.387	.1354	50.5	.7775	6.473	.1545
28.5	.8844	7.364	.1358	51.0	.7753	6.455	.1549
29.0	.8816	7.341	.1362	51.5	.7732	6.437	.1554
29.5	.8789	7.318	.1366	52.0	.7711	6.420	.1558
30.0	.8762	7.296	.1371	52.5	.7690	6.402	.1562
30.5	.8735	7.273	.1375	53.0	.7669	6.385	.1566
31.0	.8708	7.251	.1379	53.5	.7649	6.368	.1570
31.5	.8681	7.228	.1384	54.0	.7628	6.350	.1575
32.0	.8654	7.206	.1388	54.5	.7608	6.334	.1579

For example, a fuel oil having a gravity of 30° A. P. I., measured at a temperature of 60° F., has a specific gravity of .8762. Each gallon of such oil weighs 7.296 pounds, and each pound occupies a volume of .1371 gallon.

17. In the past, the Baumé hydrometer has been considerably used in the oil industry to determine the gravity of oils. Its graduations differ slightly from those of the A. P. I. scale, although the 10° mark on both scales represents the same specific gravity. In order that readings on the Baumé hydrometer may be converted into equivalent readings on the A. P. I. scale, Table II is given. It will be observed that there is very little difference between corresponding values, so that, for ordinary purposes, it matters little which scale is used. But for accurate work, the A. P. I. scale should be adopted, as it is now the standard in the oil industry.

18. Viscosity.—The resistance of a liquid to internal movement, or the resistance to flow, is its viscosity; this is also sometimes called the fluidity of a liquid. For purposes of comparison, the viscosity of an oil is usually observed at 60° F., but the viscosity changes in accordance with the temperature. For instance, a heavy oil might have a viscosity of 20°, measured by the Engler viscosimeter, at 150° F., and a viscosity of 4° Engler at 250° F. Usually the heavy oils have a high viscosity, whereas the lighter oils have, as a rule, a low viscosity. Oils of the same specific gravity will not necessarily have the same viscosity.

19. Methods of Determining Viscosity.—The viscosity of a liquid may be determined in various ways, as, for instance, by observing the ability of the liquid to oppose the movement of a body through it. It is more commonly found by noting the time required for a definite quantity of the liquid to pass through an orifice or a short pipe under known conditions of temperature and head. This principle is used in the best and most well-known types of viscosimeters, such as the Engler, Saybolt, and Redwood. The Engler and Saybolt viscosimeters are most commonly used in the United States for determining the viscosity of fuel oils. With the Engler viscosimeter, the viscosity is indicated as the ratio of the time required for water to flow out

TABLE II

DEGREES A. P. I. CORRESPONDING TO DEGREES BAUMÉ

Degrees Baumé	Degrees A. P. I.	Degrees Baumé	Degrees A. P. I.	Degrees Baumé	Degrees A. P. I.
10.0	10.00	25.0	25.16	40.0	40.32
10.5	10.51	25.5	25.67	40.5	40.83
11.0	11.01	26.0	26.17	41.0	41.33
11.5	11.52	26.5	26.68	41.5	41.84
12.0	12.02	27.0	27.18	42.0	42.34
12.5	12.53	27.5	27.69	42.5	42.85
13.0	13.03	28.0	28.19	43.0	43.35
13.5	13.54	28.5	28.70	43.5	43.86
14.0	14.04	29.0	29.20	44.0	44.36
14.5	14.55	29.5	29.71	44.5	44.87
15.0	15.05	30.0	30.21	45.0	45.38
15.5	15.56	30.5	30.72	45.5	45.88
16.0	16.06	31.0	31.22	46.0	46.39
16.5	16.57	31.5	31.73	46.5	46.89
17.0	17.08	32.0	32.24	47.0	47.40
17.5	17.58	32.5	32.74	47.5	47.90
18.0	18.09	33.0	33.25	48.0	48.41
18.5	18.59	33.5	33.75	48.5	48.91
19.0	19.10	34.0	34.26	49.0	49.42
19.5	19.60	34.5	34.76	49.5	49.92
20.0	20.11	35.0	35.27	50.0	50.43
20.5	20.61	35.5	35.77	50.5	50.93
21.0	21.12	36.0	36.28	51.0	51.44
21.5	21.62	36.5	36.78	51.5	51.94
22.0	22.13	37.0	37.29	52.0	52.45
22.5	22.63	37.5	37.79	52.5	52.96
23.0	23.14	38.0	38.30	53.0	53.46
23.5	23.64	38.5	38.81	53.5	53.97
24.0	24.15	39.0	39.31	54.0	54.47
24.5	24.66	39.5	39.82	54.5	54.98

