



(86) **Date de dépôt PCT/PCT Filing Date:** 2008/06/24
(87) **Date publication PCT/PCT Publication Date:** 2009/01/22
(45) **Date de délivrance/Issue Date:** 2015/08/11
(85) **Entrée phase nationale/National Entry:** 2010/01/05
(86) **N° demande PCT/PCT Application No.:** EP 2008/005078
(87) **N° publication PCT/PCT Publication No.:** 2009/010157
(30) **Priorité/Priority:** 2007/07/13 (DE10 2007 032 683.3)

(51) **Cl.Int./Int.Cl. C10G 1/00** (2006.01),
C10B 49/22 (2006.01), **C10B 53/06** (2006.01),
C10G 1/02 (2006.01)

(72) **Inventeurs/Inventors:**
ANASTASIJEVIC, NIKOLA, DE;
SCHNEIDER, GUENTER, DE;
MISSALLA, MICHAEL, DE

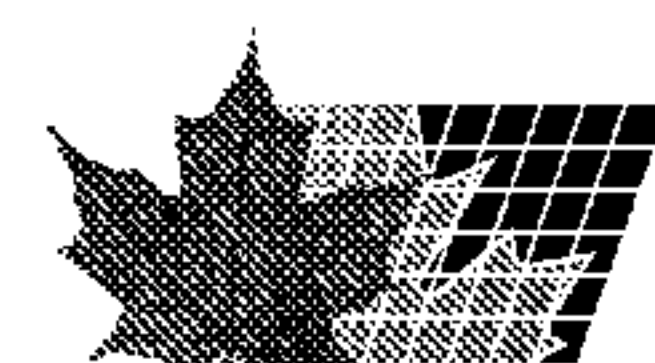
(73) **Propriétaire/Owner:**
OUTOTEC OYJ, FI

(74) **Agent:** ROBIC

(54) **Titre : PROCÉDE ET INSTALLATION DE RAFFINAGE DE SOLIDES PETROLIFERES**
(54) **Title: PROCESS AND PLANT FOR REFINING OIL-CONTAINING SOLIDS**

(57) **Abrégé/Abstract:**

For refining oil-containing solids, in particular oil sand or oil shale, there is proposed a process with the following steps: supplying the oil-containing solids to a reactor and expelling an oil-containing vapor at a temperature of 300 to 1000 °C, - supplying the oil-containing vapor expelled in the reactor to a cracker, in which the heavy oil components are broken down, separating the products obtained in the cracker and withdrawing the product streams, introducing the solids left in the reactor including the unevaporated fraction of heavy hydrocarbons into a furnace, burning the heavy hydrocarbons left in the solids in the furnace at a temperature of 600 to 1500 °C, preferably 1050 to 1200 °C, recirculating hot solids from the furnace into the reactor, wherein the oxidizing atmosphere of the furnace is separated from the atmosphere of the reactor by a blocking device.



(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
22 January 2009 (22.01.2009)

PCT

(10) International Publication Number
WO 2009/010157 A3

(51) International Patent Classification:

C10G 1/00 (2006.01) **C10B 49/22** (2006.01)
C10G 1/02 (2006.01) **C10B 53/06** (2006.01)

(21) International Application Number:

PCT/EP2008/005078

(22) International Filing Date: 24 June 2008 (24.06.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

10 2070 032 683.3 13 July 2007 (13.07.2007) DE

(71) Applicant (*for all designated States except US*): **OUT-OTEC OYJ** [FI/FI]; Riihitontuntie 7, FIN-02200 Espoo (FI).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **ANASTASIJEVIC, Nikola** [DE/DE]; Zum Niddersteg 11, 63674 Altenstadt (DE). **SCHNEIDER, Günter** [DE/DE]; Ziegelhüttenstrasse 19, 64653 Lorsch (DE). **MISSALLA, Michael** [DE/DE]; Kleine Schmieh 34, 61440 Oberursel (DE).

(74) Agent: **KEIL & SCHAAFHAUSEN**; Cronstettenstrasse 66, 60322 Frankfurt am Main (DE).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

(88) Date of publication of the international search report:

9 April 2009

(54) Title: PROCESS AND PLANT FOR REFINING OIL-CONTAINING SOLIDS

(57) Abstract: For refining oil-containing solids, in particular oil sand or oil shale, there is proposed a process with the following steps: supplying the oil-containing solids to a reactor and expelling an oil-containing vapor at a temperature of 300 to 1000 °C, - supplying the oil-containing vapor expelled in the reactor to a cracker, in which the heavy oil components are broken down, separating the products obtained in the cracker and withdrawing the product streams, introducing the solids left in the reactor including the unevaporated fraction of heavy hydrocarbons into a furnace, burning the heavy hydrocarbons left in the solids in the furnace at a temperature of 600 to 1500 °C, preferably 1050 to 1200 °C, recirculating hot solids from the furnace into the reactor, wherein the oxidizing atmosphere of the furnace is separated from the atmosphere of the reactor by a blocking device.



WO 2009/010157 A3

Process and Plant for Refining Oil-Containing Solids

The present invention relates to a process and a plant for refining solids containing oil and/or bitumen, in particular oil sand or oil shale.

Oil or tar sands are black sand formations chiefly dating from the Mesozoic, which are spread worldwide and have a mineral oil content of about 5 to 18 %. In contrast to liquid petroleum, the oil sands are thickly viscous and must first be separated from the sand and be processed to crude oil. In the regions near the surface, the oil sand is recovered by strip mining by means of huge bucket-wheel and dragline excavators and ground to a grain size $< 30 \mu\text{m}$. The heavy oil is extracted by means of hot water and steam, wherein at the top a suspension with organic phase is accumulated. The lower part is separated and repurified. Therefore, very much water is required for oil recovery, which in addition is discharged not quite oil-free.

