

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) Publication number:

0 607 862 A1

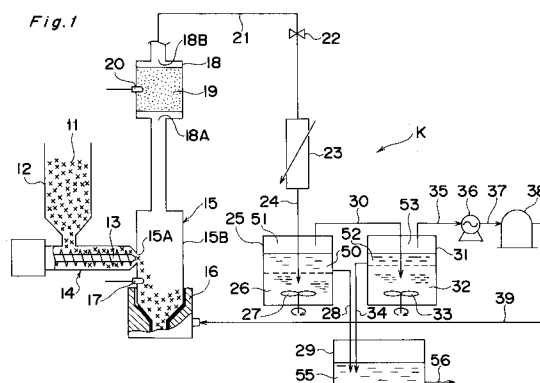
(12)

EUROPEAN PATENT APPLICATION(21) Application number: **94100382.4**(51) Int. Cl.⁵: **C10G 1/10, C10G 57/02, C10G 1/00**(22) Date of filing: **12.01.94**(30) Priority: **22.01.93 JP 9238/93**(43) Date of publication of application:
27.07.94 Bulletin 94/30(84) Designated Contracting States:
DE FR GB(71) Applicant: **Mazda Motor Corporation**
No. 3-1, Shinch
Fuchu-cho
Aki-gun Hiroshima-ken(JP)(72) Inventor: **Takahashi, Toshiki, Ha-404, 1088-1,**
Nakashima
Takaya-cho,
Higashihiroshima-shi
Hiroshima-ken 729-17(JP)

Inventor: **Tanimoto, Yoshio**
13-40, Nakano 2-chome,
Aki-ku
Hiroshima-shi, Hiroshima-ken 739-03(JP)
Inventor: **Muraoka, Akemi**
2-14-503, Tennonishijo 1-chome
Kure-shi, Hiroshima-ken 737(JP)
Inventor: **Fukushima, Tatsuto**
2-6-18, Setohaimu,
Fuchu-cho
Aki-gun, Hiroshima-ken 735(JP)

(74) Representative: **Müller-Boré & Partner**
Patentanwälte
Isartorplatz 6
D-80331 München (DE)(54) **Method of obtaining hydrocarbon oil from waste plastic material or waste rubber material and apparatus used for carrying out the method.**

(57) A method of obtaining hydrocarbon oil (50, 52) from waste plastic material (11) or waste rubber material, comprising the steps of: subjecting the waste plastic material (11) or the waste rubber material to thermal cracking at a temperature exceeding 450 °C so as to obtain a thermal cracking product; subjecting the thermal cracking product to catalytic cracking by using solid acid catalyst (19) so as to obtain a catalytic cracking product; cooling the catalytic cracking product so as to obtain first hydrocarbon oil (50) and cracking gas component (51); and subjecting the cracking gas component (51) to oligomerization by using polymerization catalyst (32) so as to obtain second hydrocarbon oil (52), and an apparatus (K) used for carrying out the method.

**EP 0 607 862 A1**

BACKGROUND OF THE INVENTION

The present invention relates to a method in which waste plastic material or waste rubber material is recycled so as to obtain hydrocarbon oil and an apparatus used for carrying out the method.

In present motor vehicles, a vehicle body panel, various interior parts, tires, etc. are formed by polymer such as plastic or rubber material and ratio of plastic material or rubber material used for each motor vehicle has been raised gradually. Therefore, even if only one motor vehicle is scrapped after its service life, a considerable quantity of waste plastic material or waste rubber material is generated. Since a number of motor vehicles are scrapped every day at present, a total quantity of waste plastic material or waste rubber material is enormous.

Such waste plastic material or waste rubber material, which is produced in huge quantity only in connection with motor vehicles, is tested for various effective recycling purposes in various industrial fields including car industry. Furthermore, efforts for further promoting the recycling are being exerted. Under these circumstances, Japanese Patent Laid-Open Publication No. 63-178195 (1988) proposes, as one example of recycling of waste plastic material or waste rubber material, that hydrocarbon oil is produced from waste plastic material and the produced hydrocarbon oil is used as fuel, etc.

