

June 21, 1932.

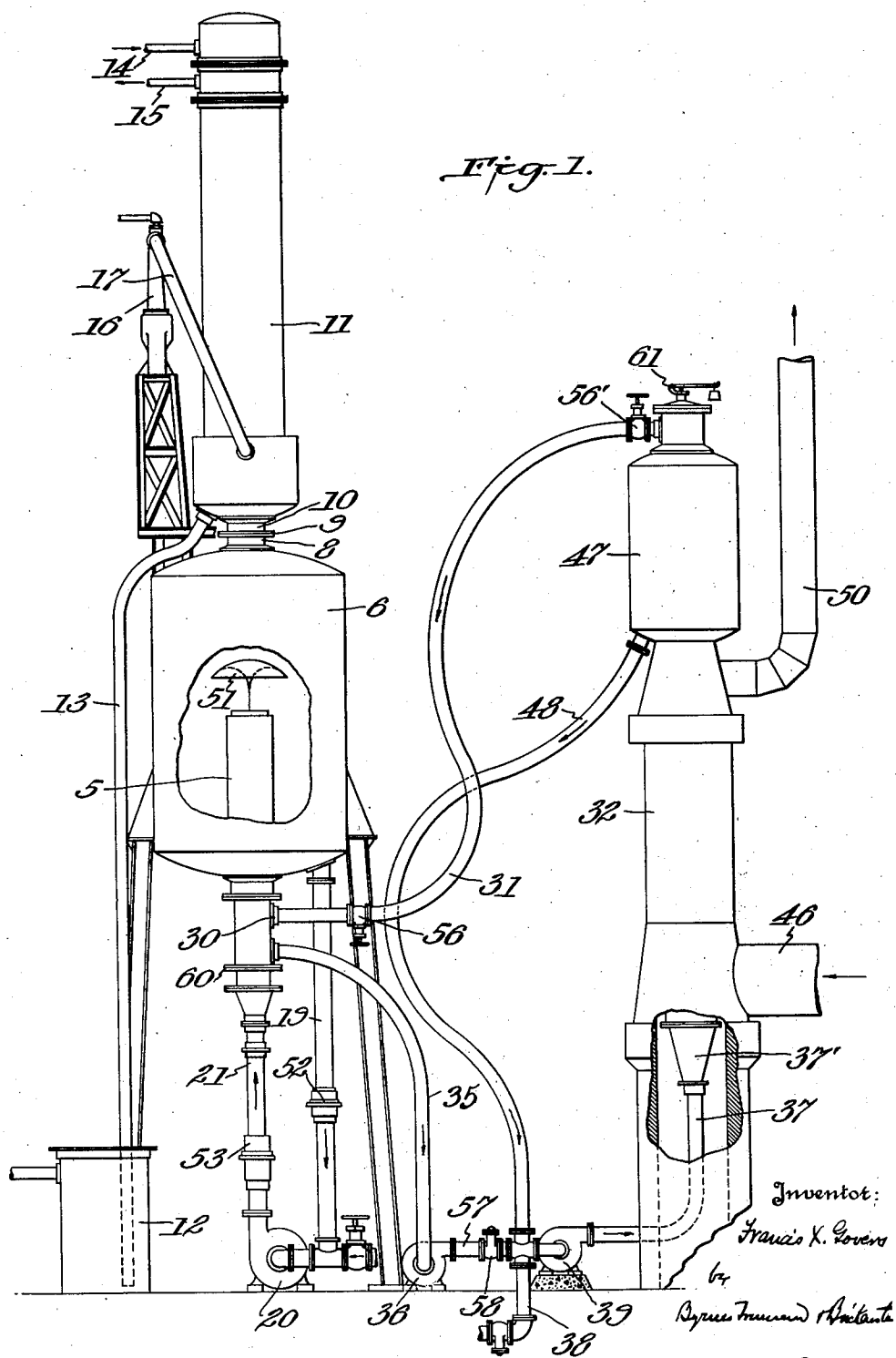
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1,864,349

