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54 **Apparatus and method for reclaiming waste oil.**

57 An apparatus and a method are provided for reclaiming a useful oil product from waste oil, such as used lubricating oil. The apparatus comprises an oil feed means (19), a boiler (18), a heater (17) and separating means (18,48). The heater (17) is used to heat the waste oil in the boiler (18) to a temperature such that lighter hydrocarbons of the waste oil volatilize, but such that heavier hydrocarbons remain unvolatilized, trapping contaminants therewith. The separating means separates the volatilized lighter hydrocarbons from the unvolatilized heavier hydrocarbons and contaminants.

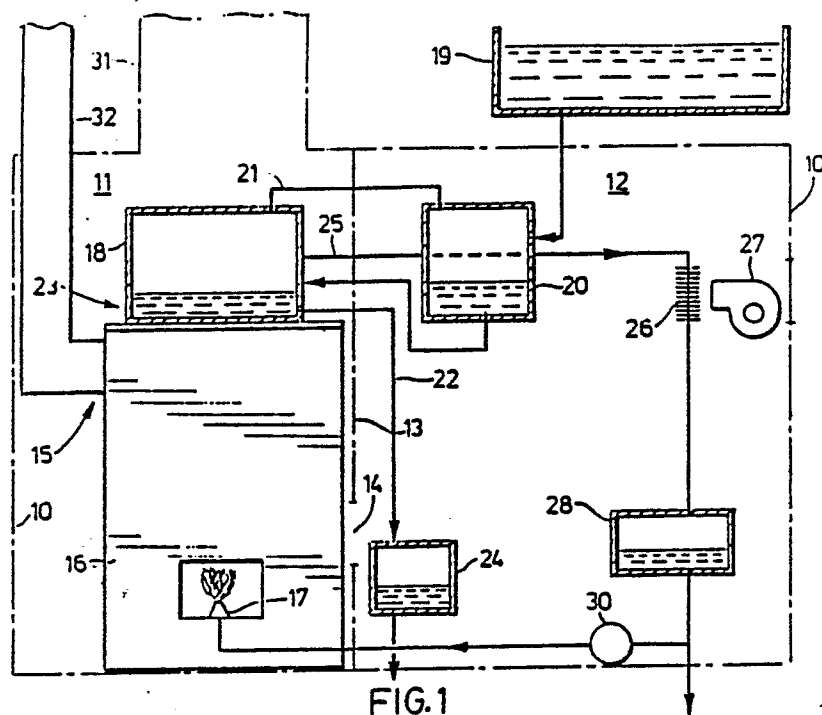


FIG.1

APPARATUS AND METHOD FOR RECLAIMING WASTE OIL

This invention relates generally to an apparatus and a method for reclaiming waste oil, more particularly for removing various contaminants present in waste oil which make it unsuitable for re-use as a heating fuel, diesel fuel, and so forth.

In this specification, the term "waste oil" refers to oil which has been used as motor oil or some other lubricating oil, or as hydraulic oil or in some other such application. In use, these oils are changed periodically. The drained and recovered waste oil typically contains substantial amounts of contaminants, which may include dirt, metallic particles (including heavy metals, such as molybdenum, chromium, cadmium, vanadium, copper and so forth), oxides and salts, gasoline and gasoline additives (such as tetraethyl lead), as well as detergents and performance additives.

Many millions of gallons of such waste oil are produced annually in North America. In the past, waste oil has been used on dirt roads for dust control, or simply dumped in sanitary sewers or land fill sites. However, increasingly such methods of disposal are seen as being unacceptable causes of hydrocarbon pollution to the environment. Re-refining of waste oil is practised to a certain extent. However, known methods for re-refining waste oil require complex chemical treatments and generally do not produce a high grade product. Transportation costs further detract from the economic viability of this manner of dealing with waste oil.

In the past, it has also been proposed that waste oil be used as a heating fuel. However, furnaces of the known type for burning such oil have met with limited success. During conventional combustion of waste oil, a residue accumulates in the burner. The residue is formed of the various contaminants and the heavier hydrocarbons which form a hard binding resin. As a result, the burner must frequently be cleaned of the accumulated hard residue, typically twice per day. In order to clean the burner, the furnace must be turned off and allowed to cool. This is extremely inconvenient and represents a major inefficiency. Furthermore, removal of the cooled and hardened residue from the burner is a difficult task, typically requiring strenuous physical labour.

It is an object of the present invention to obviate or mitigate the disadvantages of the prior art in this field.