In a known method of producing hydrocarbon oil from waste plastic material, the waste plastic material is subjected to thermal cracking so as to obtain thermal cracking gas and the thermal cracking gas is subjected to catalytic cracking by using proper catalyst so as to obtain catalytic cracking gas and then, the catalytic cracking gas is cooled so as to obtain hydrocarbon oil having relatively low boiling point. For example, in a method disclosed in the above mentioned prior art document No. 63-178195 (1988), thermal cracking of the plastic material is performed in melt phase at a temperature of 390 °C to 500 °C, while catalytic cracking of the thermal cracking gas is performed at a temperature of 200 °C to 350 °C by using zeolite as the catalyst. As a result, low-boiling hydrocarbon oil containing 22 carbon atoms or less is obtained. This known method in which the hydrocarbon oil is obtained by thermal cracking, catalytic cracking and cooling steps can be applied to not only waste plastic material but waste rubber material.

When the hydrocarbon oil is produced from waste plastic material or waste rubber material as described above, catalyst such as zeolite used for catalytic cracking of the thermal cracking gas produced through thermal cracking of the waste plas-

tic material or the waste rubber material is maintained at not more than a predetermined temperature lower than a temperature for thermal cracking of the waste plastic material or the waste rubber material so as to prevent heat deterioration of the catalyst. Therefore, the thermal cracking gas produced through thermal cracking of the waste plastic material or the waste rubber material is cooled by the catalyst during catalytic cracking. As a result, high-boiling hydrocarbon component (wax component) contained in the thermal cracking gas adheres to the catalyst, thereby resulting in drop of function of the catalyst.

Thus, as a measure for restraining drop of function of the catalyst for catalytic cracking, a method is considered in which content of the high-boiling hydrocarbon component in the thermal cracking gas is lowered by further raising temperature for thermal cracking of the waste plastic material or the waste rubber material such that amount of the high-boiling hydrocarbon component adhering to the catalyst for catalytic cracking is reduced. However, in this case, content of low-boiling hydrocarbon component in the catalytic cracking gas, which is kept in gaseous state without being converted to hydrocarbon oil even when being cooled, increases. As a result, recovery of the hydrocarbon oil drops undesirably.

SUMMARY OF THE INVENTION

Accordingly, in view of the above mentioned disadvantages inherent in prior art, an essential object of the present invention is to provide a method of obtaining hydrocarbon oil from waste plastic material or waste rubber material and an apparatus used for carrying out the method, in which when thermal cracking gas obtained by thermal cracking of the waste plastic material or the waste rubber material is subjected to catalytic cracking by using proper catalyst so as to obtain catalytic cracking gas and the catalytic cracking gas is cooled so as to obtain the hydrocarbon oil, not only heat deterioration of the catalyst for catalytic cracking and drop of function of the catalyst for catalytic cracking due to adherence of high-boiling hydrocarbon component thereto can be restrained effectively but recovery of the hydrocarbon oil can be raised.

In order to accomplish this object of the present invention, a method of obtaining hydrocarbon oil from waste plastic material or waste rubber material, according to the present invention comprises the steps of: subjecting the waste plastic material or the waste rubber material to thermal cracking at a temperature exceeding 450 °C so as to obtain a thermal cracking product; subjecting the thermal cracking product to catalytic cracking by

using solid acid catalyst so as to obtain a catalytic cracking product; cooling the catalytic cracking product so as to obtain first hydrocarbon oil and cracking gas component; and subjecting the cracking gas component to oligomerization by using polymerization catalyst so as to obtain second hydrocarbon oil.

In this method, it is preferable that the catalytic cracking product is obtained at a temperature of 120 °C to 250 °C.

Meanwhile, an apparatus for producing hydrocarbon oil, according to the present invention comprises: a thermal cracking portion in which waste plastic material or waste rubber material is subjected to thermal cracking at a temperature exceeding 450 °C so as to obtain a thermal cracking product; a catalytic cracking portion in which the thermal cracking product is subjected to catalytic cracking by using solid acid catalyst so as to obtain a catalytic cracking product; a cooling portion in which the catalytic cracking product is cooled so as to obtain first hydrocarbon oil and cracking gas component; an oligomerization portion in which the cracking gas component is subjected to oligomerization by using polymerization catalyst so as to obtain second hydrocarbon oil; and a recovery portion for recovering the first and second hydrocarbon oils from the cooling portion and the oligomerization portion, respectively.

Meanwhile, in this apparatus, it is preferable that the catalytic cracking product is obtained in the catalytic cracking portion at a temperature of 120 °C to 250 °C.

