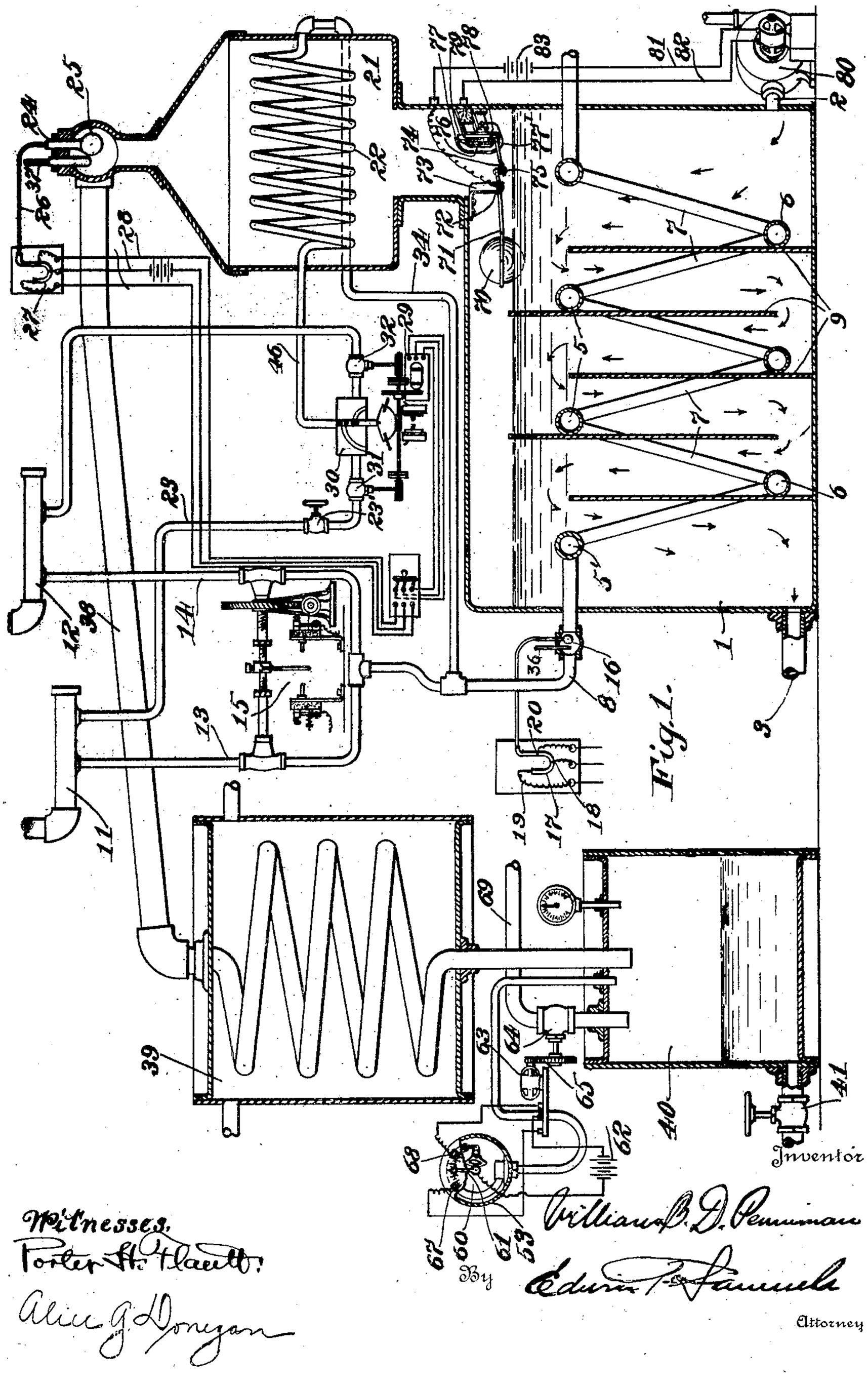
June 19, 1923. 1,459,515

W. B. D. PENNIMAN

APPARATUS FOR CRACKING OILS

Filed March 10, 1917 2 Sheets-Sheet 1



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