through the orifice to the time required for the liquid. That is, the time required for the oil, divided by the time required by the water, equals the viscosity on the Engler scale.

On the Saybolt viscosimeter, the viscosity is measured by the number of seconds required for 60 cubic centimeters of the liquid to flow through its measuring orifice. The relation between the Engler and Saybolt notation varies in accordance with the different viscosities of the oil, but a rough, handy rule is that 37.5 seconds on the Saybolt scale equals 1° on the Engler scale. This rule is not, of course, accurate for all viscosities, but is a fairly close approximation.

20. Flash Point.—The flash point of an oil is the temperature at which inflammable vapor or gas is given off. It is easily determined by heating the oil, and, as the temperature rises, testing it with a spark or a flame until the vapor which is distilled off ignites. The temperature of the oil is then taken and indicates the flash point. The flash point is usually given in terms of the *closed-cup* or *open-cup* test. A flash point of from 110° to 200° F. is considered to be within safe limits for fuels used in domestic furnaces. The recognized standard instruments for determining the flash point by the closed-cup method are the Pensky-Marten and the Abel. When the flash point is determined by the open-cup process, the cup is open to the atmosphere; when determined by the closed cup the vessel is closed in at the top, whereby the flash point will be determined sooner and at a lower temperature than if the vessel is open. The closed-cup test is considered the more accurate.

21. Fire Point.—The fire point of an oil is the temperature at which the oil will ignite and continue to burn. It should be low enough for the atomized oil to ignite fairly easily when a torch is applied. It is determined by the same means used in determining the flash point, except that the oil is heated further, after obtaining the flash point, until the oil takes fire and continues to burn for at least 5 seconds.

22. Heat Value.—The heat value of a fuel oil is usually expressed in terms of the number of British thermal units contained in 1 pound of the liquid. A British thermal unit, commonly abbreviated B. t. u., is the amount of heat necessary to raise 1 pound of water from 62° to 63° F. The number of heat units or B. t. u. in any oil can be determined by an instrument called a calorimeter, or may be calculated from the ultimate analysis of the oil. The heat value of an oil may be found approximately, if its Baumé density is known, by the use of the formula

$$Q = 18{,}650 + 40(B - 10)$$

in which Q = heat value, in B. t. u. per pound;
B = density of oil, in degrees A. P. I.

EXAMPLE.—What is the approximate heat value of a fuel oil whose density is 21.5° A. P. I.?

SOLUTION.—Apply the formula, and the heat value is

$Q = 18{,}650 + 40\ (21.5 - 10) = 18{,}650 + 460 = 19{,}110$ B. t. u. Ans.

The heat value of oil fuel varies between 17,000 and 20,000 B. t. u., but 18,000 to 19,000 B. t. u. is the usual value. The heat value per gallon may be found by multiplying the heat value per pound by the weight of a gallon of the oil as given in Table I.

23. Coefficient of Expansion of Oil.—In the United States, all oil is sold by volume instead of by weight. Therefore, when measuring a quantity of oil, it is necessary to know the temperature of the oil at that time. The standard temperature for measurement is 60° F., and all measurements made at any other temperature must be corrected for expansion. The unit expansion of different grades of oil varies, but an average value is .0004 per degree Fahrenheit; that is, for every degree of increase in temperature, the volume of the oil is increased by .0004 times the original volume.