As described above, in the method of obtaining the hydrocarbon oil from the waste plastic material or the waste rubber material, according to the present invention and the hydrocarbon oil producing apparatus of the present invention, the waste plastic material or the waste rubber material is subjected to thermal cracking at a relatively high temperature exceeding 450 °C so as to obtain the thermal cracking product and the thermal cracking product is subjected to catalytic cracking at a relatively low temperature of, for example, 120 °C to 250 °C by using the solid acid catalyst so as to obtain the catalytic cracking product. Therefore, content of the high-boiling hydrocarbon component in the thermal cracking product is lowered. Thus, even during catalytic cracking at a relatively low temperature, drop of function of the solid acid catalyst for catalytic cracking due to adherence of the high-boiling hydrocarbon component thereto can be restrained effectively. Meanwhile, since the solid acid catalyst for catalytic cracking is maintained at a relatively low temperature, heat deterioration of the solid acid catalyst is restrained effectively. Furthermore, the cracking gas component which is obtained together with the first hydrocar-

bon oil by cooling the catalytic cracking product is oligomerized by using the polymerization catalyst so as to produce the second hydrocarbon oil. Accordingly, in addition to the first hydrocarbon oil obtained by cooling the catalytic cracking product, the second hydrocarbon oil is obtained by oligomerization of the cracking gas component, so that recovery of the hydrocarbon oil is raised greatly.

BRIEF DESCRIPTION OF THE DRAWINGS

This object and features of the present invention will become apparent from the following description taken in conjunction with the preferred embodiment thereof with reference to the accompanying drawings, in which:

Fig. 1 is a schematic view of a hydrocarbon oil producing apparatus of the present invention, which is used for carrying out a method of obtaining hydrocarbon oil from waste plastic material or waste rubber material, according to the present invention; and

Fig. 2 is a schematic view of an experimental apparatus employed for comparison between the method of the present invention and another method.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings, there is shown in Fig. 1, a hydrocarbon oil producing apparatus K of the present invention, which is used for carrying out a method of obtaining hydrocarbon oil from waste plastic material or waste rubber material, according to the present invention. In Fig. 1, the apparatus K includes a hopper 12 in which recycling material 11 such as waste plastic material including polypropylene or waste rubber material is stored. A screw conveyor 14 is provided in operative association with the hopper 12 so as to, by using a rotating screw 13, grind and deliver to a thermal cracking tank 15 the recycling material 11 supplied from the hopper 12.

The thermal cracking tank 15 is constituted by a tank body 15B having an inlet port 15A and a heater 16. A discharge portion of the screw conveyor 14 is coupled with the inlet port 15A such that the recycling material 11 supplied from the inlet port 15A into the tank body 15B is heated for thermal cracking by the heater 16. A temperature sensor 17 for detecting temperature of interior of the tank body 15B is provided on the tank body 15B. Temperature control of the heater 16 is performed on the basis of detection output of the temperature sensor 17 such that thermal cracking temperature in the tank body 15B is maintained at a predetermined temperature exceeding 450 °C.

An upper portion of the tank body 15B of the thermal cracking tank 15 is coupled with a gas inlet port 18A of a catalytic cracking tank 18 in which thermal cracking gas obtained, as thermal cracking product, in the tank body 15B is subjected to catalytic cracking. The catalytic cracking tank 18 contains aluminum chloride ($\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$) 19 acting as solid acid catalyst and the thermal cracking gas supplied through the gas inlet port 18A from the tank body 15B is brought into contact with the aluminum chloride 19 so as to be subjected to catalytic cracking. A temperature sensor 20 for detecting temperature of interior of the catalytic cracking tank 18 is provided on the catalytic cracking tank 18. The catalytic cracking tank 18 is heated by a heater (not shown) undergoing temperature control on the basis of detection output of the temperature sensor 20 such that catalytic cracking temperature in the catalytic cracking tank 18 is maintained at a temperature of 120 °C to 250 °C.

One end of a duct 21 is connected with a gas outlet port 18B of the catalytic cracking tank 18. The duct 21 is provided with a pressure compensated flow control valve 22 and the other end of the duct 21 is connected with an inlet of a cooler 23 in which catalytic cracking gas obtained, as catalytic cracking product, in the catalytic cracking tank 18 is cooled. An outlet of the cooler 23 is led to a neutralization tank 25 via a duct 24. The neutralization tank 25 stores 20 % sodium hydroxide (NaOH) aqueous solution 26 acting as neutralization liquid and includes a rotary stirrer 27 for stirring the 20 % sodium hydroxide aqueous solution 26. The duct 24 extending from the outlet of the cooler 23 has a distal end dipped into the 20 % sodium hydroxide aqueous solution 26 in the neutralization tank 25.