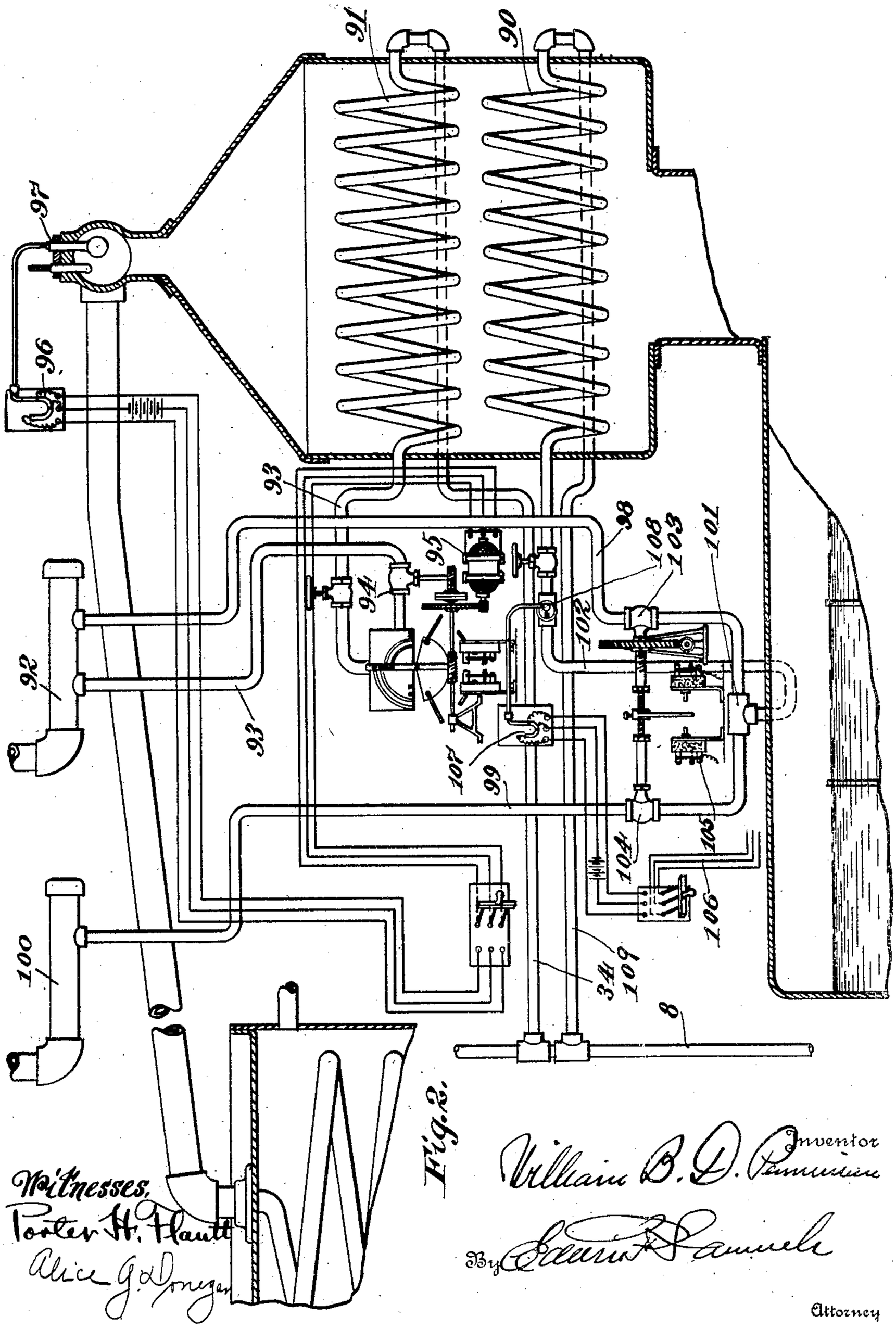

Fig. 2.

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Patented June 19, 1923. 1,459,515

UNITED STATES PATENT OFFICE.

