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(54) **Title:** DECOMPOSITION OF WASTE PLASTICS

(57) **Abstract:** Far infrared ray heating technology is used to breakdown waste plastic and resultant heavy oils into usable products. Waste plastics may thus be processed into petroleum products and used to generate energy.

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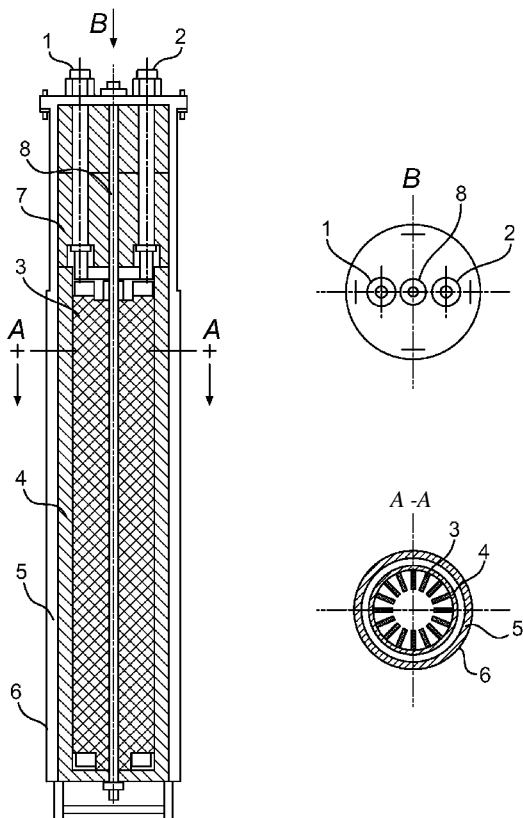


FIG. 1

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TITLE**DECOMPOSITION OF WASTE PLASTICS****Summary of the Invention**

Conventional reactors for converting waste plastics into oil, for example, as disclosed in U.S. patents 5,947,721, 5,951,826 and 5,584,969, all use high temperature flue gas to supply the heat required to decompose the plastics into oil. The reactors and processes therein involve some disadvantages. First the heating efficiency of the reactors is not high. The high temperature flue gas transfers the heat to the outer surface of the reactor, and then the outer surface conducts the heat to the plastics in the reactor. Because the heat is not directly transferred to the plastics, the heating efficiency is low. Nevertheless, despite the low heat-conducting efficiency there are serious problems from coking on the inner wall of the reactor. The decomposition of oil usually applies pyrolysis conditions cure heavy oil to light oil, increasing the efficiency of the light oil. Thus, pyrolysis is one desirable waste plastic and waste oil reclamation method, as it is an economical and environmentally desirable sound process.

Because the heat-conducting coefficient of typical waste plastic is low, it is difficult to conduct the heat into it from the heat source. But certain plastics absorb far infrared radiation easily, and when the waste plastics are heated by far infrared radiation, the heating rate and heating efficiency is increased. Consequently, the invention involves a process using far infrared radiation to decompose plastics to a liquid or liquid-gas mixture which can be further processed into useable oil products, fuels, or used to generate electrical power. In the process of the invention, melted plastic undergoes pyrolysis to produce a gas-oil mixture. The pyrolysis produces coke, which is removed from the reactor, and the gas-oil mixture can be subjected to further processing to recover gas, a light oil and a heavy oil. The invention thus involves a process for converting waste plastic into oil, comprising subjecting waste plastic to a plurality of far infrared radiation sources in intimate contact with said plastic in a reactor which contains an agitator which distributes the waste plastic past

the radiation sources. Unlike known processes, the energy source promoting decomposition of the plastic is internal to the reactor, and directly in contact with the plastic. The plastic can be polypropylene, polyethylene, polyethylene terephthalate, polystyrene or a mixture thereof. The plastic can further contain polyvinylchloride preferably in an amount of up to 2% by weight. Decomposition of the plastic takes place in the liquid phase. The plastic can be crushed and melted in a screw extruder prior to introduction to the reactor, or melted directly in the reactor where it will be decomposed.

The far infrared sources preferably comprise an electrical resistance heating element, a heat-absorbing material, a protective shell and thereon a far infrared radiation generating coating. The far infrared radiation sources are preferably disposed about the reactor such that the radiation generated from each source intersects with that of another source. The far infrared radiation has a frequency which is selected to maximize absorption by the plastic. The frequency preferably is 4.0 - 1000 μm , more preferably 4.0 - 25 μm . PP, PE, PVC, PS, PET and other plastics have their own special absorbing wavelength band, as is well known, and can all be processed in accordance with the invention.

Various metal oxides, nitrides, carbides and borides are far infrared radiators, and emit far infrared radiation of different wavelengths when heated, and the wavelength is different at different temperatures. It is thus possible to get high heating efficiency by selecting the wavelength of the far infrared radiation within desired ranges by selecting the appropriate far infrared ray radiator and working temperature. The "FIR" heater can composite electrical resistance space, far infrared radiator, insulator, and protective shell. The protective shell contains an isolation device that is made of metal, for example, iron or stainless. The isolation device, which separates the heater from the stream in the reactor, is preferably resistant to high temperature, high pressure and corrosion. In order to enhance the emitting of the far infrared radiation, a layer of the far infrared radiator may cover the outer surface of the far infrared ray heater. The far infrared ray radiator can be made into various shapes, for example, rod-shape, band-shape and other shapes, and on the outside can be encased by metal pipe, and finally painted with the far infrared radiator, whereby

far infrared radiation can directly heat the plastics. The protective shell is preferably in the form of a rod over the heating element and heat-absorbing material, although any shape is permissible. Preferably, the rod is bullet-shaped. When decomposed, the plastics will generate coke. This coke will cover the outer surface of the radiator, thus decreasing the heating efficiency. Consequently, an agitator is installed in the reactor. The flowing liquid causes the coke to peel off the rods, and the heating efficiency is not affected or minimally affected. The agitator may be a gate, propeller, combinatorial agitator or other shapes of agitator. The sludge in the reactor may be discharged into a screw drier in which the heavy oil components in the sludge are re-cracked under high temperature and the gas products go back to the reactor. At the end of the drier, the dried sludge is cooled and crushed into pieces which can be collected as carbon residual.