The diagram shown in Fig. 2, made by Mr. J. C. Buxton, Chief Engineer, Singer Building, New York, and published with his permission, affords a convenient means for making an approximate correction for expansion and thus determining the equivalent volume of oil at the standard temperature of 60° F. The method is to find from the diagram the proper correction factor and to multiply this by the observed volume of oil.

For example, suppose that at a temperature of 100° F. a quantity of oil measures 5,000 gallons, and that the equivalent volume at 60° F. is to be found. To obtain the necessary correction factor, locate the vertical line marked *100* on the hori-

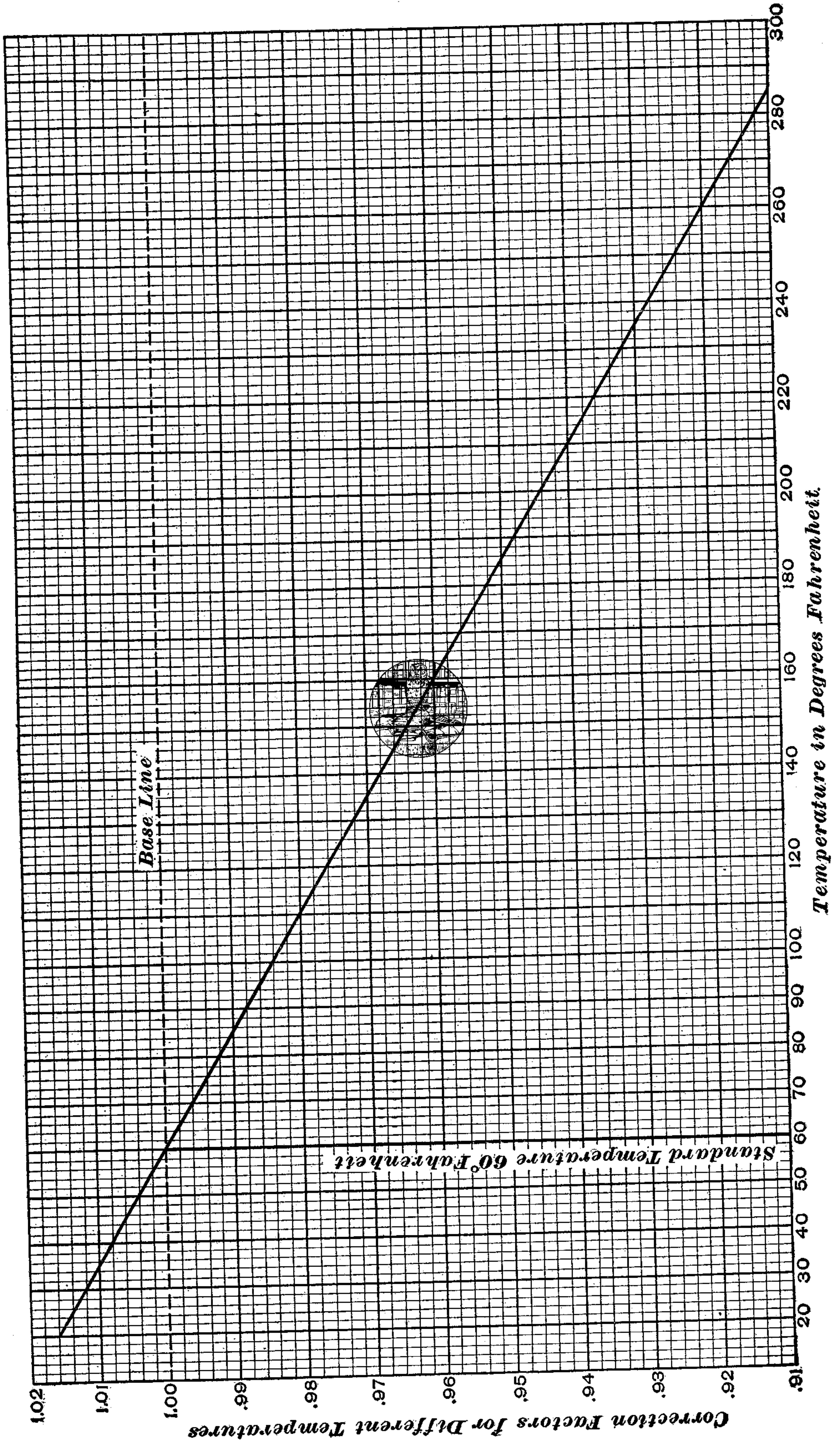
Base Line
Standard Temperature 60° Fahrenheit
Temperature in Degrees Fahrenheit
20
30
40
50
60
70
80
90
100
120
140
160
180
200
220
240
260
280
300
Correction Factors for Different Temperatures
1.02
1.01
1.00
.99
.98
.97
.96
.95
.94
.93
.92
.91