WILLIAM B. D. PENNIMAN, OF BALTIMORE, MARYLAND.

APPARATUS FOR CRACKING OILS.

Application filed March 10, 1917. Serial No. 153,793.

To all whom it may concern:

Be it known that I, WILLIAM B. D. PENNIMAN, a citizen of the United States of America, and resident of the city of Baltimore, State of Maryland, have invented certain new and useful Improvements in Apparatus for Cracking Oils, of which the following is a specification.

This invention relates to the cracking of oils, an important feature being a method of and apparatus for maintaining a predetermined constant or otherwise predetermined temperature of the vapors and gases given off when the oil is heated, the oil in the still being at the same time preferably maintained at a substantially constant or regulated temperature. This cracking is done most efficiently under pressure. The object is to obtain a product of uniform volatility and uniform purity regarding its freedom from heavier oils, and otherwise, to obtain the more valuable products in the greatest quantity at the lowest cost and to reduce the waste.

In connection with the cracking of oils for the purpose of turning kerosene and like hydrocarbons into the lighter hydrocarbons, it is found that while a portion of the oil is changed to a light hydrocarbon, the vapor given off from the oil also includes a quantity of heavier oil which is not cracked but merely vaporized. Part of this heavier oil thus vaporized is condensed almost as soon as it leaves the liquid and the condensation continues throughout the passage of the vapor to the condenser where the lighter products are reduced to a liquid for further treatment or transportation.

It is understood that all such lighter oils, as gasoline, are in fact mixtures of various hydrocarbons, the heavier ones being soluble in the lighter. These components are vaporized and hence condensed from their vapors at different temperatures, the heavier hydrocarbons, meaning the less volatile ones, being vaporized and condensed at the higher temperatures. The volatility of the final product of the cracking is therefore to a large degree dependent on the temperature at which the gases or vapors given off from the heated oil pass to the stillhead, as well as on the temperature of the still. This fact seems to have been given very little attention in the past, the apparatus used being in most instances dependent on cooling of the vapors by air drafts and the like. Such temperature regulation cannot be accomplished with any degree of regularity. As variations in temperature of the vapors give very considerable variations in the composition and volatility of the product obtained at the conclusion, the products of cracking have never been and cannot with the apparatus in use be made uniform as to volatility.

The object of this invention is to provide regulation whereby predetermined and constant temperature of these vapors can be reached and maintained which, with regulation of still temperatures and pressures, etc., results in a uniform and constant product, and particularly in a greatly increased production of volatile liquid or gasoline. This regulation as to vapor temperature is accomplished in the present instance by subjecting the passing current of hydrocarbon vapors and gases to the action of a heat-carrying vehicle by which means a regulated amount of heat is abstracted from, or, if necessary, added to the vapors.

In the form of apparatus in connection with which this invention has been developed, I use a coil of pipe in the path of vapor through which a fluid having a definite thermal capacity, i. e., in controlled quantities and at controlled temperatures, is passed. This may be water, steam or other liquid or vapor at a temperature such that the hydrocarbon vapors coming from the material being cracked and coming in contact with the outside of the pipes containing the said fluid will bring such hydrocarbon vapors to a predetermined temperature. This temperature is ordinarily so chosen that the heavier hydrocarbons up to a certain standard are condensed, separating them from the vapors of the lighter hydrocarbons whereby the latter are obtained at a predetermined volatility and purity.

The fluid heat vehicle may be supplied from a single source in regulated quantities the quantity being automatically controlled by a thermostat which may be in the path of the gases, or fluid from two sources under different thermal conditions may be used, the temperature and quantity of the fluids from the respective sources being controlled by a thermostatic apparatus exposed to the temperature of the gases and vapors. The thermostat may in either case be actuated by temperatures directly related to those of the gas instead of direct exposure to the gases. In the present instance, I use either

wet steam or any convenient fluid from one source in regulated quantities, or steam from two sources under different thermal conditions, mixed in proportions determined by a thermostatic apparatus exposed to the temperature of the gases and vapors being treated, or to temperatures proportionate to those of the vapors.