Oil shale refers to mountain-forming formations of marl or other types of clayey bituminous sediment rock from various geological eras, which are rich in organic matter (kerogen) from fossilized microorganisms or from pollen. The recovery of oil from oil shale traditionally is effected by mining and subsequent pyrolysis (carbonization at 500°C). Alternatively, underground recovery (*in situ*) is used by injecting a steam-air mixture into the rock, which was previously loosened by blasting, and igniting a flame front which expels the oil.

Thus, the recovery of crude oil from oil sands or oil shale is relatively cost-intensive. With rising petroleum prices, the recovery of crude oil from oil sands and oil shale, however, becomes increasingly interesting in economic terms. An essential problem in the present recovery of oil from oil sands and tar sands is the nec-

essary high consumption of water and the emission of waste waters containing residual oil.

From U.S. Patent 4,507,195 there is known a process for coking contaminated oil shale or tar sand oil on solids distilled in retorts. The hydrocarbonaceous solids are mixed with a hot heat-transfer material, in order to raise the temperature of the solids to a temperature suitable for the pyrolysis of the hydrocarbons. The mixture is kept in the pyrolysis zone, until a sufficient quantity of hydrocarbon vapors is released. In the pyrolysis zone, a stripping gas is passed through the mixture, in order to lower the dew point of the evolved hydrocarbon vapors and to entrain the fine particles. Accordingly, a mixture of contaminated hydrocarbon vapors, stripping gas and entrained fine particles is obtained from the pyrolysis zone. From the contaminated hydrocarbon vapors, a heavy fraction is separated and thermally cracked in a fluidized bed consisting of the fine particles, whereby the impurities along with the coke are deposited on the fine particles in the fluidized bed. The product oil vapors are withdrawn from the coking tank. As heat-transfer material, recirculated pyrolyzed oil shale or tar sand is used, which has been passed through a combustion zone, in order to burn off carbon residues and provide the heat for the pyrolysis of the raw material. Since there is no pressure seal between the combustion zone and the pyrolysis furnace, the oxidizing atmosphere of the combustion zone can enter the pyrolysis furnace and impair the quality of the oil vapor. In addition, thermal cracking in the coking tank consumes very much energy and therefore is expensive.

From EP 1 015 527 B1, there is also known a process for the thermal treatment of feedstock containing volatile, combustible constituents, wherein the feedstock is mixed with hot granular solids from a collecting bin in a pyrolysis reactor, in which relatively high temperatures exist. In the reactor, cracking reactions in the gases and vapors should be caused thereby.

Beside the thermal cracking used in the above-mentioned processes, there are also known catalytic cracking processes. In Fluid Catalytic Cracking (FCC), the heavy distillate of a refinery is broken down into gases, liquefied gases and gasolines, preferably into long-chain n-alkanes and i-alkanes. Cracking generally is effected at temperatures between 450 and 550°C and a reactor pressure of 1.4 bar by means of an aluminosilicate-based zeolite catalyst. FCC crackers are described for instance in US 7,135,151 B1, US 2005/0118076 A1 or US 2006/0231459 A1. An exemplary catalyst is disclosed in WO 2006/131506 A1. Other processes are e. g. coking or hydrocracking

It is the object of the present invention to provide a more efficient process for recovering crude oil from oil-containing solids.

This object substantially is solved with the invention by a process with the following steps:

- supplying the oil-containing solids to a reactor and expelling an oil-containing vapor at a temperature of 300 to 1000°C, preferably 350 to 900°C,
- supplying the oil-containing vapor expelled in the reactor to a catalytic treatment, in which the heavy oil components are cracked,
- separating the products obtained in the treatment and withdrawing the product streams,
- introducing the solids left in the reactor including the unevaporated fraction of heavy hydrocarbons into a furnace,

- 4 -

- burning the heavy hydrocarbons left in the solids in the furnace at a temperature of 600 to 1500°C, preferably 1050 to 1200°C,
- recirculating hot solids from the furnace into the reactor, wherein the oxidizing atmosphere of the furnace is separated from the atmosphere of the reactor by a blocking device.

According to another embodiment, the invention relates to a process for refining oil-containing solids, in particular oil sand or oil shale, with the following steps:

- supplying the oil-containing solids to a reactor and expelling an oil-containing vapor at a temperature of 300 to 1000°C,
- supplying the oil-containing vapor expelled in the reactor to a cracker, in which the heavy oil components are broken down,
- separating the products obtained in the cracker and withdrawing the product streams,
- introducing the solids left in the reactor including an unevaporated fraction of heavy hydrocarbons into a furnace,
- burning the unevaporated fraction of the heavy hydrocarbons left in the solids in the furnace at a temperature of 600 to 1500°C, preferably 1050 to 1200°C,
- recirculating hot solids from the furnace into the reactor, wherein the oxidizing atmosphere of the furnace is separated from the atmosphere of the reactor by a blocking device, wherein the blocking device between the furnace and the reactor includes a downpipe through which a stream of solids is withdrawn from the furnace, and a rising pipe which is branched off from the downpipe in upward direction close to the bottom of the same, and
- supplying conveying gas into the rising pipe, wherein the stream of solids withdrawn from the furnace is fluidized by the conveying gas and transported to the reactor through the rising pipe.

The oil contained in the oil-containing solids is volatilized in the reactor for 50% to 90%, preferably 70% to 80%, and supplied to the treatment, in particular to an FCC cracker.

