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Remarks:

Amended claims in accordance with Rule 86 (2) EPC.

(54) **Method and apparatus for cracking hydrocarbons**

(57) The present invention is directed to a method for cracking hydrocarbons whereby the hydrocarbon educt is fed to a reactor in which the educt is provided with deuterium or deuterium compounds or with the disintegration product thereof. The invention further is directed to a reactor for cracking hydrocarbons having an inlet and an outlet as well as a substance which is adapted to release deuterium or deuterium compounds in the

heated state when applying electric current pulses. The invention is further directed to an ultrasonic reactor having a spherical reactor wall in which at least two ultrasonic generators are provided at opposite portions of the reactor such that the ultrasonic waves are focused in the centre of the reactor.

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Description

[0001] The present invention is directed to a method of cracking hydrocarbons. The invention is further directed to reactors for cracking hydrocarbons.

[0002] Currently, the most frequently used techniques for cracking hydrocarbons such as crude oil are thermal and catalytic cracking, the latter method usually applying zeolithes as catalysts. These techniques are well-known in the art and have several advantages. However, despite intensive research in the past decades several technological drawbacks exist. Some of these drawbacks are the deactivation of the catalyst due to blocking of active sites which deactivation changes the catalyst performance and thus the product spectrum with time-on-stream. Among other drawbacks, there is further the problem that the mixed flow of liquid, gas and solid phase exist in the reactor which results in a complex structure of the reaction system and causes problems in handling, scale up and modelling of such reactors.

[0003] The output of light fractions applying the above mentioned techniques is limited to approximately 70 % and a further increase above this value is difficult to obtain applying conventional thermal or catalytic cracking. Further, the power consumption of these processes is relatively high.

[0004] It is the object of the present invention to provide a method and apparatus for the cracking of hydrocarbons having a high efficiency and selectivity.

[0005] This object is solved by the method of claim 1 as well as by the reactors referred to in claims 15 and 26. The method according to the invention is characterised in that the hydrocarbons, e. g. crude oil, oil, pitch etc. are fed to a reactor in which the hydrocarbons are mixed/enriched with deuterium, deuterium compounds and/or disintegration products thereof such as protons. Deuterium or deuterium compounds are formed within the hydrocarbons and/or by treating a substance which is adapted to act as a source for deuterium or compounds thereof.

[0006] Accordingly, in a preferred embodiment of the invention the educt, i. e. hydrocarbons pass within the reactor a substance which emits deuterium or deuterium compounds when excited with an electromagnetic field. This electromagnetic field may be obtained by heating said deuterium source to a high temperature and by subsequent application of electric current pulses.

[0007] The electromagnetic field may be an electromagnetic field of carbon. Thus, in a preferred embodiment the invention is based on the enrichment of the hydrocarbons by hydrogen/protons whereby a steady flow of hydrocarbons is treated with a high frequency electromagnetic field of carbon which is produced by heating up a substance to a high temperature and further by applying electric current pulses to the thus heated substance.

[0008] In known prior art cracking processes the carbon amount is decreased which the hydrogen amount is maintained. According to the present invention it is possible to maintain the carbon amount and increase the hydrogen content.

[0009] The substance may be heated up to its melting state.

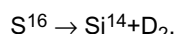
[0010] The electric current pulses may have a density of between 10^6 and 10^8 A/mm². The duration of the pulses can be up to 0,01 μ s. Of course, these values are examples and do not exclude the application of other current densities and pulse durations.

[0011] According to a preferred embodiment of the invention the method suggested herein consist in the high frequency electromagnetic field of carbon which is applied as the factor influencing upon atoms of the substance, i. e. the deuterium source and is formed due to the great electric current pulses let through the heated substance.

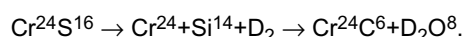
[0012] The source of deuterium or deuterium compounds are preferably graphite or metals such as magnesium, chrome, molybdenum or their compounds such as carbides, nitrides, oxides, sulfides.

[0013] When, e. g., graphite is heated with voltaic arc, the lines of 0,8 and 1,2 μ m are usually considered to appear in the voltaic arc radiation spectrum apart from everything. Such lines correspond to oscillations of carbon atoms. Further, when to have metallic chrome heated the same carbon lines (frequency) at a wave length range between 0,8 and 1,2 μ m appear in the spectrum of heated chrome. Containing 24 protons, some chrome atoms (Cr^{24}) seem to consist of four carbon atoms (C_{13}^6), i. e. $\text{Cr}_{52}^{24} = 4 \text{C}_{13}^6$. The hydrocarbons similar to paraffins contain about carbon C_{12}^6 but not C_{13}^6 . Nevertheless, the carbon lines of chrome displace towards the space of low frequencies. Therefore, the power lines of carbon (C_{13}^6) result in great restructures of hydrocarbons, which evidence in reducing the ties between carbon ligands and in tearing off the deuterium (D_2) from large atom constructions.