In the accompanying drawing I have illustrated an apparatus embodying my invention so far as it is related to the apparatus, the apparatus indicated being also one by means of which my process may be put into operation.

Figure 1 is a vertical section through the apparatus, the same being distorted for convenience in bringing out the features which it is desired to illustrate.

Figure 2 is a similar view showing a modified form of stillhead temperature controlling apparatus.

The apparatus, as shown, consists of a closed tank or still 1 containing the hydrocarbon, kerosene or the like, to be treated. Preferably a supply of oil is maintained entering through the supply pipe at 2 and the unvaporized liquid or residue being led out of the still at the discharge orifice 3 whence it may be led to another still or brought back again into the present still or retained for various uses in the arts.

In the form of the apparatus disclosed, the hydrocarbon to be cracked is heated from within in substantially the manner illustrated in my Patent No. 766,841. This is the form of still in which regulation of the oil temperature is most easily accomplished and so best adapted to use with my method of regulating vapor temperatures which is claimed in combination with regulation of the oil temperatures and still pressures as well as separately, and I would have it understood that all the heating by steam herein illustrated and referred to is intended to be accomplished without the production of high pressures along the general lines of the disclosure in said Patent No. 766,841. In the present instance the steam system for heating the still consists of parallel headers 5 at the top and 6 at the bottom of the still, the same being connected by pipes 7 and the end header 5′ at the top receiving the steam from the supply pipe 8. Transverse to the body of the still or tank, I have shown upright baffles 9 alternately placed, the first one being spaced up from the bottom, the second extending down into contact with the bottom of the tank and being spaced downward considerably from the top and so on, alternately through the tank or still, all being so arranged as to cause the hydrocarbon being cracked to circulate in contact with the headers and connecting pipes. For this purpose the headers are placed each near the top or bottom of a corresponding baffle. The cold oil when introduced is first brought into contact with the steam about to leave the still and therefore at the lowest temperature and passes forward as it becomes hotter into contact with steam of a higher and higher temperature as the point of introduction of the steam at the header 5′, just over the point of exit of the residue, is approached.

Steam at a regulated temperature is supplied to the header 5′ as follows: The pipes 11 and 12 carry each a supply of steam, one at a high temperature and the other at a comparatively low temperature, one being if desired, superheated and the other wet, or if found desirable other fluids supplied from two sources under different thermal conditions may be used. In the present instance we will refer to the pipe 11 as the superheated steam pipe and 12 as the wet steam pipe. Steam is led from these two sources to the supply pipe 8 by pipes 13 and 14 controlled by the valve system 15 indicated herein and more fully illustrated in my Patent No. 902,600.

This valve system 15 with the electric operating means is controlled by a thermostatic element 16 shown in the form of an air bulb inserted in a pipe 8 and connected to a U-shaped tube 17 containing mercury with a central terminal 18 in the tube which is always in contact with the mercury, and two terminals 19 and 20 also in the tube but so arranged that only one is in contact with the mercury, and hence in circuit, at a time. These are in contact respectively for the forward and reverse operation of the electric means actuating the valve system to open one valve and close the other and vice versa, as the mercury moves back and forth in response to the expansion and contraction of the air effected by the changes of temperature of the fluid in the pipe 8.

From the still 1, the vapors and gases pass into the stillhead 21 or otherwise into contact with the pipe, coil or other heat transferring member through which a fluid having a predetermined or regulated thermal capacity is passed. The object is to bring the vaporized material or vapor and gases to a predetermined temperature whereby the less volatile constituents are condensed and thus separated from the volatile product, or the greatest quantity of products of the desired volatility is otherwise obtained. This is accomplished by bringing the vapors and gases to a predetermined regulable temperature. The volatile product is thus rendered uniform and its volatility controlled. As the value of the product depends on the nearest possible approach to the desired volatility, to have a known and definite value, it must be controlled and made uniform in this respect.