- 5 -

Here, the heavy oil components are broken down into light oil components. The remaining oil content or oil product content left in the solids is burnt in the furnace, in order to generate the heat required in the reactor, which is transferred to the reactor via the solids withdrawn from the furnace. Between the furnace and the reactor, a seal is provided, in order to separate the oxidizing atmosphere of the furnace from the distillation section and avoid an oxidation, combustion or even explosion of the oil vapors generated in the reactor. By using a catalytic cracker, the amount of light oils in the product streams can be increased with lower energy consumption as compared to normal cracking.

In accordance with a preferred aspect of the invention, the oil-containing solids are dried in a one- or multistage drier at a temperature of 80 to 120°C before being introduced into the reactor. With minimum loss of oil, the water content thereby should largely be removed from the oil-containing solids. The gas stream withdrawn from the drier can be supplied to the furnace as an additional fuel or used e.g. as fluidising gas in other parts of the process. Alternatively, the ultralight hydrocarbons contained therein can for instance be separated by distillation and be utilized as product. Alternatively, the water then can also be supplied to a waste water treatment plant.

To minimize the mass flow of the heat transfer medium recirculated from the furnace into the reactor, it is provided in accordance with a development of the invention to preheat the possibly predried oil-containing solids in a one- or multistage preheater to a temperature of 110 to 300°C. The amount of heat to be supplied to the reactor in addition thereby is reduced correspondingly. A fluidized bed with steam as heat transfer medium or a molten-salt reactor can be used as preheater. The heat can also be transferred indirectly.

The reactor serves the in particular distillative evaporation of the oil contained in the possibly predried and preheated solids. For optimizing the heat transfer from the calcined material recirculated from the furnace to the preheated oil-containing solids, a circulating fluidized bed, a stationary fluidized bed, an annular fluidized bed or a transport or flash reactor can for instance be used.

- 6 -

In accordance with the invention, the fluidization of the reactor is effected by means of gas streams, which are obtained from a preheating stage and/or the cracker and contain light hydrocarbons. Nitrogen, hydrogen, carbon dioxide, gas mixtures containing air or oxygen, or part of the waste gas from the furnace can, however, also be supplied to the reactor as fluidizing gas. The air or the oxygen here can be used for adjusting or initiating a partial combustion for adaptation of the temperature or yield. If hydrogen is also used for the fluidization, the cracking of the heavy hydrocarbons can be promoted thereby. It is also possible to perform the fluidization by means of an inert gas such as nitrogen.

The fluidizing gases can be supplied to the reactor cold, in the temperature of the exhausted stream (e.g. as waste gas of the furnace), further preheated or even cooled.

To raise the efficiency, the reactor can be operated under a reduced pressure in the range from 0.001 to 1 bar. Lowering the pressure promotes the evaporation of the oil from the solids. Furthermore catalytic substances or the like and e.g. microwaves or ultrasonic energy can be supplied to the reactor to increase or control the evaporation of the oil from the solids.

In a further embodiment of the invention, the atmospheres of the drying and/or preheating stage are also separated from each other or the reactor. This avoids uncontrollable input of other gases, e.g. oxygen, from the drying and/or preheating stage.

Since the gas streams withdrawn from the reactor and the preheater still contain fine solid particles, the gas streams are passed through a dedusting means in accordance with the invention before being introduced into the cracker.

Cracking preferably is effected in an FCC cracker at a temperature of 400 to 600°C, in particular 450 to 550°C, and at a reactor pressure of 1 to 2 bar, preferably 1.3 to 1.5 bar, by means of an aluminosilicate-based zeolite catalyst. Therefore it is also in accordance with the invention to operate the reactor at this pressure. If the pressure in the reactor is below the FCC unit, the pressure has to be increased by e.g. blowers or injectors.

- 7 -

In accordance with the invention, the subsequent separation of the products contained in the cracker is effected in a distillation column, from which the product streams such as gasoline, diesel oil, light hydrocarbons, etc. are withdrawn.

The cracking process is promoted in that the gas withdrawn from the reactor already is hot. The cracker can include a circulating fluidized bed, to which the gas stream withdrawn from the reactor is supplied as secondary air, an annular fluidized bed, wherein the gas stream withdrawn from the reactor is supplied via the central tuyère, or a stationary fluidized bed, or can be a flash reactor.

The furnace serves the generation of heat for the reactor, wherein the high temperature of e.g. 300 to 800°C required in the reactor is introduced into the reactor via the solids heated in the furnace. To ensure a complete combustion of the heavy oil components left in the solids or of the oil products, the combustion in the furnace is performed in an atmosphere rich in oxygen in accordance with the invention, which can be produced by supplying air, air enriched with oxygen or pure oxygen. The combustion gas can be supplied cold or preheated.

What is used as furnace in accordance with the invention is a circulating fluidized bed, an annular fluidized bed, a stationary fluidized bed, a transport or flash reactor, a rotary kiln or a grid combustion. To increase the energetic efficiency, a staged combustion is preferred (e.g. a sub- and an over stoichiometric stage of the supplied gas with respect to the oxygen demand of the combustion material). Additional fuel in the form of untreated oil-containing solids, coal, waste materials or the like can be supplied to the furnace.

The temperature in the furnace should be as high as possible, as thereby a higher temperature can be achieved in the reactor, which leads to higher yields. At higher temperatures, however, less oil-containing residual fraction from the reactor will get into the furnace, so that additional fuel is required. The optimum is to be determined by means of the properties of the oil-containing material and/or possible supply of additional fuels.

In accordance with a development of the invention, the heat generated in the furnace is recovered from the waste gas and/or the calcination residue. This can be effected in a

- 8 -

way known in principle by means of a heat recovery system, for instance in the form of a fluidized-bed cooler and/or fluidized-bed heater, a heat recovery cyclone, a waste heat boiler or a Venturi/cyclone combination. It is also possible to utilize the heat generated in the furnace for preheating the fluidizing gas streams of the drier, preheater, reactor and/or cracker or for indirectly heating the preheater and/or drier. The heat can also be used for steam recovery.