METHOD OF EVAPORATING LIQUIDS

Filed Nov. 5, 1928

4 Sheets-Sheet 1



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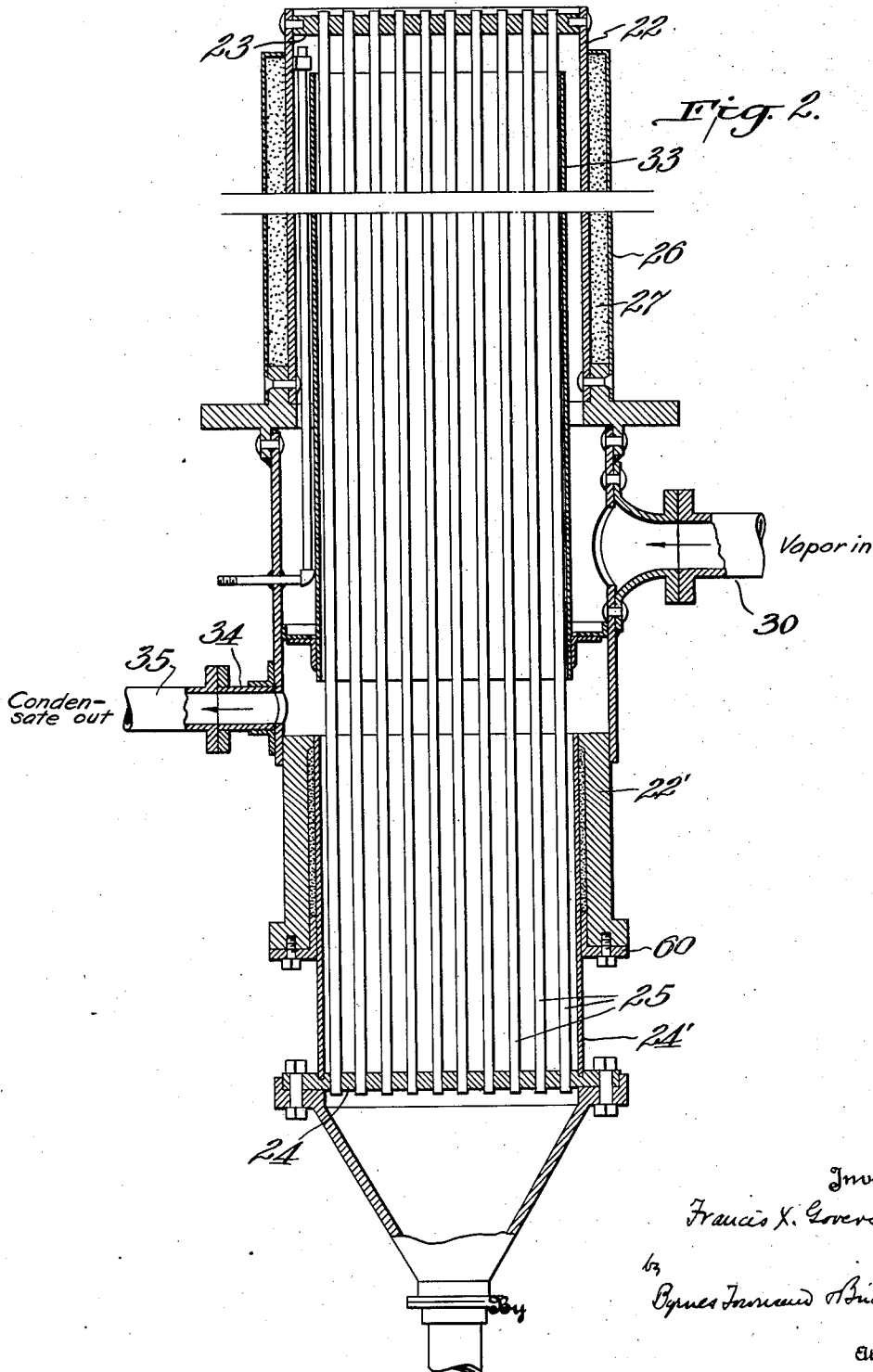
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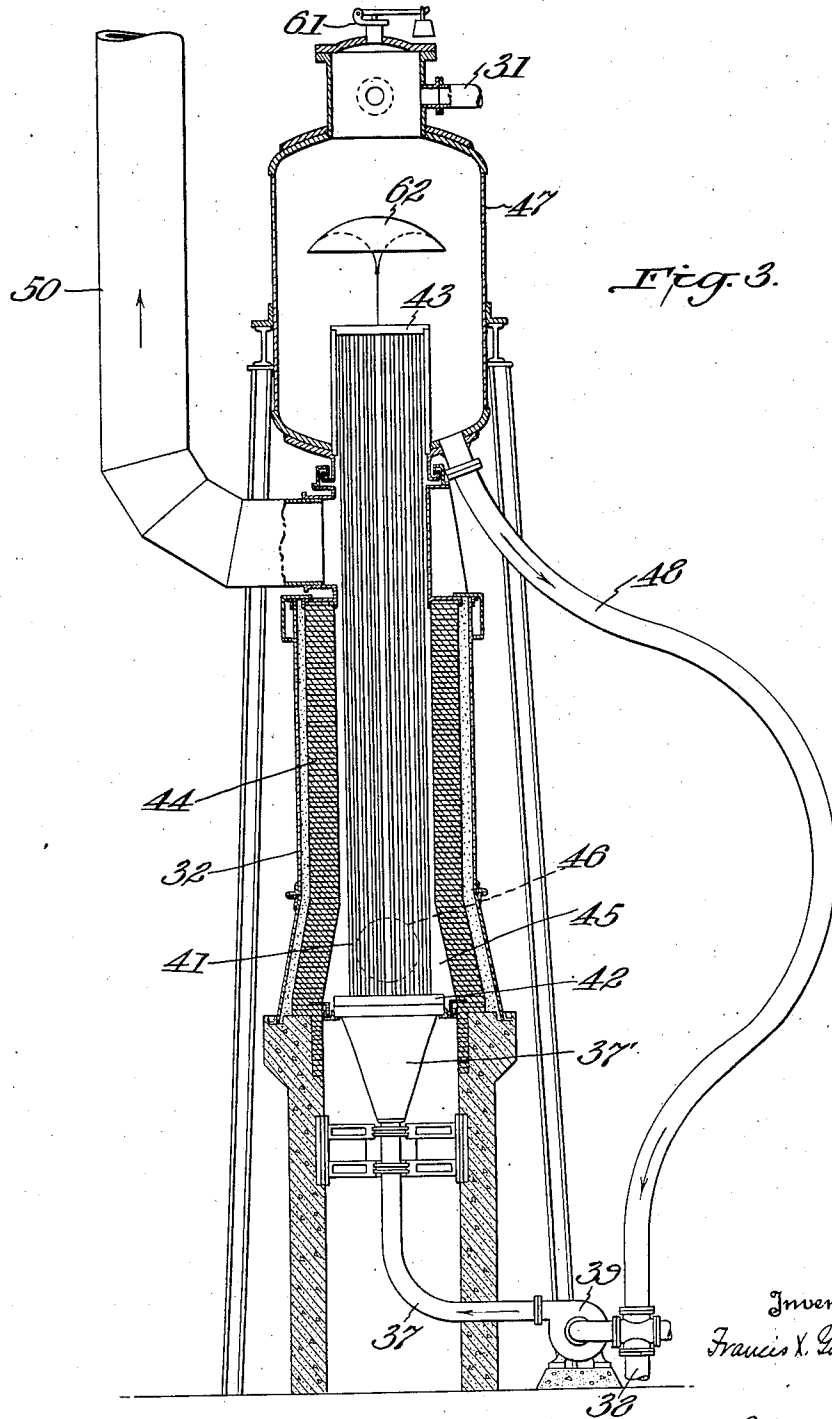