FIG. 2

zontal scale at the bottom of the diagram and follow this line upwards to its intersection with the heavy diagonal line. From that point proceed horizontally to the left until the scale at the left is reached. The point thus located will correspond to a value of .984, which is the correction factor. This factor must be multiplied by the observed volume of oil; thus, $.984 \times 5{,}000 = 4{,}920$ gallons, which is the equivalent volume at 60° F.

24. **Advantages of Oil Fuel.**—Oil fuel has several advantages over other fuels, such as the following:

1. Higher efficiency obtainable due to more nearly perfect combustion and more nearly uniform furnace conditions.
2. Increased capacity of boilers and furnaces.
3. Flexibility of control, as the fires are started and stopped easily and quickly, and it is easy to meet varying loads.
4. Absence of smoke.
5. Absence of ashes.
6. Saving in labor.
7. Ease of handling, both in storing and in burning.
8. Storage without deterioration.
9. No spontaneous combustion.
10. Decreased maintenance costs.

25. **Pour Test.**—Another test of fuel oil is the pour test, which is made to determine the pour point, or the lowest temperature at which the oil will pour, or flow, when it is chilled. In making this test, a sample of the oil is put in a jar that is closed by a cork in the center of which is a thermometer that extends down into the oil. The temperature of the sample is lowered gradually until a point is reached at which the oil becomes solid; that is, it retains its form in the jar even when the jar is tilted to such a degree that the surface of the oil stands vertical. The temperature at this point is called the solid point. The pour point is taken at 5 degrees above the solid point. The pour test should be applied to oils having specification numbers from 1 to 4, inclusive. This test is intended to protect the buyer against distillates that contain wax.

26. Distillation Range.—The temperatures at which definite percentages of the oil are vaporized should be determined. The sample of oil is subjected to gradually increasing temperatures until the whole is vaporized. The temperature at which vaporization begins is called the initial point, and that at which it ends is called the end point. The range of temperature between these two points is the distillation range. The initial point shows the approximate temperature required to produce the formation of sufficient vapor to maintain continuous combustion; and the end point shows the temperature at which all of the oil can be vaporized and burned.

27. Water and Sediment.—Specifications for fuel oil commonly contain a clause relating to the amount of water and sediment allowable. For No. 1 oil it should not exceed .05 per cent., and for No. 6 oil it should not exceed 2 per cent. Neither water nor sediment can add to the heat value of the oil, and an excessive amount of water may possibly cause the oil flame to be extinguished. To determine the percentage of water and sediment in an oil, a sample is placed in a tube and whirled in a centrifuge, which is a machine that causes the sample to be subjected to centrifugal force. The water and sediment, being of greater specific gravity than the oil, are separated from it by this centrifugal action and collect in the bottom of the tube.

EQUIPMENT FOR OIL BURNING

REQUIREMENTS FOR COMBUSTION OF OIL

28. Essential Conditions.—There are four essential conditions that must be met if oil fuel is to be burned successfully. They are:

1. The oil must be atomized.
2. Sufficient air to insure complete combustion must be intimately mixed with the atomized oil.
3. Combustion must be completed while the oil particles are in suspension in the air.
4. A refractory lining must enclose the chamber in which combustion takes place.