This invention also extends to a plant for refining oil-containing solids, such as oil sand and oil shale, but also oil-containing or oil evolving, granular (and thus fluidizable) materials or wastes, comprising a reactor to which oil-containing solids are supplied, a furnace to which solids coming from the reactor and fuel are supplied, a return conduit through which hot solids produced in the furnace are recirculated to the reactor, a blocking device for separating the gas atmospheres of the furnace and of the reactor, a cracker to which oil-containing vapor expelled from the oil-containing solids in the reactor is supplied and in which the heavy oil components are broken down, and a separating means for separating the products obtained in the cracker.

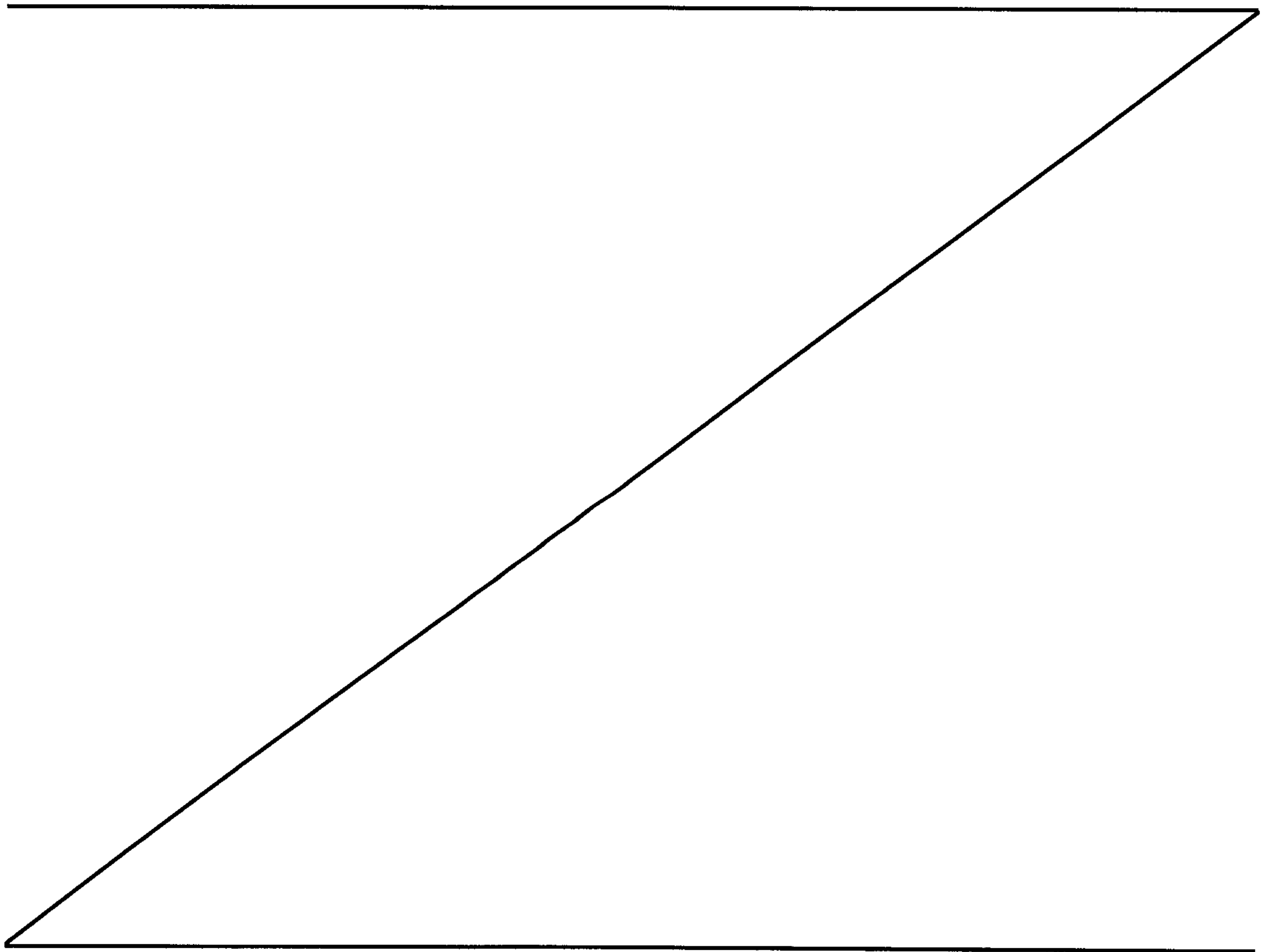
In accordance with a development of the invention, the plant can also include a drier and a preheater for drying and preheating the introduced solids as well as a dedusting means and/or a heat recovery system.

According to another embodiment, the invention relates to a plant for refining oil-containing solids, such as oil sand or oil shale, in particular for performing a process as defined hereinabove according to an embodiment of the invention, said plant comprising a reactor to which the oil-containing solids are supplied, a furnace to which solids coming from the reactor and fuel are supplied, a return conduit through which hot solids produced in the furnace are recirculated to the reactor, a blocking device for separating the gas atmospheres of the furnace and of the reactor, a cracker to which oil-containing vapor expelled from the oil-containing solids in the reactor is supplied and in which the heavy oil components are broken down, and a separating means for separating the products obtained in the cracker, wherein the blocking device between the furnace and the reactor includes a downpipe through which a stream of solids is withdrawn from the furnace, a rising pipe which is branched off from the downpipe close to the bottom of the same, and a conveying gas supply below the rising pipe, wherein

- 8a -

the stream of solids withdrawn from the furnace is fluidized by the conveying gas and transported through the rising pipe to the reactor.