Fig. 3.

Inventor:
Francis X. Govers

334 Repres. Fromm & Bruckenstein

Attorneys.

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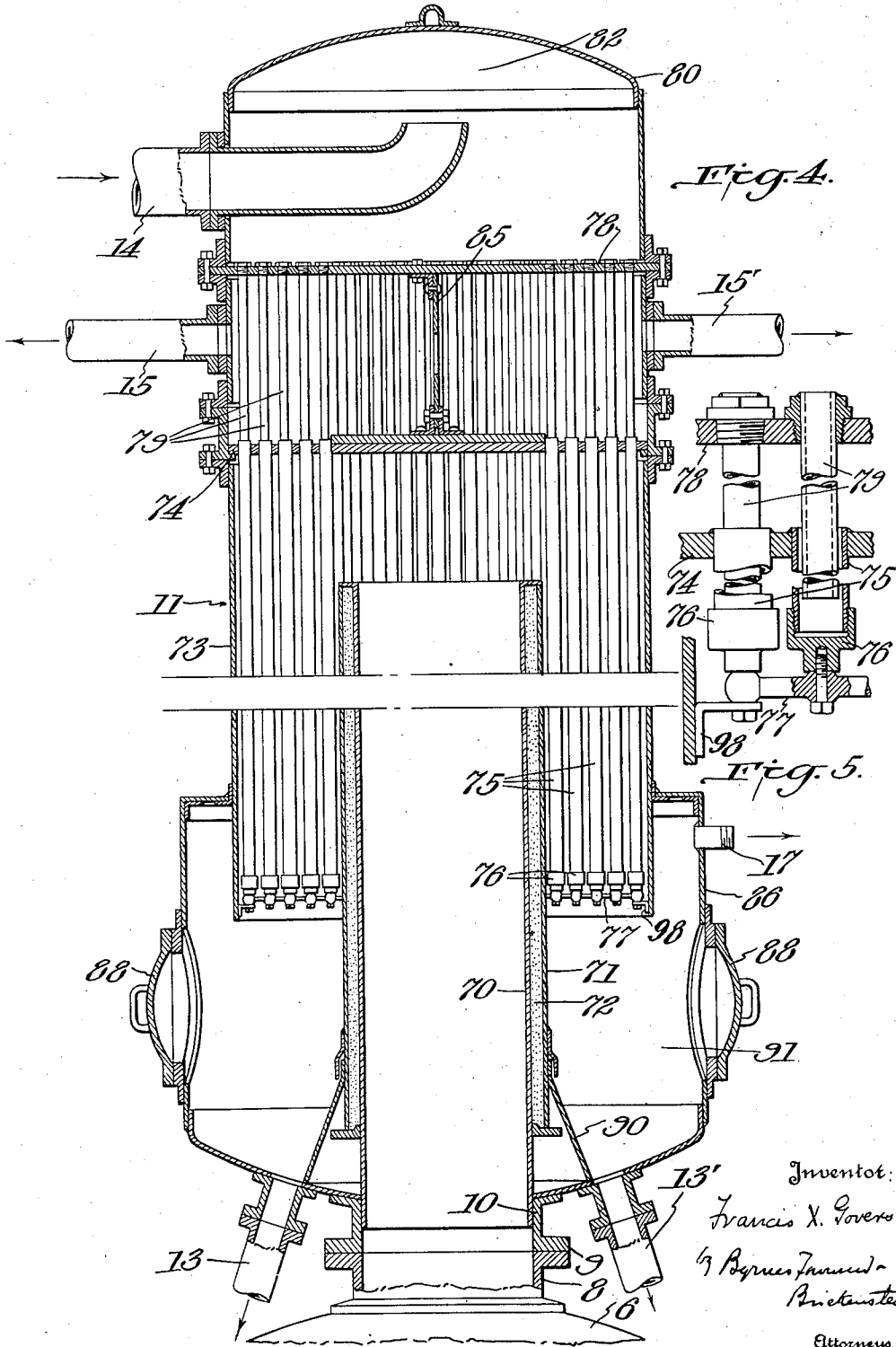
F. X. GOVERS

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UNITED STATES PATENT OFFICE

FRANCIS X. GOVERS, OF LAWRENCEVILLE, ILLINOIS, ASSIGNOR TO INDIAN REFINING COMPANY, OF LAWRENCEVILLE, ILLINOIS, A CORPORATION OF MAINE

METHOD OF EVAPORATING LIQUIDS

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This method relates to the art of distillation or evaporation of liquids, and is particularly applicable when the distillation or evaporation is to be carried out under sub-atmospheric pressure and at high temperatures.

It relates particularly to the practice of such art in the distillation of mineral oils for the manufacture of lubricants.

The desirability and superiority of close fractional overhead cuts in the manufacture of lubricating oils has long been recognized. The marked advantages of making such a fractionation under low absolute pressure have been pointed out, as well as the fact that it is possible to obtain by this means overhead distillates with as great a viscosity as desired, and within extremely narrow boiling point ranges. Fractional cuts of definite chemical composition can be produced in this manner.

In the commercial application of this principle, however, difficulty has been experienced because of the extreme readiness with which petroleum oils and their products break down under elevated temperature conditions with the resulting production of carbon and undesirable vaporous and gaseous decomposition products.