In accordance with a first aspect of the present invention, there is provided an apparatus for reclaiming a useful oil product from waste oil, comprising:

oil feed means by which waste oil is fed to said apparatus;
a boiler fluidly connected to said oil feed means and adapted to receive waste oil therefrom;
a heater for heating waste oil in said boiler to a temperature such that lighter hydrocarbons of the waste oil volatilize, but such that heavier hydrocarbons do not volatilize thereby trapping the contaminants therewith; and,
separating means fluidly connected to said boiler for separating the volatilized lighter hydrocarbons from the unvolatilized heavy hydrocarbons and contaminants, and including a first discharge conduit for the volatilized lighter hydrocarbons and a second discharge conduit for the unvolatilized heavy hydrocarbons.

Surprisingly, it has been found that such an apparatus provides a simple and effective means for removing the contaminants from the waste oil and producing a clean oil product suitable for recycling in a variety of uses, particularly for use as a heating fuel or as a diesel fuel.

Preferably, the heater of such an apparatus comprising an oil burner which is fluidly connected to the separating means and adapted to receive therefrom and to burn the reclaimed portion of the waste oil derived from the volatilized lighter hydrocarbons. Advantageously, the separating means is integral to the boiler, the boiler comprising a first discharge conduit adapted to discharge the volatilized lighter hydrocarbons, and a second discharge conduit adapted to discharge the unvolatilized heavy hydrocarbons and contaminants. Most preferably, the apparatus further comprises a condenser for condensing the volatilized lighter hydrocarbons to produce a reclaimed liquid petroleum product and also comprises a reclaimed oil reservoir for accumulating and storing same, and a sludge tank for accumulating the separated unvolatilized heavier hydrocarbons and contaminants to facilitate periodic removal.

In accordance with a second aspect of this invention, there is provided a method for treating waste oil, comprising the steps of heating the waste oil in a boiler to a temperature each that lighter hydrocarbons of the waste oil volatilize, but such that heavier hydrocarbons do not, trapping the contaminants therewith, and subsequently, separating the volatilised lighter hydrocarbons from the unvolatilized heavier hydrocarbons and contaminants. Preferably, the temperature is in the range of from about 600 to 800°F. Advantageously, the temperature is about 650°. Most advantageously, the volatilized lighter hydrocarbons are subsequently condensed to produce a reclaimed liquid oil product, at least a portion of which is then burned to heat more

waste oil in the boiler.

The present invention provides a safe, efficient and versatile means for treating waste oil, reclaiming therefrom a useful petroleum product which can be used in a number of ways, particularly as a heating fuel or as a diesel fuel. The sludge by-product derived from the heavier hydrocarbons and contaminants must still be disposed. However, it should typically represent approximately only one-tenth of the volume of the waste oil fed to the apparatus. In some cases it may be possible to reclaim valuable metals from the sludge product.

The apparatus of the present invention can be manufactured and operated at a small fraction of the cost of a re-refining plant. Thus, industrial and commercial establishments (such as automobile service stations) and others who accumulate large quantities of waste oil can utilize the waste oil as a valuable by-product, rather than having to pay to have it disposed.

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings which illustrate the invention and in which:

Fig. 1 is a schematic representation of one embodiment of the apparatus of the present invention;

Fig. 2 is a cross-sectional side view representation of an alternative embodiment of the apparatus of the present invention;

Fig. 3 is a top view representation of a portion of the apparatus of Fig. 2, taken along the plane indicated by line 3-3.

Referring first to Fig. 1, the apparatus comprises a containment structure 10 having a first substantially enclosed chamber 11 and a second substantially enclosed chamber 12 the first chamber 11 and the second chamber 12 are substantially separated from each other by a common wall 13, but they fluidly communicate with each other through an opening 14 in the wall 13. A fire box 15 in the first chamber 11 comprises a separate fire chamber 16, including a burner 17, and a distillation boiler 18 in which the waste oil is heated. Waste oil is fed from a storage tank 19 through a float chamber 20 to the boiler 18. The oil level within the boiler 18 is controlled by the float chamber 20. The float chamber 20 is sealed but a breather tube 21 passes between the boiler 18 and the float chamber 20 to equilibrate pressure. The boiler 18 is located above the fire chamber 16 and the distance between them within the fire box 15 is such that while the apparatus is operating (i.e., burning oil) the temperature at the height of the boiler 18 is approximately 650°F. At this temperature, the lighter hydrocarbons are volatilized and cracked and they exit the boiler 18 through a discharge 25. A sludge consisting of the unvolatilized heavier hydrocarbons and contaminants gradually builds up in the bottom portion 23 of the boiler 18. This sludge is emptied via a drain 22 into a sludge tank 24, and is ultimately disposed. In the event that the sludge is not emptied, the level of the sludge and oil in the burner 18 rises to the cut off level of the float chamber 20 and no further waste oil enters the boiler 18 and the apparatus is ultimately automatically shut down.