An intermediate portion in the neutralization tank 25 is led, through a duct 28, to a recovery tank 29 for recovering hydrocarbon oil, while an upper portion in the neutralization tank 25 is led to an oligomerization tank 31 by way of a duct 30. The oligomerization tank 31 stores 100 % phosphoric acid (H_3PO_4) 32 acting as polymerization catalyst and includes a rotary stirrer 33 for stirring the 100 % phosphoric acid 32. The oligomerization tank 31 is heated by a heater (not shown) such that temperature of interior of the oligomerization tank 31 reaches about 130 °C. An intermediate portion in the oligomerization tank 32 is led, via a duct 34, to the recovery tank 29, while an upper portion in the oligomerization tank 31 is led to a blower 36 through a duct 35. The blower 36 is, in turn, led to an accumulator 38 by way of a duct 37 and the accumulator 38 is further led to the heater 16 of the thermal cracking tank 15 via a duct 39.

Hereinbelow, one example of the method of obtaining hydrocarbon oil from waste plastic ma-

terial or waste rubber material by using the hydrocarbon oil producing apparatus K of the above described arrangement, according to the present invention is described. Initially, the recycling material 11 stored in the hopper 12 is supplied into the tank body 15B of the thermal cracking tank 15 from the inlet port 15A of the tank body 15B by the screw conveyor 14. Then, in the thermal cracking tank 15, the tank body 15B is heated by the heater 16 such that thermal cracking of the recycling material 11 takes place in the tank body 15B. At this time, temperature control of the heater 16 is performed on the basis of detection output of the temperature sensor 17 such that thermal cracking temperature in the tank body 15B is maintained at a predetermined temperature exceeding 450 °C. Thus, thermal cracking gas which is a thermal cracking product of the recycling material 11 is obtained in the tank body 15B.

Subsequently, the thermal cracking gas obtained in the tank body 15B is introduced into the catalytic cracking tank 18 from gas inlet port 18A of the catalytic cracking tank 18 and is brought into contact with the aluminum chloride 19 stored, as solid acid catalyst, in the catalytic cracking tank 18. As a result, the thermal cracking gas from the thermal cracking tank 15 is subjected to catalytic cracking in the catalytic cracking tank 18. At this time, temperature control of the heater of the catalytic cracking tank 18 is performed on the basis of detection output of the temperature sensor 20 such that catalytic cracking temperature in the catalytic cracking tank 18 is maintained at a temperature of 120 °C to 250 °C. Thus, the catalytic cracking gas which is a catalytic cracking product of the thermal cracking gas from the thermal cracking tank 15 is obtained in the catalytic cracking tank 18.

Thereafter, the catalytic cracking gas obtained in the catalytic cracking tank 18 is supplied to the cooler 23 through the duct 21 provided with the pressure compensated flow control valve 22 so as to be cooled by the cooler 23. Thus, in the cooler 23, low-boiling hydrocarbon oil 50 based on the catalytic cracking gas and cracking gas component 51 mainly consisting of polymer having, for example, three to four carbon atoms are obtained. Then, the low-boiling hydrocarbon oil 50 and the cracking gas component 51 which are obtained in the cooler 23 are supplied, through the duct 24, to the 20 % sodium hydroxide aqueous solution 26 stored, as neutralization liquid, in the neutralization tank 25. In the neutralization tank 25, a layer of the 20 % sodium hydroxide aqueous solution 26, a layer of the low-boiling hydrocarbon oil 50 from the cooler 23 and a layer of the cracking gas component 51 from the cooler 23 are formed sequentially upwardly in this order from a bottom of the neutralization tank 25.

Thus, the low-boiling hydrocarbon oil 50 which forms the intermediate layer in the neutralization tank 25 as described above is supplied to the recovery tank 29 through the duct 28, while the cracking gas component 51 which forms the uppermost layer in the neutralization tank 25 is supplied, via the duct 30, to the 100 % phosphoric acid 32 stored, as polymerization catalyst, in the oligomerization tank 31. Therefore, in the oligomerization tank 31, oligomerization of the cracking gas component 51 takes place in the 100 % phosphoric acid 32 and thus, low-boiling hydrocarbon oil 52 based on the cracking gas component 51 is obtained. However, since all of the cracking gas component 51 from the neutralization tank 25 is not oligomerized, a portion of the cracking gas component 51 remains as unreactive cracking gas component 53. Accordingly, in the oligomerization tank 31, a layer of the 100 % phosphoric acid 32, a layer of the low-boiling hydrocarbon oil 52 produced by oligomerization of the cracking gas component 51 and a layer of the unreactive cracking gas component 53 are formed sequentially upwardly in this order from a bottom of the oligomerization tank 31.