Brief Description of the Drawings:

Various other features and attendant advantages of the present invention will be more fully appreciated as the same becomes better understood when considered in conjunction with the accompanying drawings, in which the reference characters designate the same or similar parts throughout the several views, and wherein:

Figure 1 shows the structure of the far infrared ray-heating rods.

Figure 2 shows the structure of the reactor

Figure 3 represents another view of a reactor with far infrared ray-heating rods.

Figure 4 is a flow chart of a process involving further processing of the oil from plastic.

Figure 5 is a detailed process flow diagram.

Figure 6 is a process flow diagram of the desulfurization aspect of the invention.

Figure 1 shows the basic structure of a "FIR" heating rod. In the beginning of the rod are the connection, the pole (1) and pole (2). Then below the poles is the heating element (3). The heating element (3) is located in the center of the pipe (5), then from the inside to outside are located the far IR generator (4), e.g., carborundum, (4), metal pipe (5) and far infrared generating coating (6) in turn. AC power is introduced into the rod through pole (2) to the heating element (3). Heated by the heating element (3), the temperature of the carborundum (4) can reach 600° or above, and it transfers the heat to the pipe (5). In the meantime, the far infrared ray coating (6) receives the heat from the pipe (5), and emits the far infrared ray to heat the object or stream. In addition, in Figure 1 part 7 is the insulation material, and part 8 is the tight set. Except for the far infrared ray-heating rod, according to special needs, the far infrared radiator can be made into other shapes, for example, band and circle shape. Figure 2 shows a view of one embodiment of the present invention with a reactor, in which 21 far infrared ray-heating rods that are the same like the above far infrared ray-heating rod are installed. Among the 21 rods in the reactor, 9 rods are installed on the upper head. The waste plastics are fed into the reactor through the feeding inlet (16), then absorb the heat from the bottom rods (15) and top rods (17), and are melted and decomposed. The reactor is preferably operated under vacuum, in the absence of oxygen. In the presence of the agitator (13), the coke subsides slowly into the bottom of the reactor, and drained out together with the plastics liquor from the reactor through the sludge outlet (20) into the screw drier (not shown in this patent). This mixture of coke and plastic is called sludge at this point. The cracked gas from the decomposing plastic flows through the oil gas outlet (12) to another unit, for example, the scrubber (not indicated) where the hydrogen chloride gas can be neutralized, the fraction tower where the gas can be separated into light oil and heavy oil, or the second reactor where the catalyst is packed and the heavy component can be cracked further into light components. In addition, the reactor can have many accessories, such as, motor reducer (10), manhole (18), thermocouple well (19), level gauge nozzle (24), pressure gauge nozzle (21), gage hatch (21), safety valve nozzle (22), manual emergency vent (23), coupling (11), lug support (14). Figure 3 shows a view of one embodiment of the present invention with the reactor (34), in which the similar far

infrared ray-heating rods (27) are installed, but the type of the agitator is different. As shown in Figure. 3, in the reactor there are two agitators that are separately drawn by their own motor reducer (28) and (29). One is a column form impeller (25), and another is a gate paddle impeller (26). Between the two impellers are installed the "FIR" heating rods (27) that are fixed on the bottom head of the reactor. According to Figure 3, the reactor has plastic inlet (31), oil gas outlet (30), sludge outlet (32) and other accessories (not shown in the diagram). The hot-splitting technique of high-molecular compounds is the course that produces flammable legit oil, thereby breaking the long chains of high-molecules and the chains of complex molecules. This produces a part of light oil and meanwhile some coke from the process. This coke together with some heavy pyrolytic product will be discharged as sludge from the reactor constantly. Both dry and wet methods can be used for treatment of the sludge. For both methods, discharging of the hot-slitting sludge is performed in a closed system, that this method guarantees the safety to discharge residuals.

In addition to a process for converting waste plastics into oils, the invention optionally involves further processing into qualified automotive diesel. After the waste plastics are thermally decomposed using far infrared ray heating technology, the vapor products of the decomposition can be fractionated into gas, light oil and crude diesel oil, and the crude diesel oil can be subjected to ultrasonic desulphurization and solvent-extraction treatments to obtain qualified automobile diesel. The sludge produced in plastic decomposition can be re-cracked to remove the heavy oil components, crushed into pieces, and collected as carbon residual byproduct.

The oil products further used to produce fuels or electricity. A facility employing the process of the invention can include, for example, preprocessing unit, reaction unit, fractionation unit, HCl adsorption unit, diesel desulfurization and refining unit, sludge drying unit, circulation water unit and/or waste water collection unit. Moreover, the noncondensable gas which is produced in this facility can be burned in electricity generator to produce electricity. The quality of diesel oil which can be produced meets the requirements of Australian auto-diesel oil standard.

In a preferred embodiment shown in Figure 5, plastic is introduced into preprocessing unit, where it is firstly crushed into pieces of desired size and then loaded to a screw extruder feeding machine. In the presence of high pressure, the waste plastics are molten in the extruder cylinder and are about 200-300 °C at the inlet of the reaction unit. Alternatively, plastic of an appropriate size can be melted directly in the reactor. Far infrared radiation is used to provide energy for thermal cracking of the plastics. In the reactor, far infrared heating rods are inserted to the reactor vessel, and emit far infrared ray of a desired wavelength, which can be intensively absorbed by the plastic mixture. Because the radiation transports in the melted plastics, it heats more evenly and remarkably reduce coking. The waste plastic can be decomposed at a temperature from about 360 °C to 420 °C. An agitator in the reactor, e.g., which rotates in the rate of approximately 30 rpm, mixes the plastic liquor and makes it homogeneous. As a pyrolysis product, oil gas flows up into the fraction tower (FT-1). The sludge, which is produced in the reactor and often mixed with some the melted plastic, can be drained from the bottom of the reactor into a sludge-drying unit.