The volatilized lighter hydrocarbons from the boiler 18 pass through the discharge 25 then through a heat exchanger 26, positioned in front of a blower 27, where they are cooled and condensed. The heat given off by the heat exchanger 26 passes along in the air stream created by the blower 27 through the second chamber 12, and through the opening 14 into the first chamber 11, thus being recaptured for heating.

The condensed lighter hydrocarbons thus form a reclaimed liquid oil product which passes to a holding tank 28. From there the reclaimed oil can be emptied for use elsewhere or transferred to the burner 17, via a pump 30. The fire chamber 16 is similar to a fire chamber of a conventional oil furnace. Heat from the fire box 15 is transferred through the first chamber 11 to a heating duct 31 which connects to a building heating system. Combustion fumes pass out through a flue 32.

The furnace burner 17 may be a simple pot type burner. Alternatively, a gun type burner may be used. If a gun type burner is used, the reclaimed oil should be fed by means of a hydraulic pump maintained at a temperature of about 165°F in a heated water bath, and an in-line heater should be used to maintain the nozzle temperature about 130°F, due to the viscosity of the reclaimed oil.

Fig. 1 shows a simple embodiment of the apparatus of the present invention in order to illustrate the basic operating principle. Turning to Figs. 2 and 3, a preferred embodiment of an apparatus of the present invention will now be described. For the sake of simplicity and brevity, like parts are given the same reference numbers as used for the simple embodiment of Fig. 1 and a description of these parts is not repeated.

In this embodiment, the feed storage tank 19 is mounted within the containment structure 10. When the level of waste oil in the feed storage tank drops below a pre-set level, a float switch 40 activates a motorized pump to deliver more waste oil from external receiving-storage-settling tanks. When the power is turned on to start up the apparatus, a solenoid valve 43 is opened to permit flow from the feed storage tank and a motorized feed pump 45 is activated. Waste oil from the feed storage tank 19 first passes a "Y"

strainer 41 which removes dirt particles and entrained water. Most of the water entrained with typical waste oils can be removed while the oil is being held in the external receiving-storage-settling tanks. The remaining entrained water which is diverted by the "Y" strainer drains into a water trap tank 42 from which it can be periodically removed via a water drain 35 by opening a valve 36.

5 When the solenoid valve 43 is opened, waste oil is delivered via the feed pump 45 and also through a needle valve 44 to a pre-heater tank 46. The needle valve 44 can deliver waste oil at a rate of up to six gallons per hour. The feed pump delivers waste oil at a rate of approximately four gallons per hour, regardless of the flow rate through the needle valve. Thus, during operation, the feed rate of the waste oil varies from about four to about ten gallons per hour.

10 During operation, the pre-heater tank 46 heats the waste oil to about 200 to 300°F. From the pre-heater tank 46, the waste oil is transferred to the boiler 18. In this embodiment, the boiler 18 has an inclined base which rests on sliders 47 so that the boiler 18 can be removed from the fire box 15 like a drawer to facilitate periodic cleaning and so forth. Two inclined barriers 48 extend upwardly from the base and inwardly from the opposing sides of the boiler 25 such that the sludge which accumulates at the bottom 23 of the boiler 18 flows from side to side down the inclined base around the barriers 48. The volatilized lighter hydrocarbons exit through a raised portion 49 and thence through the discharge 25.

15 When the level of the waste oil in the boiler 18 reaches a pre-set height determined by a low level float 72 in the float chamber 20, a switch is activated to turn on the burner 17 and the fuel pump 30. The burner 17 thus begins to fire and to heat up the fire box 15, including the boiler 18. The burner 17 is held in a refractory fire pot 57 which is supported by a fire pot support 58. The burner 17 can burn reclaimed oil from the holding tank 28 or from an external reserve of conventional fuel oil. Valve 51 for reclaimed oil and valve 52 for conventional fuel oil are manually opened and closed to select the fuel. The pump 30 is held in a water immersion tank 53 heated with an electric heating coil 54 to maintain the temperature in the immersion tank at approximately 165°F. Power to the heating coil 54 and to an in-line heater next to the nozzle of burner 17 is provided by an independent source so that the temperature of the fuel supply line, pump and burner is always maintained high enough to handle the apparatus' own reclaimed oil which has a higher viscosity than conventional furnace fuel oils. The fuel line pressure can be adjusted by means of a pressure relief valve 56 and can be monitored by means of a pressure gauge 55. It has been found that an operating pressure of approximately 120 p.s.i. is desirable.