The coil 22 is supplied with fluid, prefer-

ably wet steam, at a temperature lower than that of the petroleum vapors and gases in the still, the steam being taken from one or two sources. In the latter case the temperature variation of either can be corrected by the other. The valve system is controlled by a thermal element 24 in the path of the vapor or otherwise so placed as to be affected by temperatures nearly proportionate to those of the vapor. The thermostat may be similar to that described in connection with the petroleum still herein and of the type shown and described in my Patents Nos. 902,600 or 933,577, one connection 23 to the superheated steam being permanently closed by the gate valve 23′ if wet steam only is used. The thermal element 24 consists of an air bulb 25 connected by a tube 26 with a closed U-shaped tube 27 containing mercury, having one electric terminal constantly in contact with the mercury and two terminals so arranged that the mercury shifts from contact with the one to contact with the other as the temperature of the bulb 25 changes. The contacts are suitably connected by wires 28 with the motor element 29 of the valve system indicated at 30, being preferably a substantial duplicate of the system shown in the above-recited patents so the valve motor reverses as the temperature reaches a fixed limit. The valve system 30 may be so adjusted that the valves 31 and 32 are opened and closed to the necessary degree and at the necessary intervals to give a predetermined temperature and flow of the resulting mixed fluid regulated according to the temperature of the gases, or as stated, the valve 23′ may be closed and the thermostatic apparatus 30 regulating the opening of the valve 32 to the wet steam, the desired cooling effect, the same varying almost directly with the amount of steam admitted per unit of time, will result.

In the operation of the system, steam supplied to the coil 22 from the valve system 30, passes through the coil becoming to some degree superheated by the heat extracted from the hydrocarbon vapor and gas and is then returned by pipe 34 to the steam supply pipe 8 leading to the still. This pipe comes into the pipe 8 at a point between the valve system 15 where the superheated and wet steam are mixed and the still itself, and also between this valve system and the point where the thermostatic element 16 is located. The superheated steam supplied in this way is wholly insufficient to supply the still and in order that constant flow through the coil 22 may be maintained, this is run directly into the still system in this way independently of the valve system 15, though its presence and effect on the system is communicated to the valves by the thermostatic element 16. Both the thermostatic elements 16 and 25 have immediately adjacent to them suitable thermometers 36 and 37 which serve to indicate the temperature at which the thermostats are operating and to show at once the change in the condition of the system if the automatic valve actuating means should be in any way disabled and fail to operate. From the dome over the stillhead or by any suitable path, the oil vapors are led by a pipe 38 to a condenser 39 and thence to a suitable closed container 40 under pressure, corresponding to the pressure in the still, the pressure in the still due to the permanent gases formed being regulated by any suitable pressure regulator 53. Such a regulator may consist of a pressure gauge 60 of any suitable type operating on the bent tube, diaphragm or other accepted principle. The indicating hand 61 being connected to a suitable source of electricity 62 which is also connected to a motor 63 operating a valve 64 by means of a gear 65 to the motor shaft and valve stem or in any other suitable manner, two adjustable contacts 67 and 68 on the dial of the pressure gauge being connected to opposite terminals of the motor armature, the contact of the hand or indicating head 61 with one terminal 67 connecting the motor up to give forward rotation and contact with the other terminal 68 giving reverse rotation, the forward rotation tending to close the valve and the reverse rotation to open it so that when the pressure rises above a predetermined limit, the valve is opened and when it drops below a likewise predetermined limit, the valve is closed so that the pressure builds up. A pipe 69 in which the valve 64 is located, leads to a gasometer or to a furnace whereby the permanent gas, which it will be understood collects in the condenser, is suitably stored or disposed of. The electrical diagram shown is purely theoretical, it being understood that the necessary relays and elaborations, as the field circuits, etc., can be supplied by anyone skilled in the electrical arts. They are also shown in detail in the patents referred to in this case.