Thus, the low-boiling hydrocarbon oil 52 which forms the intermediate layer in the oligomerization tank 31 is supplied to the recovery tank 29 through the duct 34. Therefore, the low-boiling hydrocarbon oil 50 supplied from the neutralization tank 25 through the duct 28 and the low-boiling hydrocarbon oil 52 supplied from the oligomerization tank 31 through the duct 34 are recovered, as low-boiling hydrocarbon oil 55, by the recovery tank 29. Meanwhile, the unreactive cracking gas component 53 which forms the uppermost layer in the oligomerization tank 31 is supplied to the blower 36 via the duct 35 and then, is fed to the accumulator 38 through the duct 37 by the blower 36. The unreactive cracking gas component 53 is further supplied from the accumulator 38 to the heater 16 of the thermal cracking tank 15 through the duct 39 so as to be recycled in the heater 16.

The low-boiling hydrocarbon oil 55 which is produced from the recycling material 11 so as to be recovered by the recovery tank 29 as described above is discharged from the recovery tank 29 via a duct 56 and is used as, for example, fuel.

In the method of obtaining the hydrocarbon oil from waste plastic material or waste rubber material, according to the present invention, thermal cracking temperature for thermal cracking of the recycling material 11 is set at a predetermined temperature exceeding 450 °C and catalytic cracking temperature for catalytic cracking of the thermal cracking gas obtained by thermal cracking of the recycling material 11 is set at a temperature of 120 °C to 250 °C on the following grounds. Ini-

tially, when thermal cracking temperature for thermal cracking of the recycling material 11 is not more than 450 °C, content of high-boiling hydrocarbon component in the thermal cracking gas obtained by thermal cracking of the recycling material 11 becomes high. Thus, experiments have revealed that during catalytic cracking of such thermal cracking gas, the high-boiling hydrocarbon component adheres to the aluminum chloride acting as solid acid catalyst for catalytic cracking, thereby resulting in extreme deterioration of catalytic function of the aluminum chloride. Meanwhile, when catalytic cracking temperature for catalytic cracking of the thermal cracking gas obtained by thermal cracking of the recycling material 11 is lower than 120 °C, activation of the aluminum chloride acting as solid acid catalyst for catalytic cracking cannot be achieved sufficiently. On the other hand, experiments have shown that when catalytic cracking temperature for catalytic cracking of the thermal cracking gas obtained by thermal cracking of the recycling material 11 exceeds 250 °C, the aluminum chloride acting as solid acid catalyst for catalytic cracking deteriorates excessively.

By using an experimental apparatus shown in Fig. 2, experiments were conducted by the present inventors for comparison between recovery of hydrocarbon oil obtained from waste plastic material in the method of the present invention and that obtained from waste plastic material in another method other than the method of the present invention. In Fig. 2, the experimental apparatus includes annular ovens 60 and 61 through which a tubular member 62 extends. One end of a duct 65 is coupled with one end portion of the tubular member 62 through a plug 63, while one end of a duct 66 is coupled with the other end portion of the tubular member 62 through a plug 64. A mouth of a container 68 is closed by a plug 67 such that the other end of the duct 66 pierces through the plug 67 into the container 68. The plug 67 is also pierced through by one end of a duct 69 and the other end of the duct 69 is inserted into a flask 71 through a plug 70. The flask 71 is disposed in an oil tank 73 placed on a magnetic stirring machine 72. A heater 74 is provided in the oil tank 73. A stirrer 75 which is remotely driven by the magnetic stirring machine 72 is provided in the flask 72. Meanwhile, one end of a duct 76 pierces through a plug 77 into the flask 71 and the other end of the duct 76 is open.