Oil gas from the reactor (R-1) which contains some heavier oil and melted plastics enters a fractionation tower (FT-1) from the bottom. At the bottom, the oil gas is separated, e.g., by passing through an umbrella-shaped cap and an upside-down cone. Because of the change of velocity and direction, droplets of some heavy oil and most of the melted plastic will be separated from the oil gas and flow back into the reactor. Then the oil gas goes up into the packing bed and exchanges heat and mass with top reflux. The heavy oil will be separated from the oil gas and can be recycled to the reactor to be decomposed again. In the top of (FT-1), the oil gas is the mixture of non-condensable gas, a gasoline component, a diesel component and some heavy oil. The reflux is the bottom liquid of (FT-2).

The oil gas from the top of (FT-1) enters (FT-2) from the bottom inlet. In (FT-2) the oil gas is distillated into light oil and middle oil. The oil gas from the top of (FT-2) is mixed with some caustic sodium solution and then is cooled in the heat exchanger (HE-1) to 40°C or so. Finally it goes into a gas/oil separator (GOS-1) to be separated into low pressure gas and liquid. The liquid is also called light oil. Some of the light oil in (GOS-1) is pumped by (P-10) back to (FT-2) as top reflux, and the rest is sent out as product.

The sweet gas from the top of (GOS-1) is conveyed to the gas storage tank (GST-1) as fuel of generator (G-1). The middle oil from the bottom of the stripping tower (STT-1) is crude diesel oil. It is cooled, e.g., to 50°C by water box (HE-2) and sent to desulfurization and solvent-extraction unit for further refining. The bottom liquid of (FT-2) is by (P-3) to the top of (FT-1) as a reflux. The oil gas from the top of (FT-2) is mixed with some caustic sodium solution which is injected directly into the top oil/gas pipe. In the pipe between (FT-2) and (GOS-1) the HCl in the oil gas is absorbed. The NaCl solution in the bottom of (GOS-1) is conveyed to caustic solution tank (CST-1) for recycling. In (CST-1), fresh caustic sodium solution is added and the mixed solution is sent back by (P-5) to mix with the oil gas from top of (FT-2). The unstable components in the crude diesel, which are mainly S-heteroatom compounds and the resin, are removed, e.g., by ultrasonic desulfurization and solvent-extraction treatment. The crude diesel oil from the bottom of middle oil tank (MT-1) and the oxidant in the oxidant storage tank (OST-1) are pumped to the ultrasonic reactor (UR-1) by (P-7) and (P-12), respectively. In (UR-1) the sulphur organic compounds are transformed to sulfoxide, sulfone or sulfosalt under the ultrasonic energy. After reaction, the mixture was delivered to oil water separator (DOS-1). The separated diesel is further pumped to static mixer (SM-1) and mixed there with the solvent from the solvent storage tank (SST-1). Then the mixture enters the settling tank (ST-1/2) consequently for complete separation of solvent from the diesel. The refined diesel is sent out as product, and the solvent in (ST-1/2) flows to solvent distillation tower (SFT-1) for flash distillation. The recovered solvent is sent to solvent storage tank SST-1 and reused. The waste solvent with high content of deposits is sent to (DOST-1) by (P-8) and further recycled to (R-1) by (P-1). The solvent is evaporated in (R-1) and recovered in (GOS-1) at time intervals (equipment not shown in the diagram), and the compounds containing S is transferred into the carbon residuals. The sludge in the bottom of reactor (R-1) is drained to the screw drier (SD-1) with jacketed heater. In (SD-1) the heavy oil in the sludge is cracked and the cracked gas goes back to (R-1). The dried carbon residual is crushed to pieces at the end of the SD-1 column and collected as byproduct. Waste water tank (WWT-1) is used to collect the waste oxidant from (DOS-1), the waste caustic solution, the oily water accumulating in some tanks (HE-2), (GOS-1), (MDT-1), (GOT-1) and (DOT-1), or emitted oil/water. The waste water in (WWT-1)

is pumped by (P-9) to water oil separator (WOS-1). The separated oil in (WOS-1) is pumped to dirty oil/solvent tank (DOST- 1) by (P-8) at time intervals and sent back to (R-1) by (P-1). Intermittently, the waste water in (WOS-1) is drained out and sent to the wastewater treatment plant.

Because some additives in the plastics contain sulfur, the oil produced in the present process may be rich with sulfur components, e.g. thiols, thioethers, disulfides, and thiophenes which lower the quality of the oils. To remove these components, the oil is typically desulfurized. In a preferred method, the oil is pumped to an ultrasonic chamber together with peroxide solution and reacts in the presence of ultrasound energy. After separation with the oxidant solution, the oil is further mixed with polar solvent for extraction of the oxidized of the sulfur components. After separation with the polar solvent, the oil is desulfurized oil which is adequate to automotive uses.

Figure 6 shows the basic flow diagram of this embodiment of invention. The oil A, which can be light oil, diesel oil, heavy oil produced from the decomposition of waste plastics, continuously flows into the middle tank (61) with heating device. In tank (61), the oil is preheated to about 50°C and sent to ultrasonic reactor (65) by pump (62).

The oxidizing solution B is preferably a mixture of peroxide solution (e.g., approximate mass percent 27%) and formic acid at the volume ratio of 2:1-10:1, and preferably 2:1-3:1. The peroxide and the formic acid are used as the oxidant and catalyst for the oxidation reaction, respectively. The oxidizing solution is prepared in corrosion resisting tank (63) and conveyed to ultrasonic reactor (65) by corrosion resisting pump (64). The volume ratio of the oxidizing solution and the oil is 1:100-1:10, preferably 2:100-3:100.

In the ultrasonic reactor (65), the oil and the oxidizing solution is intensely mixed and the sulfur organic compounds in the oil are transformed to sulfoxide, sulfone or sulfosalt under ultrasonic energy. An effective ultrasound frequency range for the oxidation reaction is from 20 kHz to 100 kHz, and from 20kHz to 40kHz the highest reaction efficiency is obtained. For 20kHz to 40kHz range of ultrasound frequency, the preferable intensity is 60- 150 watt/cm². The temperature for the reaction to generate best result is about 60°C. Because the reaction generates heat, in order to control the

temperature inner cooling device is preferably installed on the device, e.g. coiled pipe. The coolant can be water or other liquid coolant and is cycled between the reactor and an external heat-exchanging device. The reaction can be completed in very short time. Usually the retention time of the oil flow should be less than 30 mins in the reactor, and preferably it is 10-15 mins.