[0014] Sulphur, which is available in oil products, can serve as an example. When sulphur is excited with carbon lines, atoms of sulphur will turn into silicon per nuclear reaction as per:



[0015] The used catalysts (deuterium sources) such as chrome sulfides or molybdenum sulfides will turn into carbides as per:



[0016] Other sulfides also have a lot of deuterium. The above sources of deuterium are mentioned as examples. Further examples are titanium nitride, ferrum sulphide, plumbum sulphide and lead amalgam.

[0017] As mentioned above, the heating of substances which act as deuterium source can be realised by alternating or permanent flows up to having melted the above component.

[0018] Afterwards, the pulsing current of high density, e. g. up to 10^6 — 10^8 A/mm² is let through this mass. Under such electric current, many small fragments of the broken up atoms appear in the electric current surroundings. Mainly, this results in a lot of deuterium and α -particles (formed by nuclear reaction), which enrich the medium of hydrocarbons treated and/or are the subject to disintegration. Under the above mentioned treatment hydrocarbons split into small fragments. The hydrocarbons similar to paraffins are thereby treated with atomic irradiation with substances like chrome and molybdenum and their combination with carbon, oxygen, sulphur, phosphor etc.

[0019] It has to be noted that the aforementioned method can be applied to any kind of hydrocarbon such as for cracking of crude oil, gaseous condensate etc. as well as for cleaning water from organic compounds.

[0020] In a further embodiment of the invention the efflux of the reactor is fed to an ultrasonic reactor. Accordingly, the mixture obtained in the aforementioned hydrogen reactor including the deuterium source is further subject to acoustic treatment in an ultrasonic reactor. This treatment results in an essentially complete disintegration of deuterium and deuterium compounds and further, effects further cracking of the hydrocarbons. The treatment of hydrocarbons firstly in the above mentioned hydrogen reactor and the subsequent treatment of the mixture in an ultrasonic reactor leads to a homogenous and high quality final product. In a preferred embodiment of the invention the ultrasonic reactor is a spherical reactor comprising ultrasonic generators arranged in such that the ultrasonic waves are focused in the centre of the reactor.

[0021] The ultrasonic treatment in said reactor may be performed at a static pressure ranging between 0,1 and 5,0 MPa or at a variable pressure. Further, the ultrasonic treatment may be performed with a frequency ranging between 1 and 10^4 kHz. The ultrasonic intensity may be ranged between 1 and 10^4 MW/m².

[0022] The above outlined invention permits to improve both efficiency of organic compound cracking process and final product quality. It provides the opportunity to control and regulate the process. It further ensures a simplification of the technology applied and unit construction under the simultaneous improvement of safety and cutting of power expenditures.

[0023] It is to be noted that the invention can be used and realised in form of a stand alone self dependent and, e. g. trailer-based-unit or as an intermediate section of organic compound cracking in order to raise the output of light fractions.

[0024] The amount of light fractions applying the above mentioned inventive method can be raised clearly above the known limits of 70 %, i. e. to more than 95 %.

[0025] The present invention is further directed to a reactor of cracking hydrocarbon having an inlet and an outlet as well as a substance which is adapted to release deuterium or deuterium compounds in the heated state when applying electric current pulses. The inlet and the outlet of the reactor may be the same which may be the case in a batch mode of operation. In continuous mode of operation the inlet and the outlet are different from each other.

[0026] As outlined above, the substance which is adapted to release deuterium or deuterium compounds may comprise graphite or metals or carbides, sulfides, oxides and/or nitrides of graphite or of metals.

[0027] In a further embodiment of the invention said substance is electro-conductive and the reactor further comprises an electrode which is arranged relative to the surface of said substance such that an arc may be established between the electrode and the surface of said substance. In order to obtain the aforementioned arc the reactor further may comprise means adapted for changing the distance between the electrode and the surface of said substance.