It must be kept in mind that the indicated temperature of any considerable mass of oil in process of distillation is only a mean temperature indication, and parts of the mass may have been heated far above that of the indicated temperature. Thus these well known advantages of distilling petroleum products under conditions of low absolute pressure and a comparatively low and safe temperature are lost because parts of the mass are heated above the temperature at which they decompose. This tendency of parts of the mass being heated beyond the indicated temperature is accentuated in the case of petroleum oils because of their relatively high viscosity and sluggish heat conductivity.

Further, in the ordinary type of cylindrical stills, as proposed for distillation under low absolute pressure, where a considerable depth of oil is being heated, a considerable

portion of the mass is under a pressure much greater than that desired or recommended, and many of the claimed advantages are lost because of the fact that all portions of the oil are not under like conditions either of pressure or of temperature.

It is desirable in all types of lubricating oils that the flash point be as high as possible for any given viscosity oil and this desirable quality is lost in part whenever the oils under treatment are subjected in whole or in part to too high temperature conditions.

According to my invention these difficulties are largely obviated by conducting the distillation under a very low absolute pressure, advantageously about 5mm. absolute in a still the oil being heated by an indirectly heated heating element which can be maintained at the desired temperature, and circulating the oil by a force pump in rapid flow over the heating element.

By controlling the temperature of the heating element in relation to that of the oil flowing over it and causing the oil to flow at a sufficiently rapid rate, any desired temperature difference between the oil and the heating surface can be maintained, while at the same time a high rate of heat transfer is obtained.

There results a minimum of change in the oil under treatment with the retention of all the desired qualities in both its liquid or solid hydrocarbon components, while a rapid rate of distillation is obtained with resulting increase in production.

My invention is not restricted to the use of any particular apparatus, but one form which has in practice been found to be highly successful is shown in the accompanying drawings.

Referring to the drawings:

Fig. 1 is an elevation of the apparatus;

Fig. 2 is a sectional detail of the oil heater element;

Fig. 3 is a sectional elevation of a boiler for delivering hot vapor to the oil heater;

Fig. 4 is a sectional elevation of a condenser; and

Fig. 5 is a detail.

Referring to Figs. 1, 2 and 3 of the draw-

ings, the apparatus consists of an evaporator 6, having an outlet 8 connected by flange 9 to the inlet 10 to the condenser 11. Condenser 11 is connected to receiver 12 by means of a barometric discharge pipe 13. The condenser 11 is further provided with a water inlet 14 and water outlet 15, and is connected to a jet ejector 16 by means of pipe 17.

The heating element 5 (shown in detail in Fig. 2) and the evaporator 6 are connected by a circulating system comprising down-take pipe 19, circulating pump 20 and up-take pipe 21. The heating element 5 (see Fig. 2) comprises an outer shell 22, provided with headers 23 and 24 into which are expanded tubes 25. The upper header 23 is secured to the shell 22 which has, at its lower end an enlarged portion 22' within which is a packing chamber. Extending upwardly from the header 24 is a cylindrical shell 24', between which and 22' packing material, advantageously asbestos fiber, is located, which is held in place by a gland member 60. This arrangement allows for expansion of the tubes without undue strain. At its upper portion the shell 22 is surrounded by a jacket 26, the intermediate space being advantageously filled with heat insulating material 27. This construction need not be further specifically described, as it will be apparent from the drawings. The heating element is advantageously heated by hot vapor entering through the neck 30 from the pipe 31, provided with valve 56, which is connected to the boiler 32. The heating vapor passes upwardly around through the space between shell 22 and the shell 33 which surrounds the tubes 25, through which the oil passes, and the vapor then flows downwardly in contact with these tubes. The vapor is thereby condensed and collects in the bottom of the chamber above the header 24, and flows outwardly through the neck 34 which is connected to the pipe 35 leading to a pump 36 by which it is returned through pipe 57 having check valve 58 to pump 39 and thence through pipe 37 leading into a chamber 37' at the bottom of the boiler 32.