In a first experimental stage employing such experimental apparatus, hydrocarbon oil is produced from waste plastic material in the method of the present invention. At a location in the tubular member 62, which confronts inside of the annular oven 60, 50 g of polypropylene 80 is provided as

waste plastic material. Furthermore, at a location in the tubular member 62, which confronts inside of the annular oven 61, a predetermined amount of aluminum chloride 81 is provided as solid acid catalyst. On the other hand, a predetermined amount of 20 % sodium hydroxide aqueous solution 82 acting as neutralization liquid is put into the container 68, while a predetermined amount of 100 % phosphoric acid 83 acting as polymerization catalyst is put into the flask 71. The flask 71 is heated by the heater 74 provided in the oil tank 73 such that interior of the flask 71 is maintained at about 130 °C. Meanwhile, the stirrer 75 in the 100 % phosphoric acid 83 in the flask 71 is remotely driven by the magnetic stirring machine 72. In addition, while nitrogen (N₂) gas is being blown into the tubular member 62 through the duct 65, not only temperature in the annular oven 60 is set at 500 °C but temperature in the annular oven 61 is set at 250 °C.

As a result, low-boiling hydrocarbon oils are obtained in the container 68 and the flask 71, respectively. Meanwhile, unreactive cracking gas is recovered through the duct 76 provided on the flask 71. A total of weights of the low-boiling hydrocarbon oils recovered from the container 68 and the flask 71 measures about 43.5 g. Therefore, a ratio of weight of the recovered low-boiling hydrocarbon oil to 50 g of polypropylene, i.e., recovery is about 87 % (= 43.5 x 100/50).

On the other hand, in a second experimental stage employing the above experimental apparatus, hydrocarbon oil is produced from waste plastic material in another method other than the method of the present invention. In the same manner as the first experimental stage, at a location in the tubular member 62, which confronts inside of the annular oven 60, 50 g of polypropylene 80 is provided as waste plastic material and at a location in the tubular member 62, which confronts inside of the annular oven 61, a predetermined amount of aluminum chloride 81 is provided as solid acid catalyst. Likewise, a predetermined amount of 20 % sodium hydroxide aqueous solution 82 acting as neutralization liquid is put into the container 68. However, in the second experimental stage, the flask 71, the oil tank 73 and the magnetic stirring machine 72 are eliminated from the experimental apparatus. While nitrogen gas is being blown into the tubular member 62 through the duct 65, not only temperature in the annular oven 60 is set at 500 °C but temperature in the annular oven 61 is set at 250 °C.

As a result, low-boiling hydrocarbon oil is obtained in the container 68 and unreactive cracking gas is recovered through the duct 69 provided on the container 68. Weight of the hydrocarbon oil recovered from the container 68 measures about

30.0 g. Therefore, ratio of weight of the recovered hydrocarbon oil to 50 g of polypropylene, i.e., recovery is about 60 % (= 30.0 x 100/50).

It is understood from such results of the comparative experiments that recovery of the hydrocarbon oil in production of the hydrocarbon oil from waste plastic material in the method of the present invention is far superior to that in another method other than the method of the present invention.

As is clear from the foregoing description of the method of obtaining the hydrocarbon oil from the waste plastic material or the waste rubber material, according to the present invention and the hydrocarbon oil producing apparatus of the present invention, the waste plastic material or the waste rubber material is subjected to thermal cracking at a relatively high temperature exceeding 450 °C and the thermal cracking product obtained by this thermal cracking is subjected to catalytic cracking at a relatively low temperature of, for example, 120 °C to 250 °C by using the solid acid catalyst. Therefore, content of the high-boiling hydrocarbon component in the thermal cracking product is lowered. Thus, even during catalytic cracking at a relatively low temperature, drop of function of the solid acid catalyst for catalytic cracking due to adherence of the high-boiling hydrocarbon component thereto can be restrained effectively. Furthermore, since the solid acid catalyst for catalytic cracking is maintained at a relatively low temperature, heat deterioration of the solid acid catalyst is restrained effectively. Moreover, since the catalytic cracking product which is obtained by catalytic cracking of the thermal cracking product by using the solid acid catalyst undergoes a cooling process, the first hydrocarbon oil and the cracking gas component are obtained. At this time, since the obtained cracking gas component is oligomerized by using the polymerization catalyst so as to produce the second hydrocarbon oil. Accordingly, in addition to the first hydrocarbon oil obtained by cooling the catalytic cracking product, the second hydrocarbon oil is obtained by oligomerization of the cracking gas component, so that recovery of the hydrocarbon oil is improved remarkably.