30 When the burner 17 and fuel pump 30 are activated by the low level float switch 72, a coil relay also automatically shuts off the feed pump 45 and closes the solenoid valve 43. Thus, for the time being, no further waste oil is delivered to the apparatus. The waste oil already in the boiler 18 is gradually heated up by the heat from the burner 17 until it reaches the distilling temperature of approximately 650°F. At this temperature, lighter hydrocarbons are volatilized and pass out through the discharge 25 to the heat exchanger 26, while sludge builds up in the bottom 23 of the boiler 18 and gradually exits through the drain 22. As the volatilized lighter hydrocarbons are discharged and enter the heat exchanger 26, the temperature of the heat exchanger 26 rises. Increasing temperature of the heat exchanger 26 thus indicates that the waste oil in the boiler 18 has reached volatilization temperature. This is used as a signal to indicate that the apparatus is ready for steady state operation. A thermocouple mounted midway on the heat exchanger 26 responds when the temperature reaches 130°F by activating a coil relay to transfer the power to the burner 17 and fuel pump 30 to a different path for steady state operation. This path includes a sail switch which will turn off the power if the blower 27 stops operating for any reason. The thermocouple also opens the solenoid valve 43 and starts the feed pump 45 so that waste oil resumes flowing from the feed storage tank 19 through the pre-heater 46 and into the boiler 18. The oil level in the boiler 18 rises to a level pre-set by a float 70 of the float chamber 20. Float 70 controls the operating level in the boiler 18 by opening and closing the needle valve 44 to adjust the total feed rate. Typically, the apparatus runs at a steady state of about six to ten gallons per hour. The thermocouple on the heat exchanger 26 also turns on a sludge removal pump 66.

50 The holding tank 28 is provided with a pan 50 on the underside of its top where the condensed lighter hydrocarbons collect. A second tube extends from this region and connects to the flue 32 so that any remaining uncondensed volatiles entering the holding tank 28 are sucked away with the flue gases. In operation, only minute traces of volatiles have been found. A float switch 59 in the holding tank 28 activates a motorized pump which drains a portion of the reclaimed liquid oil from the holding tank 28 to an external storage tank if the depth in the holding tank 28 exceeds a pre-set level.

55 The sludge passes from the drain 22 into a settling-cooling tank 60 and from there past a heat exchanger 64 and a solenoid valve 65 to a sludge pump 66. The sludge pump 66 drains sludge to an external sludge storage tank at a rate of about 0.5 to 0.7 gallons per hour. The solenoid valve 65 directs the flow through one of two emanating branches. The solenoid valve 65 is biased to direct the flow normally

though the branch leading to the sludge pump 66. However, it may be activated to direct the flow to a shut down pump 67 instead. A "T" connects into the sludge draining line between the settling-cooling tank 60 and the heat exchanger 64, and leads to a transfer tank 61 and thence to the float chamber 20. The transfer tank 61 has an air release tube 62 with a valve 63 to release entrapped air and is included to reduce heat transfer to the float chamber.

When the apparatus is manually switched off, power is cut to the feed pump 45 and the sludge pump 66, and solenoid valve 43 is closed. The apparatus continues to operate, however, until the oil level in the boiler 18 is reduced to the level of the low level float switch 72. At this point, the low level float switch cuts power to the burner 17 and to the fuel pump 30. The apparatus then sits cooling for approximately two hours. When the temperature of the sludge in the drain 22 just upstream of the settling-cooling tank 60 has cooled to 140°F, a thermocouple activates solenoid valve 65, closing the branch leading to the sludge pump 66 and opening the branch leading to the shut down pump 67, and turns on the shut down pump 67. The sludge and any remaining oil is then completely drained from the apparatus by the shut down pump 67 to the external sludge storage tank. When the temperature of the sludge drain 22 just upstream from the first settling-cooling tank 60 has cooled to 100°F, indicating that the line is empty, a thermocouple reverses solenoid valve 65 and turns off shut down pump 67.

If the apparatus should run out of waste oil or develop a blockage in the feed line, the oil level in the boiler 18 will be lowered to the level of the low level float switch 72. This cuts power to the burner 17 and the fuel pump 30, and turns off the feed pump 45 and closes solenoid valve 43. The apparatus cools and is drained in the manner previously described.

If a blockage were to develop downstream, the oil in the boiler 18 would reach the level of a high level float switch 71. This also cuts power to the burner 17 and the fuel pump 30, and turns off the feed pump 45 and closes the solenoid valve 43. Again, the apparatus sits and cools and then drains itself.

High limit controls on the fire box 15 and on the heat exchanger 26 also similarly automatically shut off the apparatus if local temperatures exceed pre-set limits, which could occur, for example, if improper petroleum products such as gasoline are inadvertently added to the feed storage tank 19.

Example 1

This example illustrates the operability and efficiency of the invention.