The settling tank (66) (corrosion resistant) is used for separation of the oil from the aqueous solution after the ultrasound treatment. The aqueous phase settled to the bottom of tank (66) contains no peroxide but contains formic acid. It is pumped back to tank (63) by pump (67) and recycled. Some insoluble oxidation product E is discharged at time intervals. The oxidized oil C from the top of settling tank (66) is sent to static mixer (611), in which it mixes intensely with the polar solvent F powered by pump (610). In static mixer (611), the solvent or the oil is dispersed into fine droplets of diameter less than 100 μm and two phase extraction occurs. During the extraction, sulfoxide, sulfone or sulfosalt transfer to the solvent phase. The effective solvents can be dimethyl formamide (DMF), N-methylpyrrolidone, furfuraldehyde, acetonitrile or some other solvent, and DMF is preferred. For DMF solvent, good result is generated when the volume ratio of the solvent and the oil is 1:5 to 10:1, and for both efficiency and economy consideration, the ratio of 1:1 is preferred. The best temperature for the extraction is 60~80°C.

The mixture of oil and solvent is pressured out of the static mixer 11 and flows to settling tank (612) for separation of the oil and the solvent. For both economy and production efficiency consideration, the best settling time is 20-30 mins. The oil is sent out from top of tank (612) as desulphurized product G, and the bottom solvent H is sent by pump (613) to flash distillation tower (614) for recovery. In flash distillation tower (614), the solvent is evaporated and the vapor I is condensed in condenser (615). The condensed solvent flows back to solvent storage tank 9 and is recycled. The bottom sludge J of flash distillation tower (614) contains high content of sulfur and is discharged for further treatment.

Without further elaboration, it is believed that one skilled in the art can, using the preceding description, utilize the present invention to its fullest extent. The following preferred specific embodiments are, therefore, to be construed as merely illustrative, and not limitative of the remainder of the disclosure in any way

whatsoever.

In the foregoing and in the following examples, all temperatures are set forth uncorrected in degrees Celsius and, all parts and percentages are by weight, unless otherwise indicated.

Example 1: Waste plastic cement bags of polypropylene (thin-type PP) are cut into pieces and the sand sediment removed (298.5/g). They are then put into the cracking reactor and subjected to far IR radiation. The pieces begin to melt and are turning into a liquid state when the temperature of the bottom part of the reactor rises to 110°C and fuel oil appears at the exit of the condenser behind the reactor when the temperature reaches a specified range and the top temperature is 75°C. After 20 minutes the oil flow increases when the temperature in the bottom increases and the top temperature reaches 95°C. After 10 minutes at this stage, the oil flow accelerates and produces a great quantity of cracking gas, which is ignited after passing through a water-sealed tank. The bottom temperature is increased and the top temperature reaches 242°C and cracking is carried on for 35 minutes. Ten minutes after this stage, the reaction phase finishes with a top temperature of 147°C. The cracking fuel oil distilled out of the top of the reactor is 196.5/g. The yield of fuel oil is 65.83% from the cement bag and the heavy oil that contains wax at the bottom of the reactor is 62.5/g or 29.93%. Total yield of high quality fuel oil is 86.76%. Cracking gas and loss amounts to 30.54/g or 10.23% and coke is 8.96/g or 3.01%.

Action	Weight	%
Fuel oil out of top of reactor*	62.5	65.83
Heavy oil from Reactor bottom	62.5	20.93
Cracking gas & loss	54.0	10.23
Coke	8.96	3.01
*HQ Fuel oil yield total	259	86.76
Total w/debris	298.5	100

Example 2: In this experiment, 170.5/g of waste plastic from weaving bags made from polypropylene (PP) are put into the reactor for cracking. The temperature in the bottom of the reactor quickly increases and the top temperature rises to 57°C. The condensed oil begins to flow out of the condenser. After 10 minutes as the bottom temperature climbs and the top temperature reaches 146°C, oil continues to flow and gas is produced and ignited as in example 1. The molten plastic liquid continues to flow and gas is produced and ignited as in example 1. The molten plastic liquid continues to be cracked and as the upper temperature reaches 251°C, fuel oil and gas continue to flow at a rapid pace out of the top of the reactor for 25 minutes. Distillate oil obtained is 118.0/g with a yield of 69.2% while the gas and loss is about 34.0/g or 19.44% and the coke in this run, which also contains oil, is 18.5/g or 10.85%.

Action	Weight/g	%
Fuel out of top of reactor*	118	69.2
Cracking gas & loss	34.0	19.44
Coke w/oil	18.5	10.85
*HQ Fuel oil yield total	118	69.2
Total w/debris	170.5	100

Example 3: In this experiment, 47.5/g of waste plastic food bags made from polyethylene (PE) is put into the reactor for cracking. The temperature in the bottom of the reactor is slowly increased to 200°C and the bags begin to liquefy. The condensed oil begins to flow out of the condenser. As the bottom temperature climbs and the top temperature reaches 180°C for 15 minutes and is maintained this temperature for 1 hour, oil is produced. Distillate oil obtained is 42.6/g with a yield of 89.68% while the gas and loss is about 3.4/g or 7.16% and the coke in this run is 1.5/g or 3.16%. No residual heavy oil is obtained in this experiment.

Action	Weight/g	%
Fuel oil out of top of reactor*	42.6	89.68

reactor*		
Cracking gas & loss	3.4	7.16
Coke	1.5	3.16
*HQ Fuel oil yield total	42.6	89.68
Total w/debris	47.5	100

Example 4: In this experiment, 314.9/g of waste plastic from a white plastic barrel is put into the reactor for cracking. The reactor is heated for 25 minutes at which time a white gas like fog flows out of the reactor. The bottom temperature climbs to 208°C and the top temperature reaches 56°C; the plastic is fully liquefied at 330°C at the bottom side of the reactor. The molten plastic liquid continues to be cracked and as the upper temperature reaches 120°C, fuel oil and gas continue to flow at a rapid pace out of the top of the reactor for 20 minutes at which time the cracking reaction finished. Distillate oil containing wax is 207.5/g with a yield of 66.0% and the residual oil is 87.5/g or 27.8%.