Claims

1. A method of obtaining hydrocarbon oil (50, 52) from waste plastic material (11) or waste rubber material, comprising the steps of:

subjecting the waste plastic material (11) or the waste rubber material to thermal cracking at a temperature exceeding 450 °C so as to obtain a thermal cracking product;

subjecting the thermal cracking product to catalytic cracking by using solid acid catalyst (19) so as to obtain a catalytic cracking prod-

uct;

cooling the catalytic cracking product so as to obtain first hydrocarbon oil (50) and cracking gas component (51); and

subjecting the cracking gas component (51) to oligomerization by using polymerization catalyst (32) so as to obtain second hydrocarbon oil (52). 5

2. A method as claimed in Claim 1, wherein the catalytic cracking product is obtained at a temperature of 120 °C to 250 °C. 10

3. An apparatus (K) for producing hydrocarbon oil (50, 52), comprising: 15

a thermal cracking portion (15) in which waste plastic material (11) or waste rubber material is subjected to thermal cracking at a temperature exceeding 450 °C so as to obtain a thermal cracking product; 20

a catalytic cracking portion (18) in which the thermal cracking product is subjected to catalytic cracking by using solid acid catalyst (19) so as to obtain a catalytic cracking product; 25

a cooling portion (23) in which the catalytic cracking product is cooled so as to obtain first hydrocarbon oil (50) and cracking gas component (51);

an oligomerization portion (31) in which the cracking gas component (51) is subjected to oligomerization by using polymerization catalyst (32) so as to obtain second hydrocarbon oil (52); and 30

a recovery portion (29) for recovering the first and second hydrocarbon oils (50, 52) from the cooling portion (23) and the oligomerization portion (31), respectively. 35

4. An apparatus (K) as claimed in Claim 3, wherein the catalytic cracking product is obtained in the catalytic cracking portion (18) at a temperature of 120 °C to 250 °C. 40