The boiler 32 is supplied with a high boiling point liquid, such as diphenyl, delivered by supply pump (not shown) through pipe 38 leading to a circulating pump 39 from which it is delivered by pipe 37 into chamber 37' and thence into a series of tubes 41 mounted between headers 42, 43. The bank of tubes 41 is mounted within a brickwork stack 44 which may be heated in any suitable manner, as by hot gases delivered into the lower portion of the heating chamber 45 through a connection 46 (shown in dotted line) leading to any suitable heat supply. The liquid passing through the pipes is delivered against a spreader 62 into a vapor chamber 47 having a safety valve 61, from which chamber the vapors are delivered

through pipe 31 and pressure regulating valves 56, 56' to the vapor inlet 30 of the heating element 5.

The unvaporized liquid passes from the chamber 47 through the pipe 48 to the pump 39 and is circulated through the heated tubes. These pipes 48, 31 and 35 are provided with suitable bends to provide for expansion and contraction.

From the heating chamber 45 the hot gases may be delivered into a stack 50.

As a high boiling liquid, I may advantageously use melted diphenyl, which melts at about 158° F. and boils at about 485° F., and at a pressure of approximately 110 pounds has a temperature of about 750° F.

I have found that diphenyl possesses certain advantages not possessed by other heating media. I have been enabled to operate the same as a heat-exchanging medium for periods of many months and at continuously maintained temperatures of over 700° F. without the formation of tars, decomposition products and gases, and substantially without change in the chemical purity of the diphenyl. Such temperatures have been in the range where other organic heating media undergo considerable and progressive deterioration with the formation of tars which will carbonize on the heating surfaces. On the other hand, diphenyl has been found to remain of such purity as to enable substantially complete vaporization of the same at all times.

Furthermore, diphenyl vapors when applied to the heat exchange surfaces condense and fully wet these surfaces so that an efficient and complete contact is maintained at all times between the heat exchange surfaces and the fresh incoming diphenyl vapors. By reason of the efficient and ready transfer of heat from the condensing diphenyl vapors a very low heat differential between the vapors and the fluids being heated can be maintained.

This is of great importance in the heating of organic fluids generally and is of particular importance in the heating of mineral oils preparatory to distillation for the production of high grade lubricating oils. It is there especially important to avoid all traces of cracking by local overheating, and it is possible to accomplish this by the use of the diphenyl heating system by reason of the efficient heat transfer at low temperature differential.

By means of the system shown, the tubes in the heating element 5 are externally heated by the hot diphenyl vapor and can therefore be readily maintained at any desired temperature.

The oil is continuously forced upwardly by the pump 20 through the heated tubes 25 and the mixed liquids and vapors are discharged against the spreader 51 in order to permit the

separation of the oil vapors from the liquid oil which flows downwardly through the pipe 19 to the pump 20.

The temperature of the vapor delivered through pipe 31 is controlled by varying the pressure under which the high-boiling point liquid is vaporized. The temperature of the tubes through which the oil is circulated can thus be accurately controlled. The rate at which the oil is heated in its passage through the heated tubes may be controlled by varying the speed of the circulating pump 20.

There can thus readily be maintained any desired temperature difference between the heated surfaces and the flowing oil in contact therewith, thereby enabling the gradual, uniform heating of the body of oil to the desired distillation temperature without any danger of overheating portions thereof, and cuts may be taken off within as narrow ranges of temperature as considerations may dictate.

All pipes conveying hot liquids or vapors are heavily insulated to avoid loss of heat, and all pipes containing diphenyl are provided with means for liquefaction or for maintaining the diphenyl in liquid state.

The pipes 19 and 20 are provided with slip joints 52 and 53 to provide for expansion and contraction.

The heating element is also provided, as above described, with means including the member 60 for permitting movement due to expansion and contraction because of varying temperature conditions of the shell 24', connected to and forming part of the tube sheet 24, which is in turn connected to pipe 21.

Pipe 21 is free to move in the slip joint 53. This arrangement permits the up and down movement of the lower tube sheet, and thus avoids undue strains.

The system is provided at all necessary points with heat and pressure indicating devices.

One form of condenser which has been found in practice to be advantageous is shown in Figs. 4 and 5.

The condenser 11 as a whole is supported on a neck 10, by a flanged connection 9 to the outlet 8 of evaporator 6. Secured to the inner wall of the neck 10, as by electric welding, is an upwardly extending vapor pipe 70, around which is a casing 71, enclosing heat insulating material 72.