In a preferred aspect of the invention, the blocking device between the furnace and the reactor includes a downpipe through which a stream of solids is withdrawn from the furnace, a rising pipe which is branched off from the downpipe in upward direction close to the bottom of the same, and a conveying gas supply below the rising pipe, wherein the stream of solids withdrawn from the furnace is fluidized by the conveying gas and transported to the reactor through the rising pipe. This provides not only for a control of the mass flow of the heat transfer medium supplied to the reactor, which is controllable via the supply of conveying gas, but also for a reliable pressure seal between the oxidizing atmospheres of the furnace and the reactor. An oxidation, combustion or even explosion of the oil vapors expelled in the reactor can reliably be avoided. Apart from the above-mentioned so-called



sealpot construction, there can also be used e. g. a lock hopper, a non-return valve or a combination of these elements.

5 In a development of the invention, a blocking device for separating the gas atmospheres of the dryer and/or the preheater and of the reactor is also provided. The separation device for the atmospheres of the drying and/or preheating stage from each other or the reactor can be the same as described between furnace and reactor, but in this case the downpipe comes from the drying stage or the preheating stage.

10 Developments, advantages and possible applications of the present invention can also be taken from the following description of embodiments and the drawing. All features described and/or illustrated per se or in any combination form the subject-matter of the invention, independent of their inclusion in the claims or their back-reference.

15

In the drawing:

20 Fig. 1 schematically shows a plant for performing the process of the invention,

Fig. 2 schematically shows a blocking device arranged between the furnace and the reactor.

25 A plant for refining oil-containing solids, which is schematically shown in Fig. 1, includes a one- or multistage drier 2, to which oil-containing solids such as oil sand or oil shale are supplied via a supply conduit 1. Via a conduit 3, the dried oil sand or oil shale is supplied to a one- or multistage preheater 4, in which the solids are preheated to a temperature of 150 to 300°C. Via a conduit 5, the solids thus pre-

30 heated then are supplied to a distillation reactor 6, in which the solids are heated

to 600 to 800°C and thereby a large part of the oil contained in the solids is expelled. Upon passing through a dedusting means 8 (which can be configured as a cyclone, multiclone, filter or a combination thereof), the resulting oil vapor is supplied via a conduit 7 to an FCC cracker 9 with an aluminosilicate-based zeolite catalyst. In the cracker 9, the heavy oil components are broken down into light hydrocarbons, which are separated in a succeeding separating means 10, e.g. a distillation column.

The solids left in the reactor 6 upon expulsion of the oil vapors, which still contain an unevaporated fraction of heavy hydrocarbons, are supplied via a conduit 11 to a fluidized-bed furnace 12, to which additional fuel or heat transfer medium for starting up the furnace 12 can be supplied via conduits 13, 14.

From the furnace 12, a return conduit 15 leads to a blocking device 16 not illustrated in Fig. 2, which is used for separating the furnace and reactor atmospheres and is connected with the reactor 6 via a conduit 17.

The waste gas from the furnace 12 is supplied to a heat recovery system 19 via a conduit 18 and then via a conduit 20 to a gas cleaning 21. The calcination residue of the furnace 12 also is supplied to a heat recovery system 23 via a conduit 22.

Via a conduit 24, hot air obtained in the heat recovery systems 19, 23 can be introduced into the furnace as combustion air.

In Fig. 2, a so-called sealpot is illustrated in detail as an example for a suitable blocking device 16. The descending return conduit 15, which also is referred to as downpipe 50 or downer, through which hot solids are discharged as heat transfer medium for the reactor 6, is branched off from the furnace 12. The inlet region of the downpipe 50 also is referred to as head 51 of the downpipe. Just before the bottom 52 of the downpipe 50, an upwardly directed conduit, which also is referred

to as rising pipe 52 or riser, is branched off from the downpipe 50 and extends substantially vertically to the top. The diameter of the downpipe 50 is about twice as great as that of the rising pipe 53. The inlet region or base 54 of the rising pipe 53 can slightly protrude into the downpipe 50 or terminate flush with the wall of the downpipe. At the upper end or head 55 of the rising pipe 53, the rising pipe opens into a discharge pot 56, from which the solids can flow off into the reactor 6 via the conduit 17. At the bottom 52 of the downpipe 50, below the rising pipe base 54, conveying gas is supplied via a tuyère 57 which is connected to a supply conduit 58, in order to fluidize the stream of solids in the rising pipe 53. As fluidizing gas, any suitable conveying gas can be used in principle. Preferably, a third, in particular inert gas, such as nitrogen, is used to ensure the separation of the gas atmospheres between the fluidized bed in the furnace 12 and the head of the rising pipe 53.

The plant for refining oil-containing solids in accordance with the present invention substantially is constructed as described above. In the following, its mode of operation, function and action will be explained.

The ground or unground oil-containing solids supplied via supply conduit 1 are dried and heated to a temperature of 80 to 120°C (approx 1 bar pressure) in the drier 2, for instance by means of fluidizing air supplied via a fluidizing conduit 25a. The gas stream containing water, vapor and super-light oil components is discharged via a discharge conduit 26 and can be supplied to the furnace 12.