29. Atomization of Oil.—When coal is used as a fuel, the furnace contains a considerable amount of fuel; but experiments with oil fuel soon demonstrated that methods adapted to solid fuels were not adaptable to oil, and that the latter could not be successfully burned in bulk. To insure satisfactory burning of fuel oil, the oil must be finely atomized, that is, converted into a minutely divided spray. By properly atomizing the oil, each particle of the spray is exposed to the air necessary for its complete combustion. Ability to atomize the oil finely is the factor that determines a good burner. The point is much more important than many believe, and is absolutely essential for highest efficiency.

30. Mixture of Oil Spray and Air.—After the oil has been properly atomized, it must be mixed intimately with air in the correct ratio, in order to produce complete combustion. There are different methods of admitting air to accomplish this mixture. In any case, the main object to be attained is the thorough mixing of the oil spray and the air, so that each particle of oil shall receive from this air all the oxygen required for its perfect combustion. The real secret of efficient oil burning is finely atomized oil intimately mixed with the correct amount of air.

31. Burning Oil in Suspension.—After the oil has been atomized and discharged into the combustion chamber, its combustion should take place before any of the minute oil particles strike the comparatively cooler surfaces that enclose the chamber. Oil is not burned in a liquid form. It must be changed to a gas, or vaporized, before combustion will take place. If, before gasification occurs, it strikes a surface that cools it below the temperature at which it will ignite and burn, combustion will be checked and a deposit of unburned carbon will be formed. Hence, the mingled stream of air and atomized oil should be subjected to heat, to produce vaporization of the oil, before it is allowed to come in contact with the metal surfaces of the boiler.

32. Furnace or Combustion Chamber.—It must not be assumed from the foregoing statements that the design and construction of the boiler furnace or combustion chamber are not important, because, as a matter of fact, a suitable furnace is essential. The form and arrangement of the furnace will depend on the type of boiler and the style of burner or atomizer used, but a furnace usually consists of a chamber lined with firebrick or some other refractory. After the fires have been burning for some time, the lining becomes incandescent and in this condition is a great aid to combustion.

TYPES OF OIL BURNERS

33. Classification.—Broadly, the devices used to prepare fuel oil for combustion in the furnaces of domestic heaters may be divided into two classes, namely, vaporizing burners and atomizing burners. In the vaporizing type, the oil flows to the burner by gravity from an elevated tank, is caused to spread out on a hot plate or casting, and is vaporized by the heat of this plate. The gas then mixes with air introduced by natural draft, and combustion takes place. The hot plate is kept heated by the combustion of fuel and thus the vaporizing process is continuous. However, this type of burner demands a volatile fuel, which means that oils of high A. P. I. gravity must be used, and these are the relatively high-priced oils.

34. In the atomizing type of burner, the oil is broken up into a finely divided mist by delivering the oil under pressure from a small orifice, by blowing a jet of air across the outlet orifice of the oil nozzle, or by whirling the oil off the edge of a rotating cup or disk by centrifugal force. With the atomizing type of burner, it is possible to utilize the cheaper fuels of lower volatility and greater specific gravity; also, a better mixing of the air and the atomized fuel can be obtained by introducing air from a fan or a blower, the result being a more efficient combustion of the fuel and better performance of the boiler.

35. There are other ways of classifying oil burners. For example, the method of furnishing draft may form the basis, in which case they are known as natural-draft or mechanical-draft burners. The method of delivering the oil provides another means of classification, as by gravity, pump, vacuum, or pressure tank. Classification may be based on methods of ignition, which are as follows: Hand torch, gas pilot, oil pilot, electric, and gas-electric. Still other classifications may be based on the way the flame is applied in the boiler, the kind of automatic control used, the source of power, and the kind of power-driven equipment.