Example 5: In this experiment, 36.5/g of plastic foam lining made from polystyrene (PSF) is put into the reactor for cracking. The pieces begin to melt and are turning into a liquid state when the temperature of the bottom part of the reactor increases and fuel oil appears at the exit of the condenser behind the reactor when the temperature reaches a specified range and the top temperature is 85°C. The cracking reaction is maintained at a higher temperature in the bottom with the top temperature reaching 248°C for 44 minutes. The first distillate oil obtained is milky white with some clouding and finally a transparent yellow. The distillate oil is 24.2/g with a yield of 66.3% while the residual oil is 4.5/g or 12.3% in this experiment. Overall, a total yield of 78.6% was attained.

The preceding examples can be repeated with similar success by substituting the generically or specifically described reactants and/or operating conditions of this invention for those used in the preceding examples.

From the foregoing description, one skilled in the art can easily ascertain the

essential characteristics of this invention and, without departing from the spirit and scope thereof, can make various changes and modifications of the invention to adapt it to various usages and conditions.

The entire disclosures of all applications, patents and publications, cited herein are incorporated by reference herein.

We Claim:

1. A process for converting waste plastic into oil, comprising subjecting waste plastic to a plurality of far infrared radiation sources in intimate contact with said plastic in a reactor which contains an agitator which distributes the waste plastic past the radiation sources.
2. The process according to claim 1, wherein the far infrared sources comprise an electrical resistance heating element, a heat-absorbing material, a protective shell and thereon a far infrared radiation generating coating.
3. The process according to claim 2, wherein the protective shell forms a rod over the heating element and heat-absorbing material.
4. The process according to claim 3, wherein the rod is bullet-shaped.
5. The process according to claim 1, wherein the far infrared radiation sources are disposed about the reactor such that the radiation generated from each source intersects with that of another source.
6. The process according to claim 1, wherein the plastic is polypropylene, polyethylene, polyethylene terephthalate, polystyrene or a mixture thereof.

7. The process according to claim 6, wherein the plastic contains polyvinylchloride in an amount of up to 2% by weight.
8. A process according to claim 1, wherein the plastic is crushed and melted in a screw extruder prior to introduction to the reactor, and decomposition of the plastic takes place in the liquid phase.
9. The process according to claim 1, wherein the far infrared radiation has a frequency which is selected to maximize absorption by the plastic.
10. The process according to claim 1, wherein melted plastic undergoes pyrolysis to produce a gas-oil mixture.
11. The process according to claim 10, wherein pyrolysis produces coke, which is removed from the reactor, and wherein the gas-oil mixture is subjected to further processing to recover gas, a light oil and a heavy oil.
12. A process according to claim 1, comprising:
 - a) subjecting the plastic material to thermal decomposition and pyrolysis in liquid form in a reactor vessel (R-1);
 - b) fractionating resultant decomposition product so as to obtain gas, light oil and crude diesel oil;

- c) continuously draining out sludge produced during pyrolysis and re-cracking the sludge to obtain byproduct of carbon residual,
- d) subjecting the crude diesel oil to desulphurization treatment and consecutive solvent-extraction treatment to obtain diesel oil.

13. The process according to claim 12, wherein a first fractionation tower is mounted directly on top of the reactor vessel.

14. The process according to claim 12, wherein in (d), the sludge in the bottom of reactor vessel R-1 is dried by a cylinder screw dryer with jacketed heater, and the sludge is discharged continuously into the dryer from an inlet near an end of the heater containing a motor driving the screw, and pushed to an outlet close to an opposite end, the middle of the dryer is heated to 600-700°C by the jacketed heater, heavy oil components in the sludge are decomposed into low-weight gases and conveyed back to the reactor vessel or cooled and collected, the dried sludge is crushed into powder vessel at the outlet of the dryer and collected as carbon residual.

15. The process according to claim 12, wherein the diesel oil is subjected to desulfurization.

16. The process according to claim 15, wherein desulfurization is performed by subjecting the diesel oil to ultrasound energy, in the presence of an oxidizing solution.

17. The process according to claim 15, wherein (e), the diesel oil is separated and further subjected to solvent extraction.

18. A reactor for the pyrolysis of waste plastic, comprising a reactor vessel having a feeding inlet (16) admitting plastic to a reactor chamber, a plurality of far infrared heating rods (15) and (17) disposed about the reactor chamber able to achieve intimate contact with said waste plastic, an agitator (13) which distributes the plastic past the rods, a sludge outlet (20) and a gas outlet (12).

19. The reactor according to claim 18, further comprising two agitators that are separately driven by their own motor reducer (28) and (29), a first agitator being a column form impeller (25), and a second agitator being a gate paddle impeller (26), and between the two agitators are installed infrared heating rods fixed on a bottom head of the reactor.

20. The reactor according to claim 18, further comprising a fractionation tower (FT-1) connected to gas outlet (12) said fractionation tower comprising an umbrella-shaped cap and an upside-down cone, a packing bed capable of exchanging heat and mass with top reflux in the fractionation tower, a second fractionation tower (FT-2) having a bottom inlet in communication with the top of (FT-1), and an outlet leading to heat exchanger (HE-1), said heat exchanger capable of passing product of the second fractionation tower to a gas/oil separator (GOS-1) capable of separating gas/oil into low pressure gas and liquid light oil, said separator (GOS-1) having a recycle via a pump (P-10) to FT-2 as top reflux, and an outlet for sweet gas from the top of GOS-1, optionally to a gas storage tank

(GST-1), an outlet to a stripping tower (STT-1) capable of producing crude diesel oil, said stripping tower connected to a desulphurization and solvent-extraction unit.