A prototype apparatus substantially as illustrated in Fig. 1, with a pot burner, was tested according to the following procedure. A 25 gallon sample of a typical used motor oil obtained from an automotive service station was introduced to the feed storage tank, float chamber and boiler. The apparatus was started up using 2 cups (16 oz.) of a conventional No. 1 fuel oil (kerosene). The fire chamber was heated such that the temperature of the boiler approached 650°F, and the apparatus was operated continually for 24 hours. During operation, the apparatus consumed approximately 4.25 Imperial gallons per hour of waste oil of this amount, approximately .75 Imperial gallons per hour was consumed by combustion in the fire chamber, producing approximately 1500,000 BTU/hour for heating. Approximately 3.1 Imperial gallons/hour of additional reclaimed oil was accumulated in the holding tank, and approximately .4 Imperial gallons/hour of sludge was accumulated in the sludge tank.

EXAMPLE 2

This example further illustrates the operability and efficiency of the invention.

A prototype apparatus substantially as illustrated in Fig. 1 was tested according to a procedure similar to that described in Example 1, under conditions as shown in Table I. Chemical and physical analysis were conducted on the waste oil feedstock, the reclaimed oil and the sludge, and the results are shown in Table II.

The yield of reclaimed oil was approximately ninety percent. The product compared favourably to commercial light fuel oils with respect to elemental composition and calorific value. However, the viscosity, pour point and flash point differed significantly from the corresponding values for commercial light fuels. This was attributed to distinct differences in composition. Commercial light fuels consist essentially of saturated paraffinic aliphatic hydrocarbons with a relatively narrow range of boiling points, while analysis of the reclaimed oil revealed that it contained a mixture of saturated and unsaturated aliphatic paraffinic hydrocarbons, with a very wide range of generally higher boiling points. It should be noted, however, that the cetane number of the reclaimed oil was very high, approximately 56, compared to the typical range of

40 to 45 of North American diesel fuels.

It will of course be appreciated that many variations of the apparatus and method of the present invention are possible.

TABLE I

Operating Conditions for Example 2	
Times:	
start-up to start of reclaimed oil production	= 4 h approx.
time to produce 35 gal of reclaimed oil	= 6 h approx.
Total	= 10 h approx.
production rate	= 3.6 g/h approx.
Temperatures:	
boiler during production	= 635°F (335°C)
boiler at end of production	= 645°F (340°C)
stack during production	= 595°F (313°C)
Material Balance:	
waste oil feedstock volume	= 40 gal
total volume of reclaimed oil produced	= 36 gal
efficiency (percentage recovery of reclaimed oil)	= 90%
volume of reclaimed oil burned to sustain operation	= 0.7 gal/h approx.
sludge	= 3 gal
lost due to leaks and volatilization	= 1 gal approx.

TABLE II

Analytical Data for Example 2			
	Waste Oil Feedstock	Reclaimed Oil	Sludge
Appearance	Opaque black, mobile liquid	Clear, fluorescent yellow-orange mobile liquid	Opaque, black viscous liquid
Odour	Acrid, penetrating	Acrid, penetrating	Acrid, penetrating
Water (%)	0.7	<0.05	0.05
Ash (%) *	0.99	<0.01	7.12
Sulphur (%)	0.36	0.20	1.02
Carbon (%)	83.14	84.62	81.76
Hydrocarbon (%)	12.96	13.27	11.75
Nitrogen (%)	0.12	0.05	0.28
Oxygen (%) by diff.	1.73	1.81	(-1.98)*
Gross Heat of Combustion (BTU/lb)	19159	19548	17957
Specific Gravity			
@77°/77°F	0.8915	0.8525	0.965
@60°/60°F	0.8955	0.8565	0.969
API Gravity (calc)	26.5	33.7	14.55
Cloud Point (°F)	T.D.	T.D.	T.D.
Pour Point (°F)	0	-5	+10
Flash Point (°F)**	220	95	>220
Viscosity:			
@40°C (cSt)	68.0	7.42	251.5
@50°C (cSt)	45.9	5.69	156.4
@100°C (cSt)	11.13	2.18	25.14
T.D. = Too dark to observe			

* The ash is very high for an oil sample and the ash components would be present as oxides, thereby seriously skewing the equation used to obtain "oxygen, by difference"

** Pensky-Martens Closed Cup

Claims

1. An apparatus for reclaiming a useful oil product from waste oil, comprising:
oil feed means(19) by which waste oil is fed to said apparatus;

a boiler (18) fluidly connected to said oil feed means (19) and adapted to receive waste oil therefrom;

a heater (17) for heating waste oil in said boiler (18) to a temperature such that lighter hydrocarbons of the waste oil volatilize, but such that heavier hydrocarbons do not volatilize thereby trapping the contaminants therewith; and,

separating means (18,49) fluidly connected to said boiler (18) for separating the volatilized lighter hydrocarbons from the unvolatilized heavy hydrocarbons and contaminants, and including a first discharge conduit (25) for the volatilized lighter hydrocarbons and a second discharge conduit (22) for the unvolatilized heavy hydrocarbons.