36. Vaporizing Burners.—A form of burner that depends for its action on the vaporization of the oil is illustrated in Fig. 3. It consists of two or more castings that are located inside the furnace. The base casting *a* supports the air-heating manifold *b* and the hot plate *c*, or vaporizing cone. The oil is led to the burner through the pipe *d* and is discharged at the tip

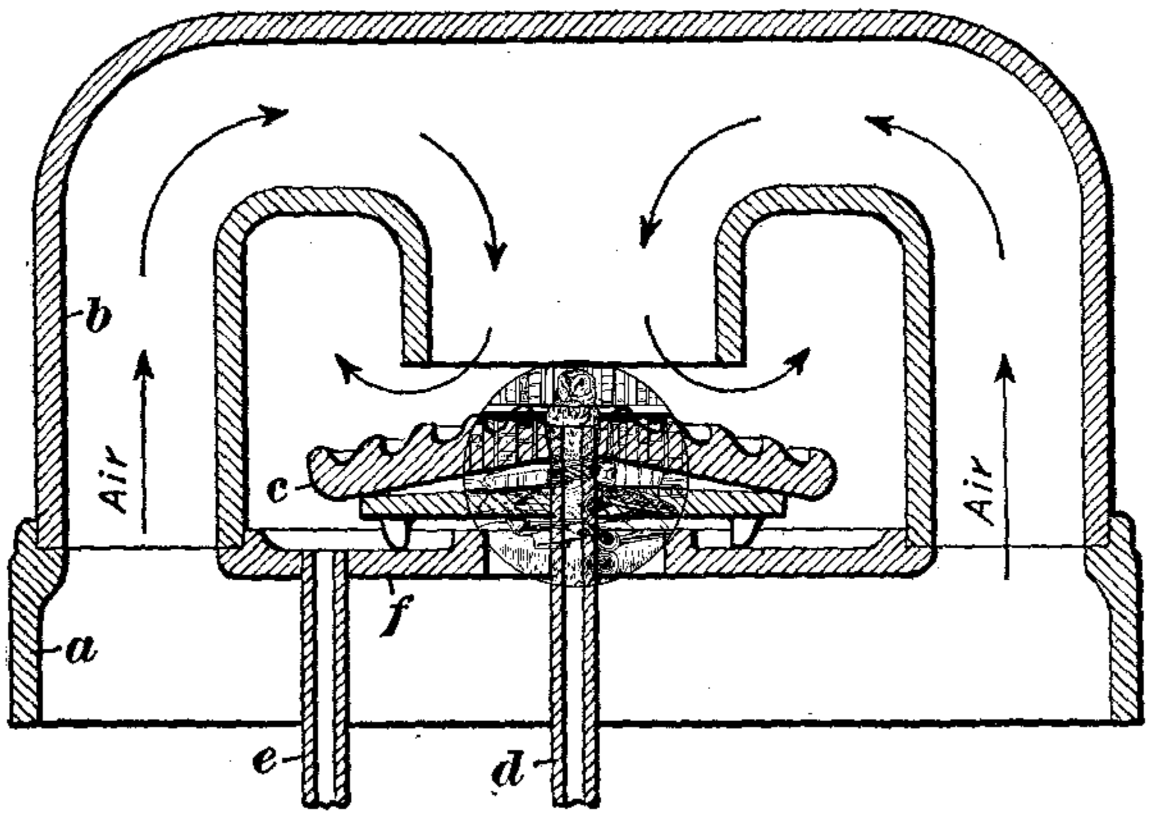

FIG. 3

of the cone, from which it flows down over the grooved face of the cone. The air to support combustion enters through the base, flows through the arms of the manifold, and is discharged downwards directly over the cone. The burner is lighted by a torch or by a gas pilot light, and the heat produced by combustion keeps the cone at such a temperature that it vaporizes the oil which flows down over it. The flames also heat the air manifold, and thus the air supply to the burner is preheated. An overflow pipe *e* is connected to the tray *f*, so that, if an excess of fuel is supplied, it will drain away. The oil is fed by gravity from an elevated tank and control may be either by hand or by an automatic arrangement.

37. If the vaporizing burner is controlled by hand, the vaporizing cone is preheated by an oil-saturated wick that is