Means is also provided for regulating the level of the oil in the still, the same being shown in the form of a float 70 on a lever 71 pivoted at 72 on a bracket 73, the lever 71 having the arm 74 on the opposite side of the pivot 72 from the float 70, pivoted at 75 to swing transversely. This pivoted arm 74 which is of conducting material travels in a vertically placed cam path 76 having conducting or contact portions 77 and 77′ on one side, i. e., the downward stroke which corresponds to the pumping or upward stroke of the float, and non-conducting or insulated portions 78 on the other side, the latter including a leaf spring 79 at the top of the upward path travelled by the tail of the lever as the float drops to the lowest oil level by which the tail of the lever 74 or fol-

lower is pressed against the contact portion of the cam and started on the pumping or contact portion of the traverse. Preferably, the pivoted tail 74 of the lever is provided with a spring which may be a spiral spring on a pivot 75 by which it is pressed into contact with the central contact member 77′. This spring also serves to carry the tail of the lever free of the contacting members at the bottom of the path and stop the pump and bring it into the upward path.

The substance of this mechanism is that it includes a float and a pump with means actuated by the float to control the operation of the pump to maintain the level of the liquid in the still. More specifically, the float is mounted on a pivoted lever, the pivot on which the lever is mounted being horizontal. The tail of the lever beyond the pivot is jointed or hinged on a vertical pivot to swing laterally. This pivot carries a cam follower which moves around the cam path as the float moves up and down. The leaf springs conduct the follower past the high and low points of the cam and prevent it from reversing. Certain portions of the cam path are made conducting so that the pump operates from the high point of the cam, i. e., corresponding to the low point of the float, to the low point of the cam reached by the follower when the float is at the top level. As the float drops, the level of the liquid receding toward the low point, the follower is out of contact and no pumping action takes place. The cam arrangement is provided to prevent continual stopping and starting of the pump. It provides a comparatively wide margin of regulation.

In this way the oil level is kept above a fixed predetermined point and between two predetermined points by the pump 80 which may be electrically driven or merely electrically controlled through the wires 81 and 82 leading to a source of electricity 83 and to the pivot 72 of the contact members 77 and 77′. The pump shown is of the electrically driven variety. Such contact making and breaking devices as are deemed necessary, including relay circuits, etc., may be provided, the showing at this point being diagrammatic.

From the receptacle 40, the condensed hydrocarbon is drawn off in any suitable manner by way of the delivery outlet 41.

I have thus outlined an apparatus and process by means of which the vapors and gases thrown off from petroleum oil, as kerosene, in cracking are brought to a uniform temperature condensing and separating from the volatile products the less volatile elements and getting a product of a uniform standard of volatility. As described, this is accomplished by bringing the vapor into heat-exchanging relation with a fluid heat vehicle of such thermal capacity per unit of time, i. e., quantity and thermal condition as related to the gases and vapors, the said quantity per unit of time or thermal condition being automatically regulated according to the temperature of the resulting gases and vapors, as to extract from these gases a sufficient amount of heat to bring them to the desired uniform temperature. The quantity of the heat vehicle, which is usually wet steam, is automatically regulated, as already pointed out, the regulation depending on the temperature of the gases after they have passed the heat regulating means. Under normal conditions by varying the quantity of the heat vehicle, increasing the quantity the more the heat to be abstracted, all the necessary regulation can be obtained, but in order to raise the temperature of this heat vehicle when necessary and vary its capacity for taking up heat or imparting heat, I have provided a second source of heat carrying fluid which may be automatically connected to the coil to be delivered in the necessary quantity whenever the temperature in the dome at the bulb 25 is such as to require it.

The apparatus and method so far described are dependent on the cracking of the oils by heating in the liquid form under pressure, the pressure serving to keep a large proportion of the hydrocarbons liquid until they reach a cracking temperature, the principal function of the stillhead coil being to cool the vapors to a uniform temperature at which the vapors of the heavier oils will be condensed and thus separated from the permanent gases and the vapors of the lighter oils, which latter are later condensed and collected, the vapors of the heavier oils being returned to the liquid and reheated.

It is found that some of the oils which are available for cracking consist in part of hydrocarbons which vaporize even at high pressures at temperatures well below their cracking temperature so that it is very difficult to crack them unless they can be heated while in the form of vapor. This heating may be accomplished in the apparatus shown in Figure 1 by using the coil 22 as a heating instead of a cooling element and the connections shown in Figure 1 are so arranged that this can be done by mere adjustment of the valve controlling apparatus to a higher temperature, as described in the patents on this subject herein cited.