2. An apparatus as recited in claim 1, wherein said heater comprises an oil burner (17) fluidly

connected to said separated means (18,49) and adapted to receive therefrom and to burn said volatilized lighter hydrocarbons.

3. An apparatus as recited in claim 2, wherein said separating means is provided by said boiler (18).

4. An apparatus as recited in claim 2 or claim 3, wherein said boiler (18) is located over said oil burner (17) at a distance such that in operation, the temperature of said boiler is in the range of about 315 to 427°C (600 to 800°F).

5. An apparatus as recited in any one of claims 2 to 4, further comprising a condenser (26) for condensing said volatilized lighter hydrocarbons, fluidly connected to said separating means (18) and adapted to receive said volatilized lighter hydrocarbons therefrom, and fluidly connected to said oil burner (17) and adapted to feed said recondensed volatilized lighter hydrocarbons thereto.

6. An apparatus as recited in claim 5, further comprising a reclaimed oil reservoir (28) fluidly connected to and between said condenser (26) and said oil burner (17), and further comprising a sludge reservoir (24) fluidly connected to said separating means (18) and adapted to receive a sludge product comprising the heavier hydrocarbons and contaminants.

7. An apparatus as recited in claim 5 or claim 6, wherein said condenser comprises a heat exchange conduit (26) having heat transfer fins extending outwardly therefrom, and further comprises a blower means (27) for blowing cooling air on said heat exchange conduit.

8. An apparatus as recited in any one of claims 2 to 7, further comprising valve means (44) to control the flow of waste oil from said oil feed means (19) to said boiler (18).

9. An apparatus as recited in claim 8, wherein said valve means (44) comprises a float chamber.

10. An apparatus as recited in claim 9, wherein said float chamber (20) comprises a first operating level float (70) operative upon said valve means (44), a second low level float (72) operative upon said valve means (44) and said oil burner (17), and a third high level float (71) operative upon said valve means (44) and upon said oil burner (17).

11. An apparatus as recited in claim 9 or claim 10, wherein said oil feed means (19) includes a feed pump (45) which delivers waste oil to said boiler (18) at a substantially constant rate, and also comprises a needle valve (44) which permits delivery of additional waste oil to said boiler at a variable rate responsive to said float chamber (20).

12. An apparatus as recited in any one of claims 9 to 11 when dependent on claim 7, further comprising a containment structure (10) having a first substantially enclosed chamber (12) wherein are disposed said float chamber (20), said heat exchange conduit (26) and said blower means (27), and a second substantially enclosed chamber (11) wherein are disposed said oil burner (17) and said boiler (18), said first and second chambers being substantially separated by a common wall (13) but being fluidly communicating to each other through a vent hole (14) in said wall and further comprising a heating duct (31) fluidly connected to said first chamber (12) for discharging heated air, a fire box (16) in which is located said oil burner (17), and a flue (32) fluidly connected to said fire box for expelling combustion fumes therefrom.

13. An apparatus as recited in claim 12 further comprising a tube extending between and fluidly connecting the upper portion (50) of said reclaimed oil reservoir (28) and said flue (32), for expelling any uncondensed volatiles entering said reclaimed oil reservoir.

14. An apparatus as recited in any one of claims 2 to 13, wherein said oil burner (17) is a gun type burner with an in-line heater to heat its nozzle, and further comprising a hydraulic pump (30) maintained in a heated water bath (53) to feed said oil burner.

15. An apparatus as recited in any one of the preceding claims, wherein said boiler (18) has an inclined base with barriers (48) extending upwardly therefrom such that the unvolatilized heavy hydrocarbons flow from side to side down said inclined base around said barriers while the volatilized lighter hydrocarbons pass over said barriers.

16. A method for treating waste oil comprising the steps of:
heating said waste oil in a boiler (18) to a temperature in the range of about 315 to 427°C (600 to 800°F), such that lighter hydrocarbons of the waste oil volatilize, but such that heavier hydrocarbons do not, thereby trapping the contaminants therewith;
and then separating said volatilized lighter hydrocarbons from said unvolatilized heavier hydrocarbons and contaminants.

17. A method as recited in claim 16, wherein the temperature is about 343°C (650°F).

18. A method as recited in claim 16, further comprising the steps of recondensing said volatilized lighter hydrocarbons, burning at least a portion of said recondensed volatilized lighter hydrocarbons, the heat of combustion from which is used to heat the waste oil in said boiler.