[0028] For fulfilling this object the reactor further may comprise a solenoid which is adapted to remove the electrode from the surface of said substance if current is applied thereto. In this embodiment of the invention the reactor further comprises a spring which exerts a force directed in the opposite direction and which is adapted to press the electrode to the surface of said means if no current flows in the solenoid. This process reiterates. As a result the cyclically broken part of the electric circuit results in electric arcing between the electrode and the surface of said substance.

[0029] In a further embodiment of the invention the reactor further comprises means for changing the tension of the spring.

[0030] In a preferred embodiment the reactor comprises a cylindrical corpus. The longitudinal axes from the inlet and from the outlet are arranged in a further embodiment perpendicularly to the longitudinal axis of the corpus. The substance which acts as a deuterium source may be arranged in an end portion of the reactor/corpus. The surface of the substance may be arranged essentially in the same plane as one of the walls of the inlet and/or outlet of the reactor so that the hydrocarbon feed is directly fed into the active zone of the reactor which is the surface of the substance abutting said electrode.

[0031] In a further embodiment of the invention the corpus of the reactor is closed at both end portions with flanges, which flanges are provided with electrical contacts. Those contacts are used for applying a current through the solenoid and the source of deuterium.

[0032] This present invention further is directed to an ultrasonic reactor having a spherical reactor wall in which at

least two ultrasonic generators are provided at opposite portions thereof such that the ultrasonic waves are focused in the centre portion of the reactor. The reactor may be composed of two hemispheres which are linked, especially welded to each other in order to concentrate the ultrasonic energy. It is further of advantage if the ultrasonic generators are oriented radially to the centre of the ultrasonic reactor. Essentially due to cavitation the ultrasonic oscillations result in destruction of hydrocarbon raw materials. The bursting of cavitation bubbles is accompanied by short-term pulses (approximately 10^{-8} s) of pressure (up to 100 MPa) and by the adiabatic heating of gas up to a temperature of approximately 10.000 °C inside the bubbles.

[0033] In a further embodiment of the reactor the ultrasonic reactor has an inlet and an outlet which are both oriented radially and which align with each other.

[0034] The invention is further directed to the use of the aforementioned hydrogen reactor and/or of the ultrasonic reactor for cracking hydrocarbons.

[0035] Further embodiments of the invention are disclosed in the drawings which show:

Fig. 1: technological scheme of the overall unit,

Fig. 2: sectional view of the hydrogen reactor,

Fig. 3: side view of the ultrasonic reactor,

Fig. 4: another side view of the ultrasonic reactor aligning with the inlet and outlet,

Fig. 5: sectional view of the ultrasonic reactor,

Fig. 6: electric scheme of the high power pulse former and

Fig. 7: dependency of temperature from time observed in the process of cracking according to the present invention.

[0036] Fig. 1 shows a technological scheme of the overall apparatus of the invention. Reference numeral 10 designates the hydrogen reactor and numeral 20 the ultrasonic reactor. The high frequency oscillators are marked with reference numeral 22. Downstream of the ultrasonic reactor 20 the viscosity sensor 30, the density sensor 40 as well as a pump 50 are arranged. Numeral 60 designates the drainage of the system. The flow controller 70 is arranged parallel to the pump 50. The hydrogen reactor 10 may be bypassed by a bypass 80. Further, reference numerals 100 and 110 refer to the voltage regulation and to a transformer.

[0037] Fig. 1 further shows the switch box 120 as well as the operator's working place 130.

[0038] Reference numeral 140 shows the hand pump which is necessary for filling the closed circuit with educt hydrocarbons, i. e. for example with crude oil. As shown in fig. 1 the hydrogen reactor 10 and the ultrasonic reactor 20 are arranged in a closed circuit. It is, of course, also possible to arrange the hydrogen reactor 10 and the ultrasonic reactor 20 subsequently to each other without feeding back the ultrasonic reactor efflux to the hydrogen reactor 10.

[0039] Fig. 2 shows the hydrogen reactor 10 in detail. The reactor 10 consists of the cylindrical corpus 200 to which upper and lower parts are welded flanges 202 and 204. In the lower portion of the cylindrical corpus 200 branch pipes 206, 208 are arranged which serve as inlet and outlet of the liquid educt/product. The inlet 206 as well as the outlet 208 are welded to the corpus 200 and align with each other.

[0040] As may be further gathered from fig. 2 the reactor 10 comprises an upper removal flange 210 and a lower removable flange 212 which are hermetically fastened to flanges 202, 204 by means of a washer and secured by means of bolts.