In Figure 2 I have shown an apparatus which retains the means for cooling the vapors to a uniform temperature for the purpose of separating the vapors of the less volatile hydrocarbons by condensation, and includes in addition a heating element in the stillhead for heating these vapors and cracking the hydrocarbons above referred to

as having a tendency to vaporize at temperatures below the cracking temperatures of these particular hydrocarbons. To this end, I have shown a plurality of heat-exchanging elements or preferably, a heating element 90 and a cooling element 91 in the stillhead, these two elements being preferably so arranged that the vapors in passing through the stillhead come first in contact with the heating and then with the cooling element. These are shown each in the form of a coil of pipe though they may of course be variously arranged, consisting of a plurality of headers with a grid of pipes, or they may be in any convenient and economical form. The cooling element or coil 91 in the present instance is connected to a source of wet steam 92 by a pipe 93, the pipe 93 having a thermostatically controlled valve 94 operated by electric means 95 including a motor connected to a mercury tube 96 with a thermostat bulb 97 in the path of the hydrocarbon gases from the still, this control and connections being substantially similar to that of the cooling coil 22 in Figure 1, except that the superheated steam pipe 23 which may be shut off in Figure 1 is omitted from Figure 2, the return pipe 34 being arranged as in Figure 1 to lead the steam to the pipe 8 which supplies the still, or being otherwise disposed of in any convenient and economical manner. The other heat transfer element or heating element 90 is controlled somewhat similarly to the coil 22 in Figure 1, i. e., there is a pipe 98 to the wet steam source 92 and a pipe 99 to the dry or superheated steam source 100. The pipes are joined in a T 101 from which a pipe 102 leads to the coil 90. The pipes 98 and 99 respectively are controlled by valves 103 and 104 operated by electric means 105 according to my patents already cited, the same being connected by wires 106 to the U tube 107 connected to the thermostat bulb 108 in the steam pipe 102 just before it enters the coil. By proper adjustment of this apparatus, steam at a predetermined constant temperature is supplied to the coil 90, the bulb 108 being, if desired, either in the inlet pipe 102 or the outlet pipe 109. The latter leads to the pipe 8 as does the return pipe from the other coil. In this way, it is made possible by merely adjusting the thermostats in accordance with the theory of operation of these devices as described in my above-recited patents to give the desired temperatures of the respective coils 90 and 91 when the vapors passing through the stillhead will be first subjected to the high temperature of the coil 90 and then to the low temperature of the coil 91, first heating the vapors so that they are subjected to the necessary cracking temperature and then cooling them so that the remaining vapors of the less volatile hydrocarbons are condensed leaving as the condensable portion of the mixed vapor and gas going over to the still only the vapors of the more volatile hydrocarbons.

Apparatus resembling in a general way the forms herein described may however be utilized to obtain any desired result in this connection, whether the object be to obtain a greater percentage of volatile liquid as near as possible of uniform volatility or to obtain the uniform non-volatile products, very volatile liquids or permanent gases, but the main object at the present time is to obtain the greatest amount of volatile liquid of as near as possible uniform volatility which can be used as gasoline.

I have thus described my invention specifically and in detail in order that its nature and operation may be fully understood; however, the specific terms herein are used descriptively rather than in their limiting sense and the scope of the invention is defined in the claims. What I claim and desire to secure by Letters Patent is:

1. In an apparatus for cracking oils under pressure, a closed container for the oil, means for heating the same, a condenser, means for leading the gas and vapor from the heated oil to the condenser, means in the form of a steam coil for bringing the gases and vapors as they pass from the container to a uniform predetermined temperature, means for supplying steam, and thermostatic means actuated in correspondence to the variations in temperature of the gases which have been in heat exchanging relation with the coil to control the passage of steam to the coil.