Subsequently, the dried solids are preheated to a temperature of 110 to 300°C in the preheater 4, which is supplied with fluidizing gas via a fluidizing conduit 25b. The light oil components expelled thereby are introduced into the reactor 6 as fluidizing gas, for instance via a fluidizing conduit 25c, or withdrawn via a discharge conduit 27 and supplied to the cracker 9 upon dedusting. In the reactor 6, the preheated solids are heated to a temperature of 300 to 800°C by means of the hot

solids recirculated from the furnace 12, whereby 70 to 80% of the oil contained in the solids is expelled. The resulting oil vapor is supplied to the dedusting means 8 via conduit 7 and introduced into the FCC cracker 9 upon dedusting, in order to break down the heavy oil components into light hydrocarbons. These hydrocarbons then are separated in the separating means 10 and withdrawn as separate hydrocarbonaceous product streams. It is possible to use some of the light oil components or gaseous components from the separating means 10 as fluidising gas for the dryer or preheater.

10 The combustion products of the furnace can be supplied to the heat recovery system 19, 23.

The solids left in the reactor 9 including the unevaporated heavy oil components are introduced into the furnace 12 via the conduit 11 and burnt at a temperature of 1050 to 1200°C. In the process, merely the oil components contained in the solids are burnt and the solids are brought to a high temperature, so that they can serve as heat transfer medium for the reactor 6. These hot solids then are recirculated to the reactor 6 via the return conduit 15, the blocking device 16 and the conduit 17.

20 **Example:**

About 1000 t/h of oil sand with an oil content of 142 t/h were supplied to the drier 2 via conduit 1 and dried at a temperature of 110°C. Via conduit 3, 988 t/h of the remaining solids were supplied to the preheater 4 and preheated there to 200°C. The remaining 986 t/h of solids were introduced into the reactor via conduit 5 and heated to 800°C. The oil vapors with a mass flow of 97 t/h, which were expelled thereby, are supplied to the dedusting means 8 and then to the FCC cracker 9 and the separating means 10. There was obtained a total product stream of 100 t/h. The waste water obtained was supplied to the furnace 12.

The solids withdrawn from the reactor 6 were introduced into the furnace 12 via conduit 11 and heated there to 1050°C by combustion of the heavy oil components contained in the solids. A solids stream of 2300 t/h was recirculated to the reactor 6 via the return conduit 15, the blocking device 16 and the conduit 17. The
5 remaining solids were withdrawn from the furnace 12 via the conduit 22 and supplied to the heat recovery system 23, from which 850 t/h of solids with a temperature of 80°C were withdrawn. The waste gas from the furnace 12, which had an oxygen content of 3%, was supplied to the heat recovery system 19 and could be utilized for generating 125 MW of energy. The waste gas of the heat recovery sys-
10 tem 19 was supplied to the gas cleaning 21 with a mass flow of 744 t/h and a temperature of 200°C, in order to remove noxious substances such as SO₂, NO_x or the like.

List of Reference Numerals:

	1	supply conduit
	2	drier
5	3	conduit
	4	preheater
	5	conduit
	6	reactor
	7	conduit
10	8	dedusting means
	9	cracker
	10	separating means
	11	conduit
	12	furnace
15	13	conduit
	14	conduit
	15	return conduit
	16	blocking device
	17	conduit
20	18	conduit
	19	heat recovery system
	20	conduit
	21	gas cleaning
	22	conduit
25	23	heat recovery system
	24	conduit
	25a-c	fluidizing conduits
	26	discharge conduit
	27	discharge conduit

	50	downpipe
	51	head of the downpipe
	52	bottom of the downpipe
5	53	rising pipe
	54	base of the rising pipe
	55	head of the rising pipe
	56	discharge pot
	57	tuyère
10	58	supply conduit

- 16 -

Claims:

1. A process for refining oil-containing solids, with the following steps:

- supplying the oil-containing solids to a reactor and expelling an oil-containing vapor at a temperature of 300 to 1000°C,

5 - supplying the oil-containing vapor expelled in the reactor to a cracker, in which heavy oil components are broken down,

- separating the products obtained in the cracker and withdrawing product streams,

10 - introducing the solids left in the reactor including an unevaporated fraction of heavy hydrocarbons into a furnace,

- burning the unevaporated fraction of the heavy hydrocarbons left in the solids in the furnace at a temperature of 600 to 1500°C,

15 - recirculating hot solids from the furnace into the reactor, wherein the oxidizing atmosphere of the furnace is separated from the atmosphere of the reactor by a blocking device, wherein the blocking device between the furnace and the reactor includes a downpipe through which a stream of solids is withdrawn from the furnace, and a rising pipe which is branched off from the downpipe in upward direction close to the bottom of the same, and

20 - supplying conveying gas into the rising pipe, wherein the stream of solids withdrawn from the furnace is fluidized by the conveying gas and transported to the reactor through the rising pipe.

2. The process according to claim 1, **characterized in** that the oil-containing solids are oil sand or oil shale.

- 17 -

3. The process according to claim 1 or 2, **characterized in** that the step of burning the unevaporated fraction of the heavy hydrocarbons left in the solids in the furnace is carried out at 1050 to 1200°C.
4. The process according to any one of claims 1 to 3, **characterized in** that the oil-
5 containing solids are dried in at least one drying stage at 80 to 120°C before being introduced into the reactor.
5. The process according to any one of claims 1 to 4, **characterized in** that the oil-containing solids are preheated to a temperature of 110 to 300°C in at least one preheating stage before being introduced into the reactor.
- 10 6. The process according to any one of claims 1 to 5, **characterized in** that the reactor is a fluidized-bed reactor.
7. The process according to claim 6, **characterized in** that gas streams containing light hydrocarbons, which are obtained from a preheating stage and/or the cracker, are supplied to the reactor as fluidizing gas.
- 15 8. The process according to claim 6 or 7, **characterized in** that nitrogen, air, oxygen, hydrogen and/or part of the waste gas from the furnace is supplied to the reactor as fluidizing gas.
9. The process according to any one of claims 1 to 8, **characterized in** that the gas streams supplied to the reactor are cold or preheated.
- 20 10. The process according to any one of claims 1 to 9, **characterized in** that in the reactor the oil-containing vapor is expelled from the solids by distillation.
11. The process according to any one of claims 1 to 10, **characterized in** that the reactor is operated under a reduced pressure in the range from 0.001 to 1 bar.