[0041] Inside the reactor there is located a thin walled bushing 214 which is filled with the substance 216 which acts as a source of deuterium and/or deuterium compounds. In this embodiment the bushing 214 is filled with a special alloy of plumbum base. The bushing 214 is fastened to a cylindrical contact 218 which is not insulated from the corpus 200 and which is passing through a central aperture in the lower removable flange 212. The contact is strengthened by means of a ring-packing washer.

[0042] The upper removable flange 210 is hermetically fastened to the upper flange 202 by means of a plate-packing washer as well as by means of bolts.

[0043] As may be further gathered from fig. 2, inside the reactor 10 is located the electrocontact arrangement comprising the holding device 220, a solenoid (not shown), a power terminal and a spring regulator. The holding device 220 is by its upper end fastened to the upper removable flange 210 as shown in fig. 2. Reference numeral 222 refers to a solenoid armature having a contact 224 at its lower end. The solenoid extends around the solenoid armature 222 between the walls 226 and 228. The solenoid is strengthened to the lower end of the holding device 220.

[0044] As further shown in fig. 2 the lower portion of the contact 224 is contiguous to a surface 216' of the substance

216. This zone is the active zone of the reactor.

[0045] The upper end of the solenoid armature 222 is linked to a spring regulator 230 by means of a rod 232 which spring regulator is electrically isolated from the solenoid and which contains a screw presser 240 which is located in the upper portion of the reactor 210 outside the reactor.

[0046] At the upper removal flange 210 there is hermetically installed a communicating contact 250 which is isolated from the corpus 200 and electrically joined with one end of the solenoid (not shown). Another ending of the solenoid is electrically connected by means of a flexible bar (not shown) to the contact 224 installed at the lower portion of the solenoid armature 222.

The operation of the reactor is as follows:

[0047] The liquid being treated enters the reactor by inlet 206. The product leaves the reactor through outlet 208. Of course, the alternate operation of inlet and outlet is possible. The electric current of required value and voltage is fed to the contacts 250, 218 installed at the lower and upper removable flanges 210, 212.

[0048] The electric circuit is formed between the upper contact 250, the coil (solenoid) and the contact 224, the bushing 214 with the special alloy 216 and the lower contact 218.

[0049] When this circuit is closed the electric current passes through the solenoid which pulls the armature 222 in an upward direction in fig. 2 against the force of the spring 230 which results in a movement of the contact 224 away from the surface 216' of the substance 216. Thus, the electric circuit is broken.

[0050] Since no current flows through the solenoid in this state no force is exerted by the solenoid and the spring 230 presses down the armature 222 with contact 224 to the surface 216' and the electric circuit again closes. This process reiterates. Thus, in the active zone of the reactor, i. e. in the lower portion of the contact 224 and the upper portion of the substance 216 a cyclically broken part of the electric current is formed which results in power electric arcing and heating effects taking place and being accompanied by interaction with substances of the special alloy 216. These processes influence the hydrocarbons passing through the reactor. As is shown in fig. 2 the lower surface of inlet 206 and outlet 208 abut with the surface 216' of the substance 216 so that the liquid is directly fed to the active zone of the reactor.

[0051] The screw presser 240 may be rotated by hand and depending on the degree of rotation the tension exerted by spring 230 is changed. This serves to regulate the frequency of the broken contact and further ensures that the apparatus is workable even if the alloy 216 inside bushing 214 is spent.

[0052] Basically, the parameters to treat hydrocarbons inside the reactor 10 can be adjusted by values of electric current and voltage fed to the reactor as well as by values of hydrostatic pressure and outlet of liquid raw material admitted to the reactor.

[0053] The substance 216 is heated due to the current flowing therethrough and further due to thermal neutrons deriving from deuterium which is emitted from the substance 216 during operation of the reactor 10. As outlined above electric current pulses of density up to 10^6 — 10^8 A/mm² are fed to the substance 216 which has been heated to a high temperature preferably up to the melted state. This treatment results in a high frequency electromagnetic field of carbon which in turn leads to the production of deuterium and α -particles which enrich the medium of hydrocarbons treated within the reactor 10.

[0054] As may be gathered from fig. 1 subsequent to the hydrogen reactor 10 the mixture is fed to the ultrasonic reactor 20. In this reactor 20 further cracking of the products take place and further disintegration of deuterium to protons and neutrons occur. The subsequent treatment of the mixture in the ultrasonic reactor 20 leads to a further cracking and to homogenisation of the reaction product.