2. In an apparatus for cracking oils, a closed container for the oil, means for heating the same, means for regulating the intensity of the heat applied within predetermined limits, means for leading the gas and vapor from the heated oil, means for bringing the gases and vapors passing from the oil to a uniform predetermined temperature and thus rendering the condensate of uniform volatility by condensing at this temperature the vapors of the heavier oils and thereby separating them from the volatile products of the cracking consisting of a steam coil in contact with which the vapors are passed, means for supplying wet steam to the coil below the temperature of the vapors and gases coming from the oil, a valve controlling the supply, and thermostatic means controlled by temperatures corresponding to the thermal condition of the oil vapor and gas, the thermostatic means being connected to the steam valve to control the same.

3. In an apparatus for cracking oils, a closed container for the oil, means for heating the same, means for regulating the in-

tensity of the heat applied within predetermined limits, said means being in the form of steam pipes in the liquid and a thermostatic regulator controlling the steam supply, means for leading the gas and vapor from the heated oil, means for bringing the gases and vapors passing from the oil to a uniform predetermined temperature and thus rendering the condensate of uniform volatility by condensing at this temperature the vapors of the heavier oils and thereby separating them from the volatile products of the cracking consisting of a steam coil in contact with which the vapors are passed, means for supplying wet steam to the coil below the temperature of the vapors and gases coming from the oil, a valve controlling the supply, and thermostatic means controlled by temperatures corresponding to the thermal condition of the oil vapor and gas, the thermostatic means being connected to the steam valve to control the same.

4. In a still for cracking oils under pressure, steam passages for heating the still from within, means for introducing oil, passing it through the still and removing the liquid residue from the still, forming a circulating system for the oil and a circulating system for the steam, the two being in reverse relation so that the entering steam is brought into heat-exchanging relation with the hot residue which is leaving the still and the entering oil is brought into contact with the steam at the lowest temperature as it is about to leave the still with corresponding intermediate contacts of the two circulations and baffles in the still, some being spaced from the bottom and the others from the top of the still, leaving a space for the oil to flow over one baffle and under the next, the steam pipes being substantially parallel to the baffles and transverse to the oil current which is deflected continually from top to bottom of the still.

5. In a still for cracking oils under pressure, means for supplying steam to heat the oil from within with pipes for distributing the same through the oil, means for supplying oil and removing the liquid residue from the still, baffle plates for controlling the direction of circulation of the oil, each baffle plate terminating in the vicinity of a steam pipe forming two circulating systems in reverse relation, the hot liquid residue just before it is removed from the still coming in contact with the entering steam and the entering oil coming in contact with the steam at the lowest temperatures when it is about to leave the still, the baffles being arranged to keep the intermediate portions of the two circulations in corresponding contact.

6. In an apparatus for cracking oils, means for heating the oil a condenser, means for leading the gas and vapor to the condenser, means for subjecting the vapors as they pass to the condenser to a substantially uniform high temperature, means for later bringing them to a substantially uniform lower temperature, said means being in the form of two steam units, two sources of steam supply at different temperatures, thermostatic means for maintaining one unit at a constant high temperature, and thermostatic means actuated in correspondence with the variations in temperature of the gases to control the passage of steam to the second unit, bringing the vapors to a predetermined lower temperature.

7. In an apparatus for cracking oils, a closed container for the oils, means in the form of steam pipes submerged in the oil for heating the same, thermostatic means for keeping the temperature of said steam pipes at a predetermined normal, a condenser, means for leading the gases and vapors from the oil toward the condenser, means for controlling the temperature of the gases as they pass to the condenser, said means being in the form of steam passages in contact with the gases, means for supplying steam to said passages, means for controlling the supply of steam to said passages, said means being controlled by the temperature of the gases and vapors after they have been in contact with the said steam passages, and means for controlling the pressure in the system, consisting of an outlet passage for the permanent gases and a pressure regulator controlling the said passage.

Signed by me at Baltimore, Maryland, this 9th day of March, 1917.

WILLIAM B. D. PENNIMAN.

Witnesses:

JOHN M. REHBERGER,

MARY G. LANAHAN.