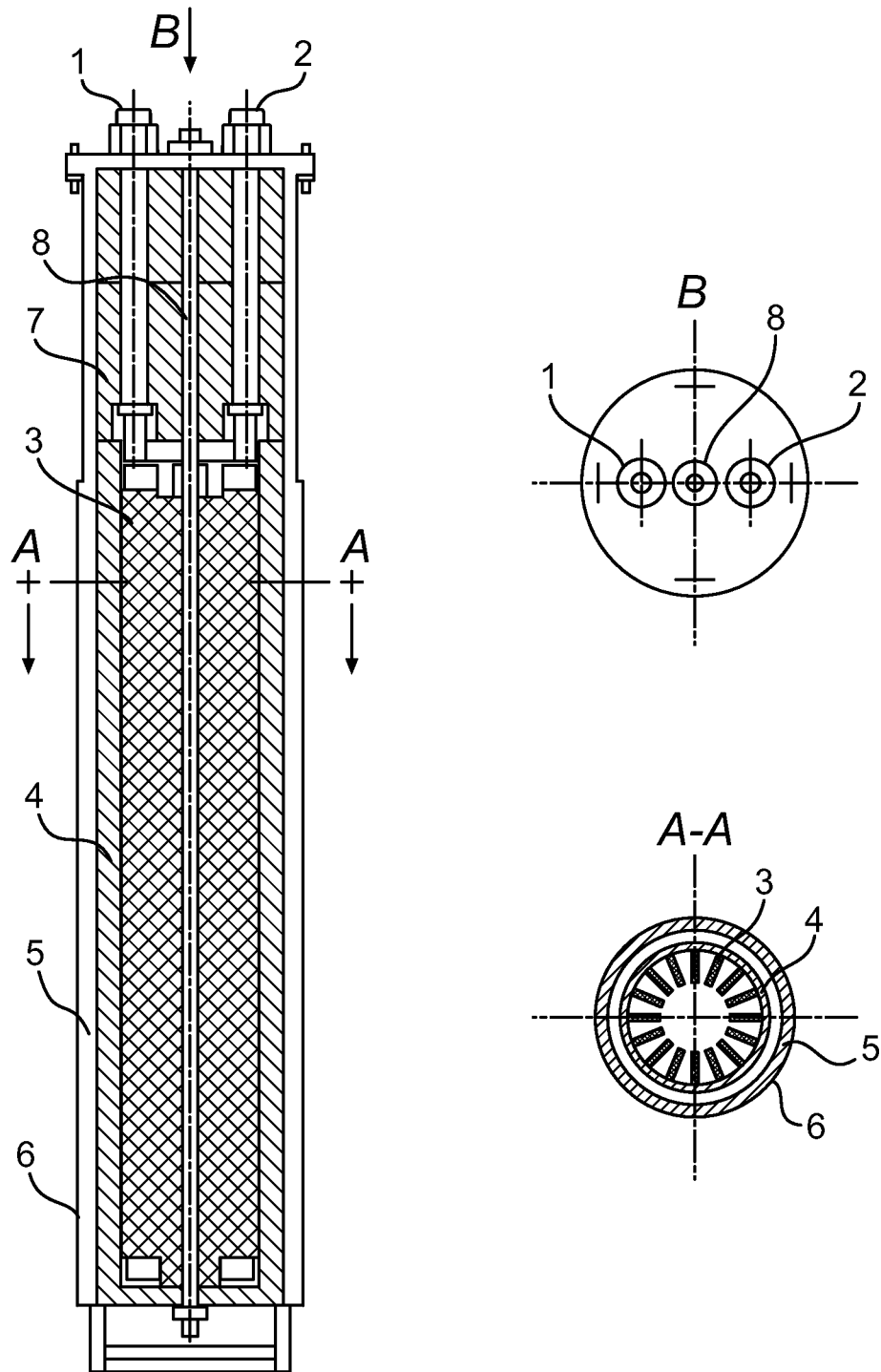


FIG. 1

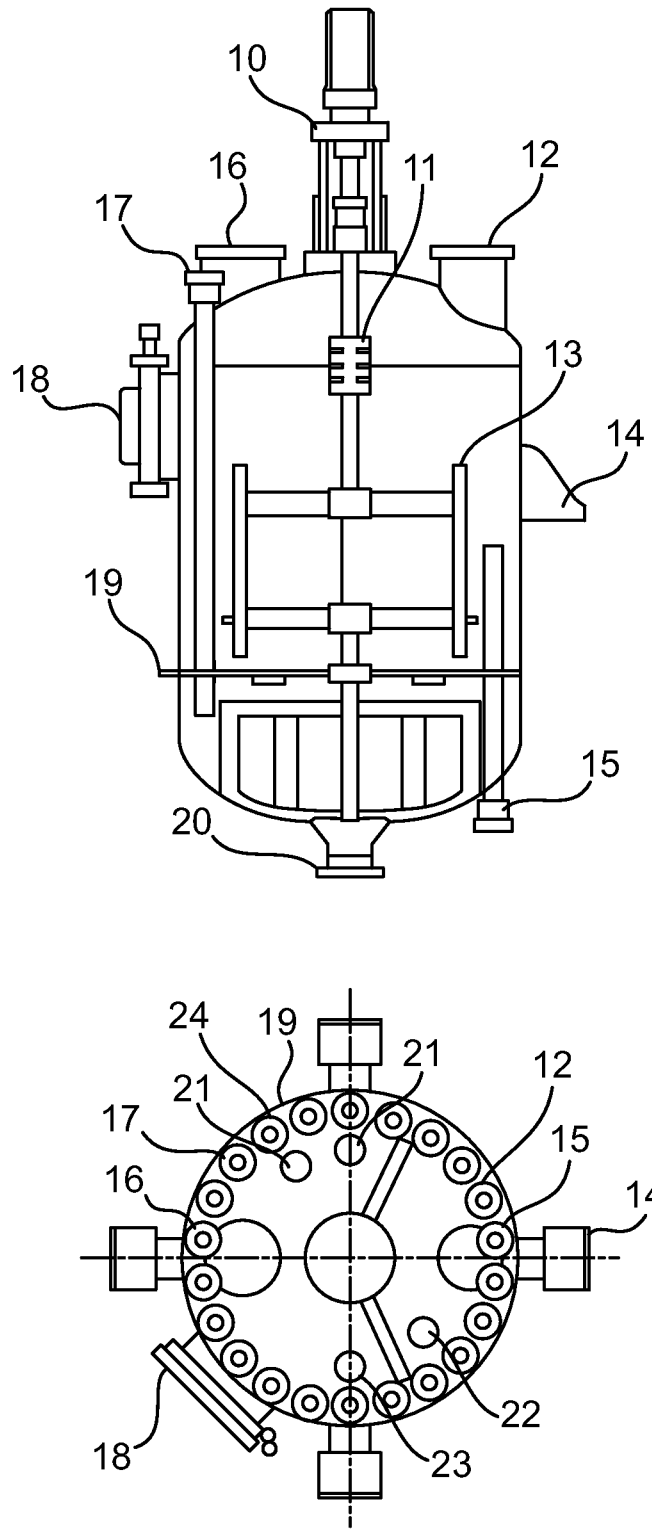


FIG. 2