[0055] The apparatus in fig. 1 shows a closed cycle including the hydrogen reactor 10 and the ultrasonic reactor 20. Of course, it is also possible to arrange both reactors subsequently to each other without recirculation. In this case the educt is fed to the hydrogen reactor 10, passes to the ultrasonic reactor 20 and is then open for further use.

[0056] Figures 3 to 5 show the ultrasonic reactor 20 in different perspectives and views. The ultrasonic reactor 20 comprises a plurality of ultrasonic generators 300. The ultrasonic reactor 20 consists of two spherical hemispheres which are welded to each other. Apparatus are located in the hemispheres which accommodate the ultrasonic generators 300. Further, as shown in fig. 4 and 5 the reactor further comprises an inlet 302 and an outlet 304 which are arranged and which align with each other. The hemispheres of the reactor are arranged radially so that their centres coincide. Thus, a spherical reactor is formed.

[0057] The threaded apertures are distributed evenly on the surfaces of hemispheres to install the ultrasonic generators 300 as shown in the figures 3 to 5. A diaphragm with aperture in the centre is welded in the place of jointing the semispheres. In each of the branch pipes forming the inlet 302 and the outlet 304 are arranged flanges with threaded apertures to join the reactor 20 to external pipelines.

[0058] Each ultrasonic generator 300 consists of the active piezoelements 306, face lap-concentrator 308, back lap 309, tightening bolts and element for electric current admission. The piezoelectric elements 306 represent the plate

washers made of hard piezoceramics. These washers are shown in figures 3 to 5 with reference numeral 306.

[0059] The abutting ends of the surfaces of the washers are silvered to ensure a reliable electric contact. The lap-concentrators 308 are of the stepped cylindrical and conic shape as shown in the figures 3 to 5. The basic mass of this lap 308 is an aluminium fusion.

[0060] The ending cylindrical part 310 of this lap 308 is of cylindrical shape and is made of titanium fusion.

[0061] In the middle portion of the lap-concentrator 308, in the zone of minimal amplitude for longitudinal oscillations there is stipulated the burr to fasten the radiator inside the reactor case.

[0062] The back lap represents the plate steel washer. Between the piezoelements 306 there is laid a thin brass washer with a petal 311 to be joined electrically to the radiator positive electrode. The piezoelements 306 are installed between the laps 308, 309 and are tightened with the bolt. The force to tighten the bolt is regulated so that to ensure both the required resonance frequency of radiator and the maximum mechanical strength of the piezoelements for their repeated cycling loading during the process of long operation. The piezoelements 306 and laps 308, 309 being tightened with the bolt form an elastic oscillating system of the radiator 300.

[0063] On the external side of the back lap 309 and by means of screw there is installed a petal 312 to be joined electrically to the radiator negative electrode.

[0064] The radiator concentrators are strengthened inside the semispheres of the reactor 20 by means of the transitional threaded bushes and pressing washers. This junction is hermetically sealed by means of packing washers. The radiator concentrators 320 are placed so that their longitudinal axes are in radial direction relatively to the centre of semispheres and the endings of the concentrators 320 are in central zones of the semisphere forming the reactor 20 at equal distances from their common centre. The above mentioned placing of the radiators 320 and the availability of diaphragm in the central zone of the case ensure a forming of the reactor active zone.

The operation of the reactor is as follows:

[0065] The liquid to be treated is admitted under pressure into the lower branch pipe forming the inlet 302 of the reactor 20. It passes through the reactor active zone forming the centre portion of the reactor 20 and leaves the reactor 20 from the upper branch pipe forming the outlet 304. The electric current of required frequency, voltage and power is fed to the terminals of the radiators from the special ultrasonic multi-channelled generator. The radiator concentrators 320 transform the fed electric oscillations into mechanical oscillations. In this case, due to the concentrator 320 a specific power of oscillation at the free endings of concentrators 320 raise in ten times in comparison with a specific power on the surface of piezoelements. So long as all free endings of concentrators 320 are near the central zone of the reactor 20 the concentration of all energy of ultrasonic oscillations made by the reactor takes place inside this zone.

[0066] Due to cavitation and other effects, the ultrasonic oscillations result in destruction of the hydrocarbon raw material. Further, disintegration of deuterium fed into the reactor is performed. Parameters and directness of influences upon raw material can be regulated by means of changing the characteristics of electric signals (power, pulse porosity, etc.) as well as by means of controlling the outlet and pressure of liquid.