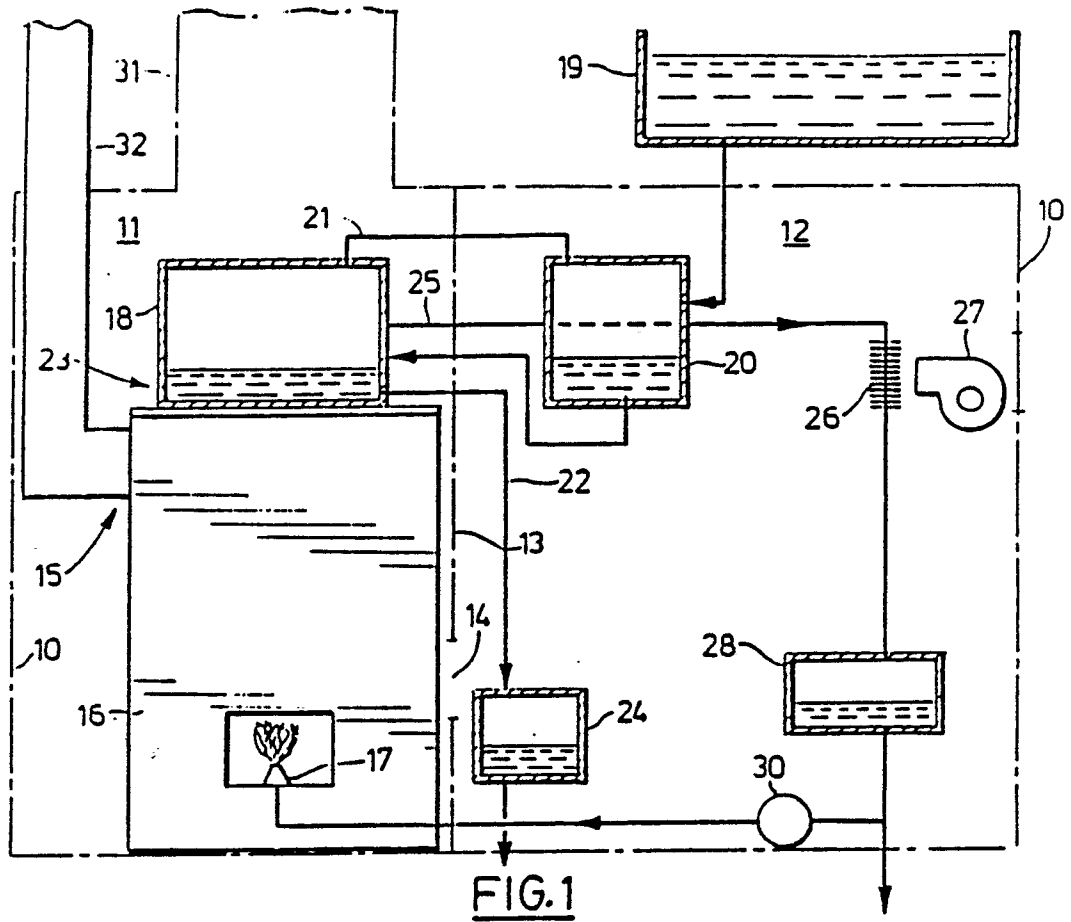


FIG. 1

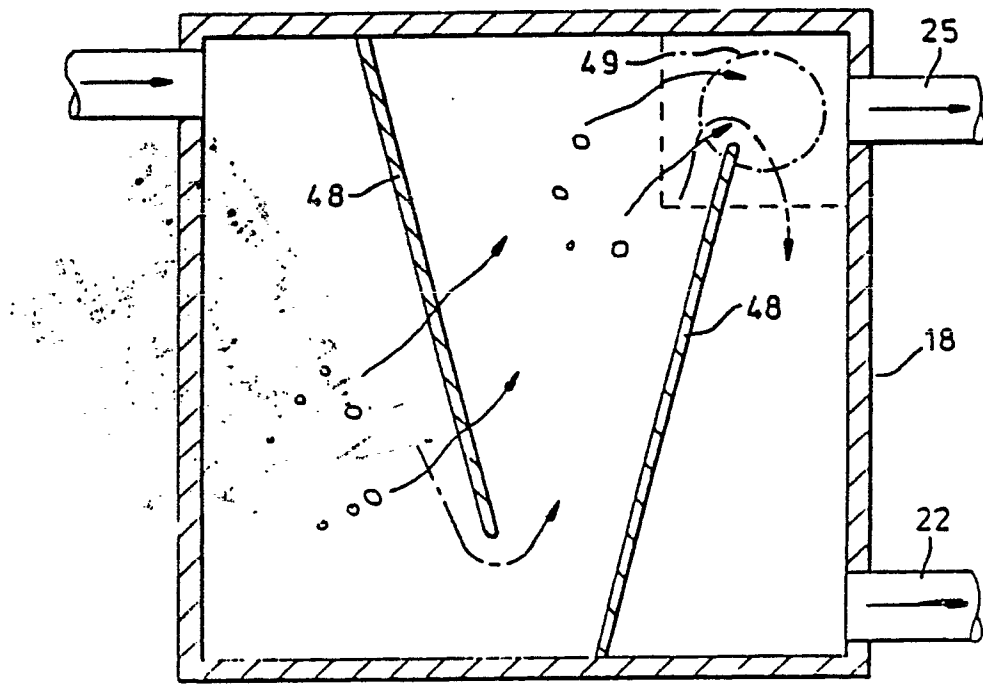