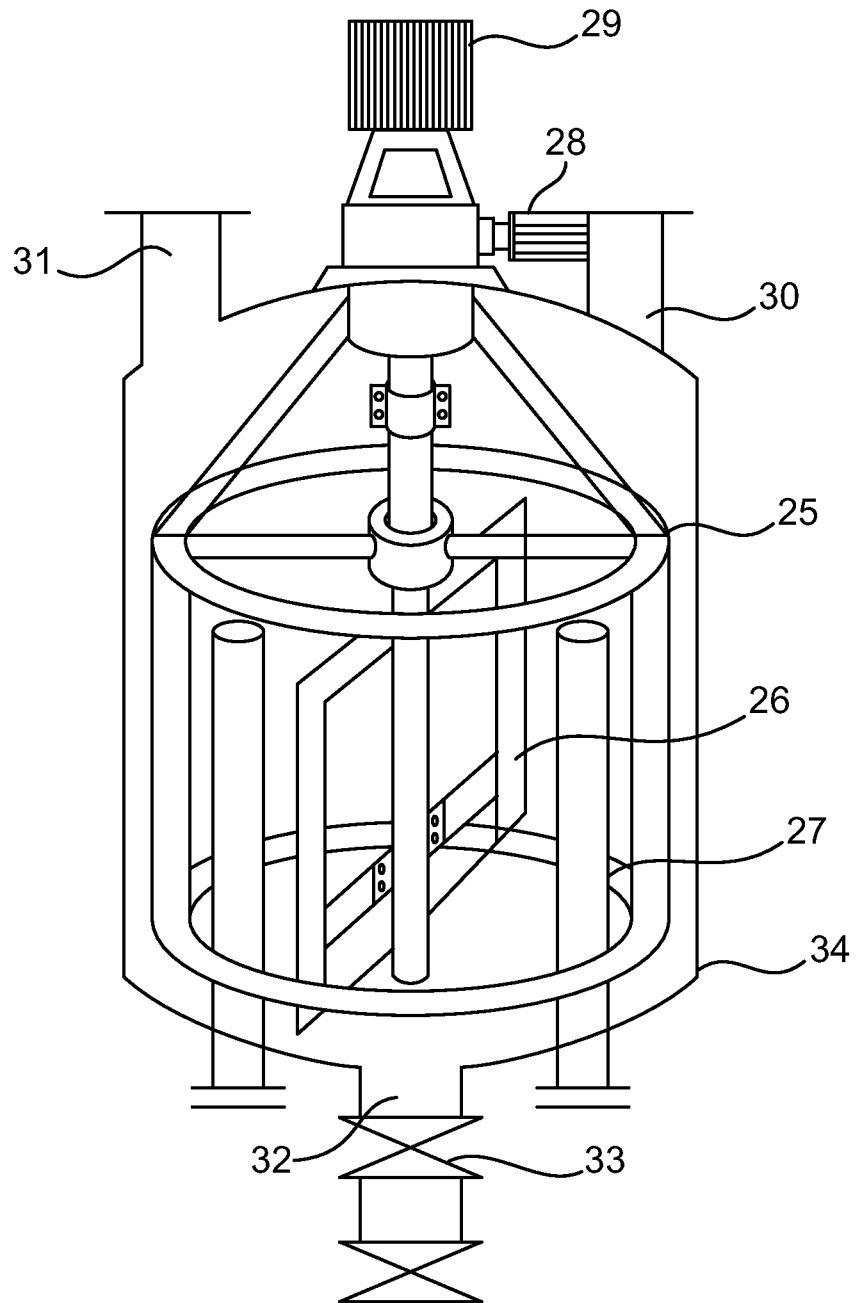


FIG. 3

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