45

50

55

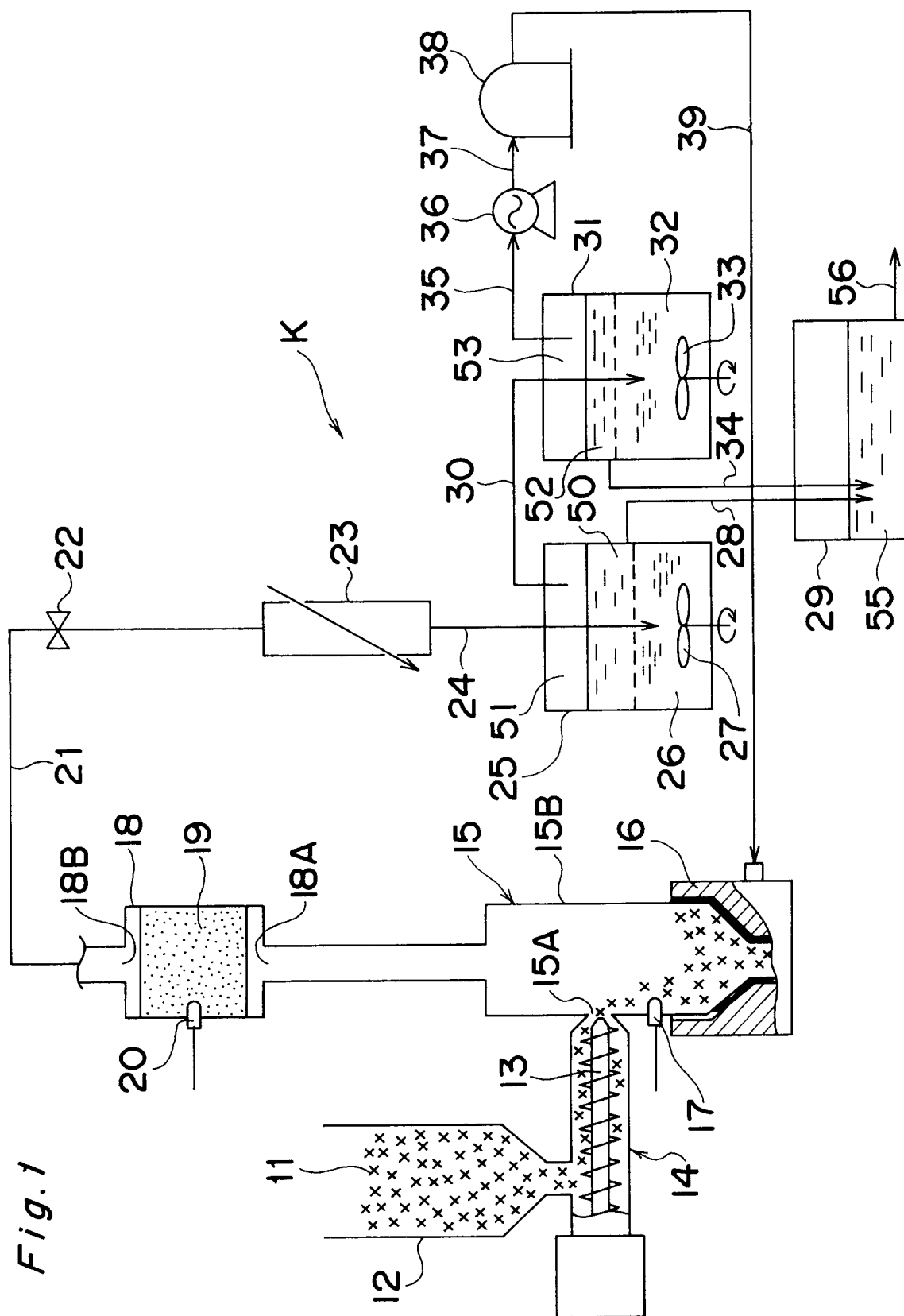
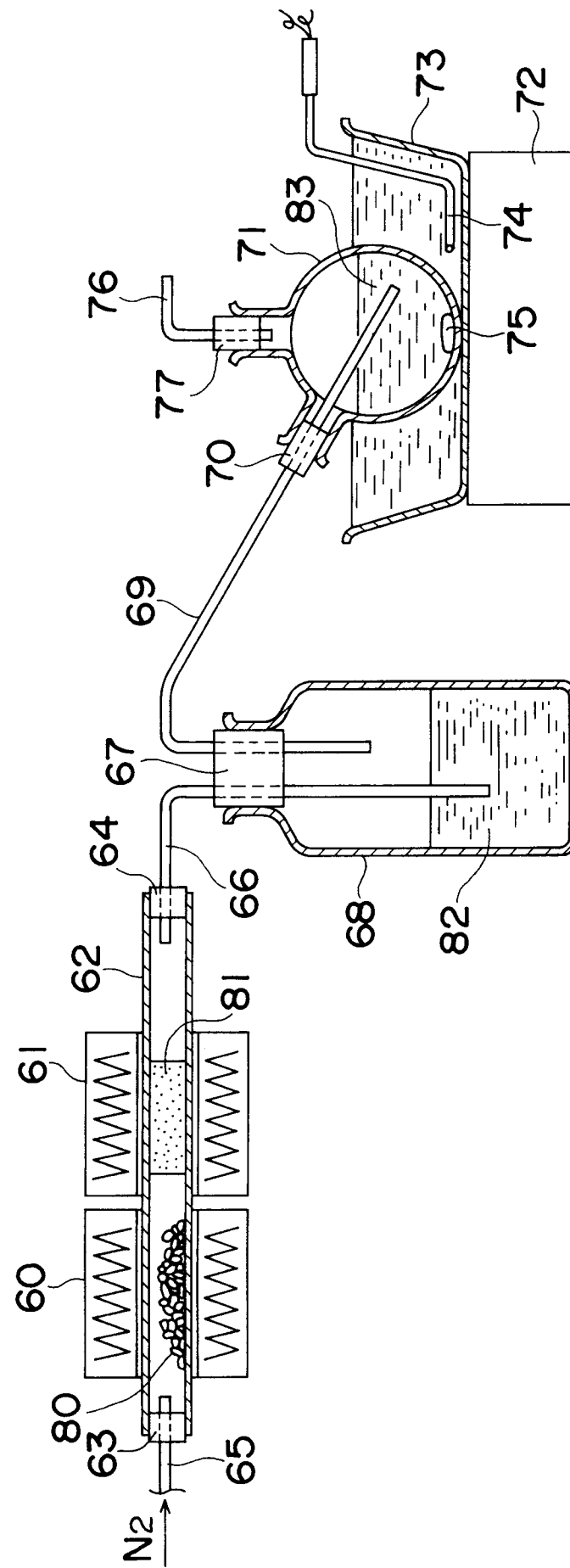


Fig. 1

Fig. 2





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 10 0382

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
Y	EP-A-0 392 590 (SHELL) * claim 1 * ---	1	C10G1/10 C10G57/02 C10G1/00
Y	US-A-4 851 601 (MOBIL) * claim 1 * ---	1	
A	FR-A-2 357 630 (ENTREPRISE DE RECHERCHES ET D'ACTIVITES PETROLIERES ERAP) -----		
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			C10G
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 5 April 1994	Examiner De Herdt, O
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	