Extending across the shell 73, and above the outlet of vapor pipe 70, is a tube sheet 74, from which depend tubes 75, into the space between the vapor pipe and the shell 73. These tubes are closed at their bottoms by caps 76, secured to a grid 77, which is supported by angle irons 98 carried by shell 73.

A second tube sheet 78 extends across the shell above the tube sheet 74, and from this upper tube sheet 78 depend open-ended pipes 79, of smaller diameter than tubes 75, and extending to the lower ends thereof. Into the

chamber 82 formed between this upper sheet 78, and the top 80 of the condenser, extends a pipe 14 for cooling liquid, such as water. From this chamber 82 the cooling liquid flows down through pipes 79 and up through pipes 75, discharging from the upper ends of pipes 79 into the chamber between the two tube sheets, from which the liquid is discharged through pipes 15, 15'. The tube sheets are braced by a perforated diaphragm 85. At its lower portion, the condenser is provided with a shell 86, secured hermetically, as by welding, to shell 73. At the upper portion of the shell is a pipe connection 17, to which may be connected a vacuum producing apparatus. Covered manholes 88, 88, are provided in the shell 86 to afford means of access. One or more exit openings to which are connected pipes 13, 13', serve for discharge of the condensed liquid. Advantageously there is provided a hood 90 extending between the bottom of shell 86 and casing 71.

In operation, the hot vapors rising through the heat insulated tube are discharged against the surrounding cooled tubes and the condensed liquid collects in the bottom portion of the structure in the chamber 91.

As shown, this self-contained condenser is mounted directly upon and in open communication with the vapor space of the still 6, and is thus free to expand and contract in accordance with variations in temperature.

It will be evident that by the use of this apparatus the oil to be distilled can be gradually heated to the required temperature without any possibility of overheating such as is liable to occur in fire-heated pipe stills or cylinder stills, since the temperature difference between the heated surface and the oil contacting therewith can be controlled as desired or required.

While my invention has been described as applied to the manufacture of lubricating oils from petroleum hydrocarbons, the method is equally applicable to the evaporation, as for concentration purposes, of other liquids, such as caustic soda lyes, etc., from which it may be desired to evaporate a liquid, while maintaining the residual portion at a high temperature.

I claim:

1. Process of vaporizing petroleum oils in vacuo which consists in supplying to the oil the heat required for distillation thereof by rapid circulation of the oil in heat transfer relation with indirectly heated surfaces maintained at controlled temperatures above that of the oil contacting therewith by means of a hot vapor of diphenyl.

2. In the process of vaporizing liquid in vacuo the steps which consist in supplying to such liquid the heat required for evaporation by rapid circulation of the liquid in heat transfer relation with indirectly heated surfaces maintained at controlled temperatures

above that of the liquid contacting therewith by means of the hot vapor of diphenyl.

3. In the heating of petroleum oil the step of imparting heat to such oil by means of diphenyl in thermal but out of physical contact with the oil and heated to a temperature in excess of the temperature of the oil.

4. In the heating of petroleum oil the step of imparting heat to the oil by means of the vapor of diphenyl in thermal but out of physical contact with the oil but at a temperature in excess of the temperature of the oil.

5. The method of heating petroleum oil which comprises boiling a body of diphenyl in a heat transfer system, leading the vapors into indirect heat exchange relationship with the oil to be heated, effecting condensation of the diphenyl and absorption of its latent heat of vaporization by the oil to be heated, and returning the diphenyl condensate to the body of diphenyl maintained substantially free from decomposition products.

6. In the heating of fluid materials the step of imparting heat to such fluid material by means of diphenyl in thermal but out of physical contact with the fluid material and heated to a temperature in excess of the temperature of the fluid material.

7. In the heating of fluid materials the step of imparting heat to such fluid material by means of the vapor of diphenyl in thermal but out of physical contact with the fluid material, and at a temperature in excess of the temperature of the fluid material.

8. The method of heating fluids which comprises boiling a body of diphenyl in a heat transfer system, leading the vapors into indirect heat exchange relationship with the fluid to be heated, effecting condensation of the diphenyl and absorption of its latent heat of vaporization by the fluid to be heated, and returning the diphenyl condensate to the body of diphenyl maintained substantially free from decomposition products.

In testimony whereof, I affix my signature.
FRANCIS X. GOVERS.