- 18 -

12. The process according to any one of claims 1 to 11, **characterized in** that the gas streams supplied to the cracker are dedusted before being introduced into the cracker.

5 13. The process according to any one of claims 1 to 12, **characterized in** that the catalytic cracking is performed at a temperature of 400 to 600°C and a pressure of 1 to 2 bar by means of a zeolite catalyst.

14. The process according to any one of claims 1 to 13, **characterized in** that the separation of the products obtained in the cracker is effected in a distillation column.

10 15. The process according to any one of claims 1 to 14, **characterized in** that the combustion in the furnace is performed in an atmosphere rich in oxygen.

16. The process according to any one of claims 1 to 15, **characterized in** that a staged combustion is effected in the furnace.

17. The process according to any one of claims 1 to 16, **characterized in** that additional fuel is supplied to the furnace in the form of untreated oil-containing solids or coal.

15 18. The process according to any one of claims 1 to 17, **characterized in** that the heat generated in the furnace is recovered from the waste gas and/or the calcination residue.

20 19. A plant for refining oil-containing solids, said plant comprising a reactor (6) to which the oil-containing solids are supplied, a furnace (12) to which solids coming from the reactor (6) and fuel are supplied, a return conduit (15) through which hot solids produced in the furnace (12) are recirculated to the reactor (6), a blocking device (16) for separating the gas atmospheres of the furnace (12) and of the reactor (6), a cracker (9) to which oil-containing vapor expelled from the oil-containing solids in the reactor (6) is supplied and in which the heavy oil components are broken down, and a separating
25 means (10) for separating the products obtained in the cracker (9), wherein the blocking device (16) between the furnace (12) and the reactor (6) includes a downpipe (50) through which a stream of solids is withdrawn from the furnace (6), a rising pipe (53)

- 19 -

which is branched off from the downpipe (50) close to the bottom (52) of the same, and a conveying gas supply below the rising pipe (53), wherein the stream of solids withdrawn from the furnace (12) is fluidized by the conveying gas and transported through the rising pipe (53) to the reactor (6).

- 5 20. The plant according to claim 19, **characterized in** that said plant allows to perform a process as defined in any one of claims 1 to 18.
21. The plant according to claim 19 or 20, **characterized in** that the oil-containing solids are oil sand or oil shale.
- 10 22. The plant according to any one of claims 19 to 21, **characterized in** that the reactor (6) is a fluidized-bed reactor.
23. The plant according to any one of claims 19 to 22, **characterized by** at least one drying stage (2) before the reactor (6).
24. The plant according to any one of claims 19 to 23, **characterized by** at least one preheating stage (4) before the reactor (6).
- 15 25. The plant according to any one of claims 19 to 24, **characterized in** that the cracker (9) includes a zeolite catalyst.
26. The plant according to any one of claims 19 to 25, **characterized in** that a dedusting means (8) is provided before the cracker (9).
- 20 27. The plant according to any one of claims 19 to 26, **characterized in** that the furnace (12) is a fluidized-bed furnace, a rotary kiln or a flash reactor.
28. The plant according to any one of claims 19 to 27, **characterized in** that a heat recovery system (19, 23) is provided downstream of the furnace (12).