FIG. 3

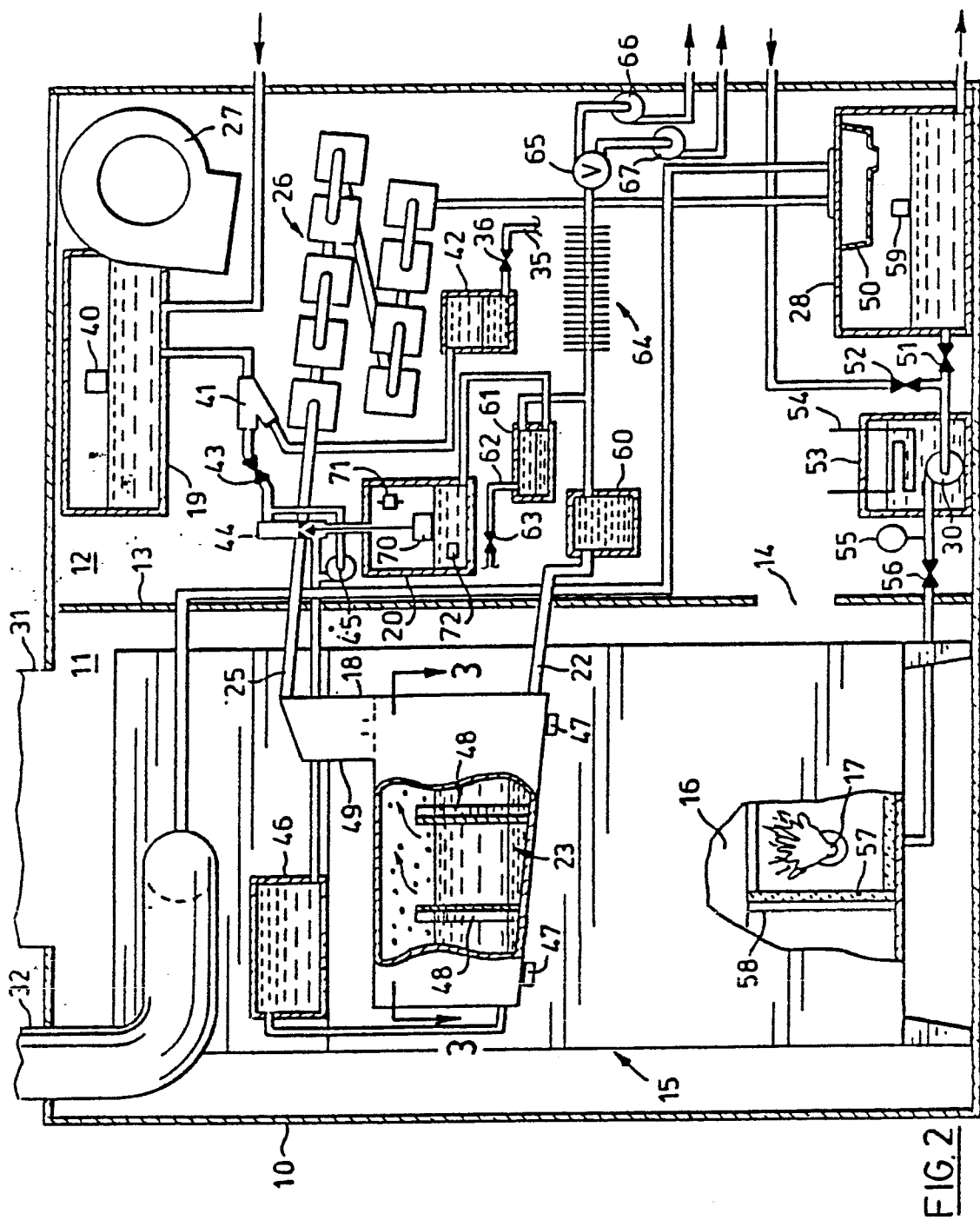


FIG. 2