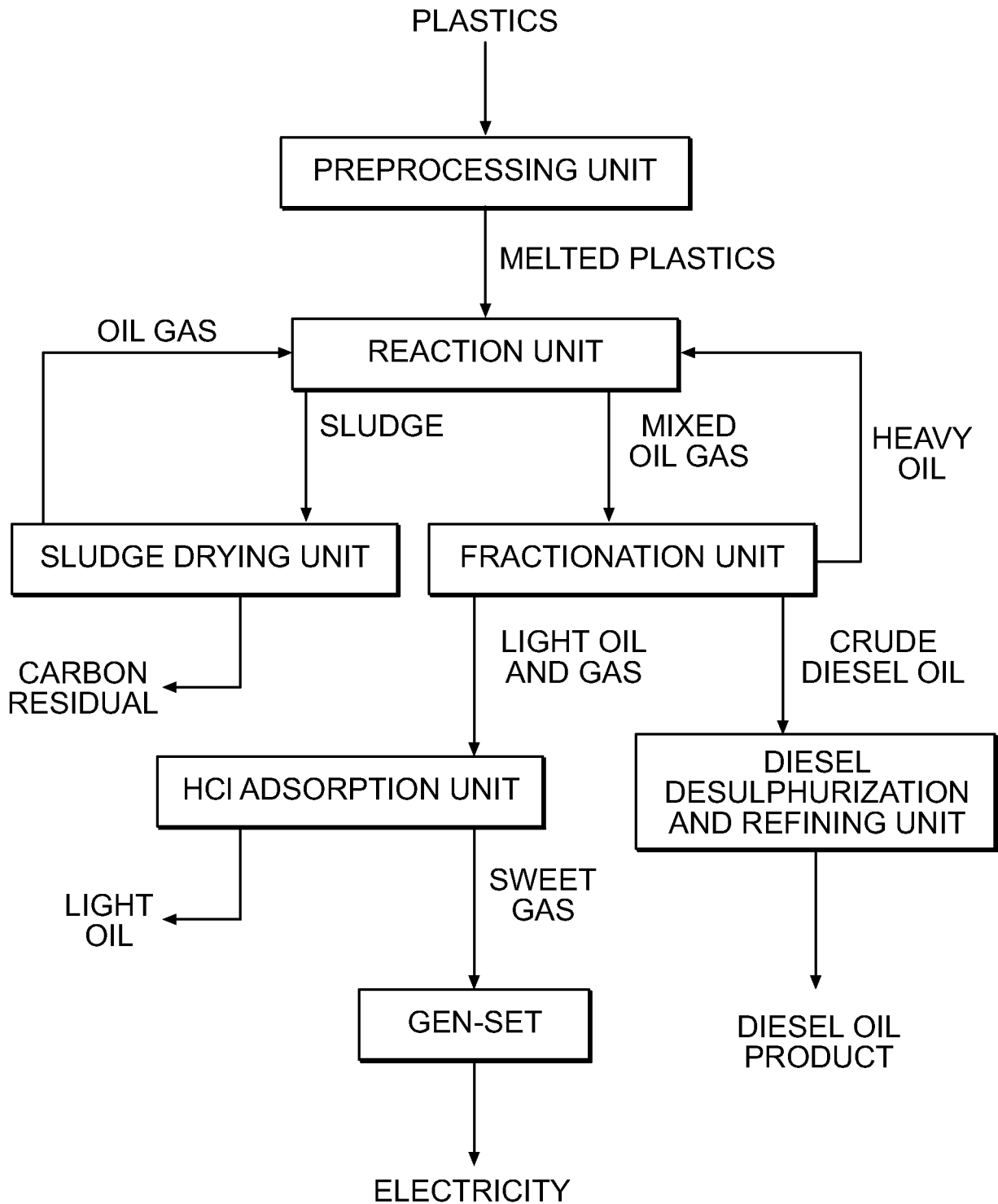


FIG. 4

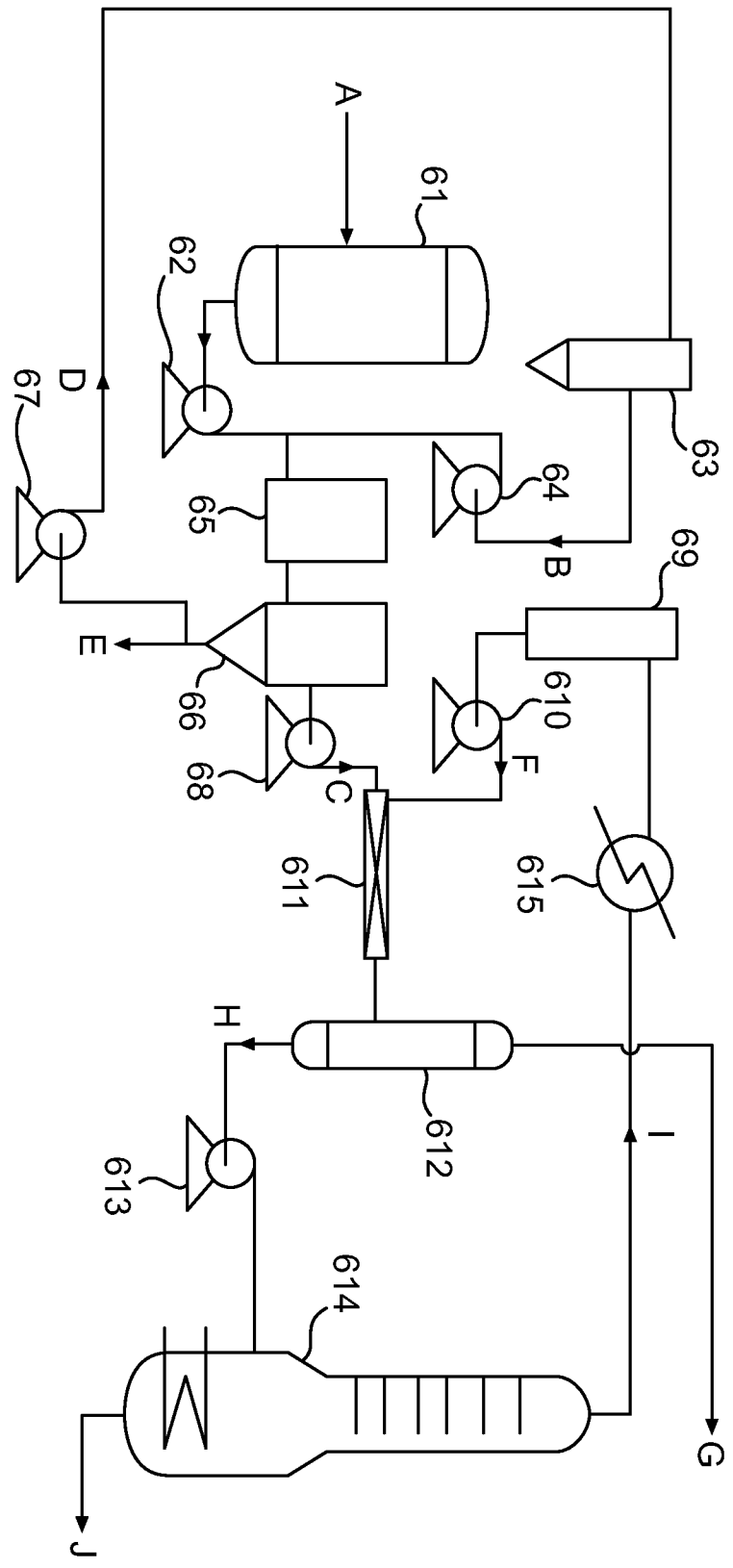


FIG. 6