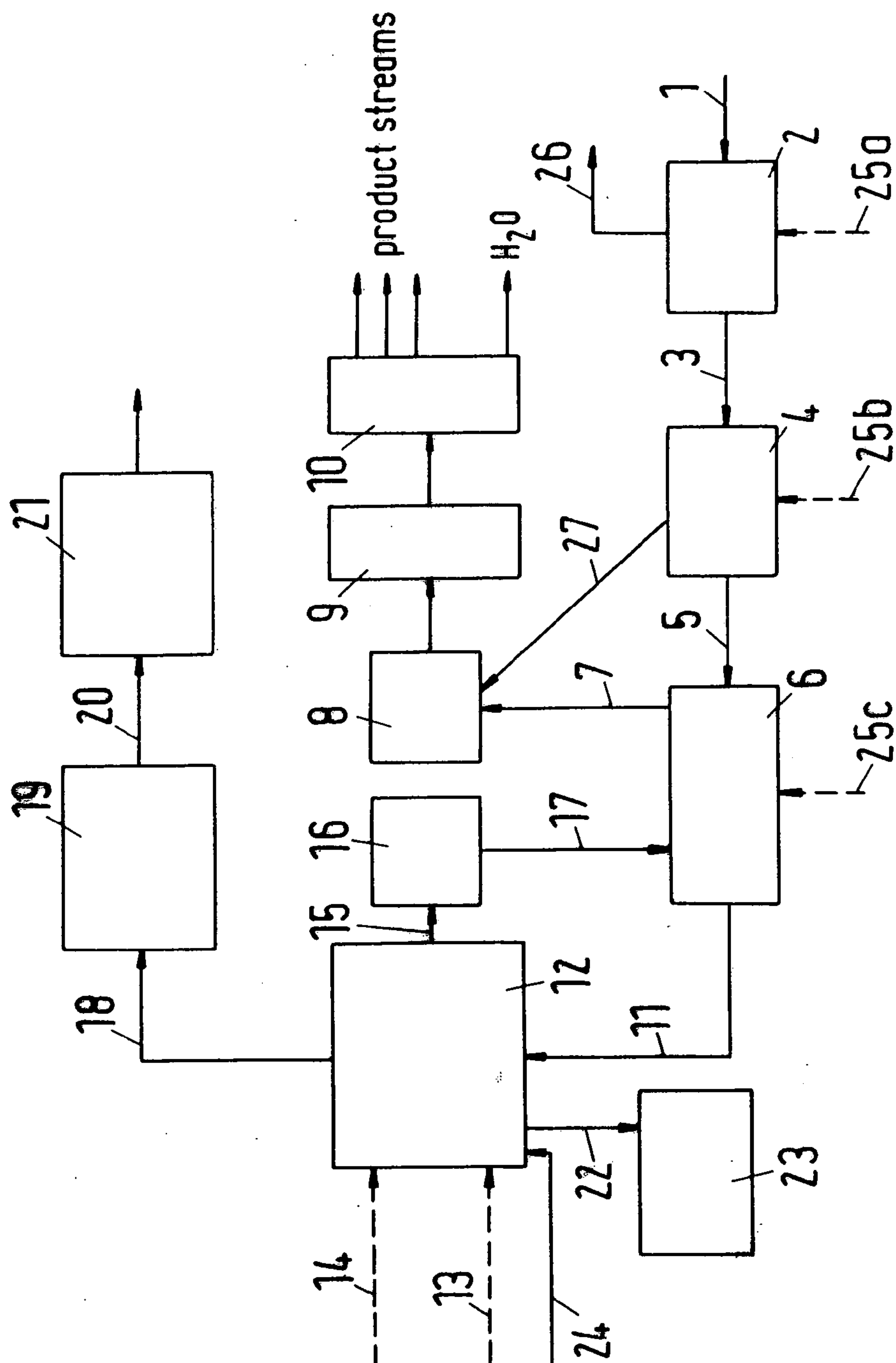
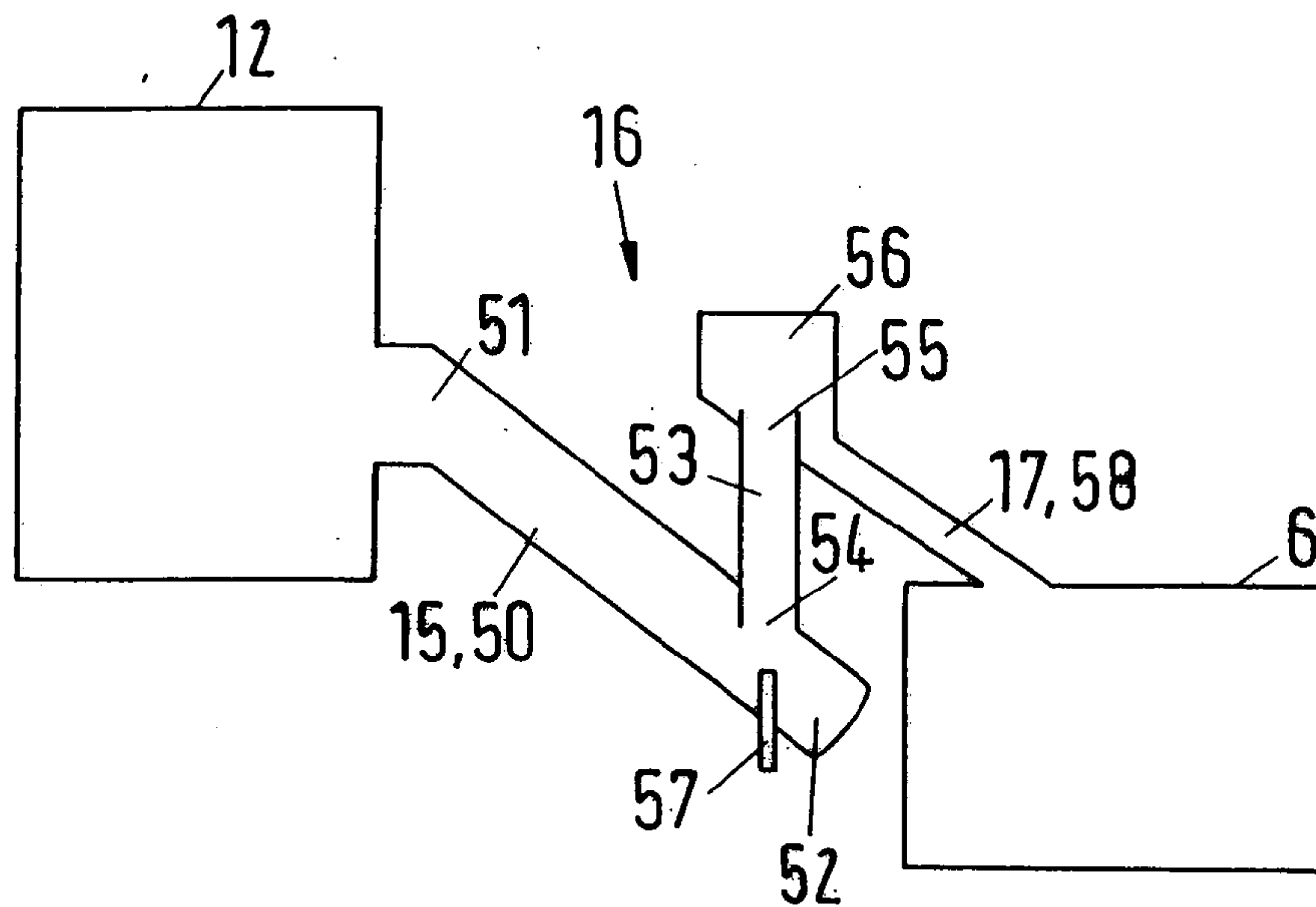


Fig.1

**Fig.2**