[0067] The specific electric capacity of the reactor shown in figures 3 to 5 is 1 kWh/m³ and the productivity is 16 m³/h which is directly related to the ultrasonic treatment as described above. The energy of the high frequency acoustic oscillations completely transform into energy of chemical transformations occurring at the molecular level within the reactor active zone. Being of comparatively low specific capacity (approximately 1,5 W/sm²) at the reactor surface all acoustic energy focuses in a central zone of the sphere of the reactor 20 inside which a cavitation arises. Compared to prior art known solutions no losses of ultrasonic energy due to circulation of the ultrasonic waves occur. Instead all the ultrasonic energy is focused on the centre portion of the reactor.

[0068] A bursting of cavitation bubbles is accompanied by the short term pulses (approximately 10⁻⁶s) of pressure (up to 100 MPa) and by the adiabatic heating of the gas up to temperatures 10.000 °C inside the bubbles.

[0069] The working hydrostatic pressure inside the reactor 20 is adjustable as per conditions of the complete technological process. The pressure is ranged within 0,1 to 5,0 MPa. The ultrasonic treatment in the reactor 20 shown in fig. 3 to 5 does not require a special heating of initial components. It could be helpful to preliminarily heat the initial raw material up to 15 to 20 °C in order to lower its viscosity in a cold surrounding.

[0070] The expected output of useful product (petroleum or diesel fuel) is approximately 90 to 95 % from the mass of initial components. By-products are sulphuric acid and dry residues up to 5 %.

[0071] Apart from the disintegration of hydrocarbon and deuterium water mixed within the educt is dissociated under the acoustic influence to the atomic hydrogen and takes part on the stabilisation of the radicals. The oxygen takes part in the formation of H₂SO₄.

[0072] The process is very flexible and can be adjusted conformably to the initial raw material and to the desired final product. The adjustment may be realised both by selecting a ratio of the process initial components and by changing the process parameter such as hydrostatic pressure, outlet, acoustic capacity and passing radiation porosity.

[0073] The reactor 20 can be operated in the single pass mode. At the process productivity of 16m³/h the reactor

approximately lasts 20 s. It is principally possible to reduce this period down to e. g. 5 s with the corresponding increase of productivity up to 50m³/h.

[0074] It is not necessary to heat preliminary raw material which is being obligatory for the ordinary cracking technology. In the unit shown in fig. 3 to 5 the process is going on at normal temperature of raw material admitted to the ultrasonic reactor 20.

[0075] Fig. 6 shows the electric scheme of the high power pulse former. In the left portion of fig. 6 the high power electric pulses are demonstrated within the reactor 10. To the reactor 10 a direct current of low voltage is applied permanently. In addition, with a certain frequency high power electric pulses are applied as mentioned above. For obtaining this goal the electric scheme as outlined in fig. 6 is used. Reference numeral 1 is directed to a pulse transformer and reference numeral 2 to a high voltage discharger. Reference numeral 5 is the adjustable high voltage source (2—10 kV) which is connected via ballasting resistors 4 to pulse formers 3.

[0076] In order to enable a synchronous start of the pulse a discharger synchronous start former 6 is provided.

[0077] As outlined above a steady DC current is applied to the reactor 10 which is provided by the adjustable DC source 7.

[0078] Fig. 7 shows a diagram representing the temperature change in the course of time. The result has been received for crude oil quantified in 100 ml and treated inside the unit shown in fig. 1. Under a temperature around 140 °C there is observed an approximately linear increase of temperature with time. At 140 °C temperature abruptly increases as well as volume which is the evidence for a high deuterium content being available inside the treated oil. As outlined above deuterium disintegrates into $D \rightarrow p+n$. The temperature increase shown in fig. 6 is due to the action of thermal neutrons.

[0079] The above mentioned process and apparatus can be used to obtain a high percent of light fractions with a high octane number. This increases the calorific value and provides a high level of combustion in an internal combustion engine. Further, at the end of the burning cycle of the internal combustion engine highly toxic radicals are absent. The product obtained with the claimed process and apparatus will provide homogeneous, uniform and economic motor fuel.

[0080] The following tables 1 —3 show the characteristics of the product obtained with the apparatus of fig. 1.

Table 1

№	Quality indices		Test results
1.	Density at 20°C, kg/m³		0,737
2.	The Engler's fraction structure	Boil commencement °C	61
		The boiled away up to 100 °C, %	32
		The boiled away up to 150 °C, %	83
		The boiled away up to 200 °C, %	94
		The boiled away up to 210 °C, %	95,5
		Ending of boiling °C	216/98
3.	Content of sulphuric compounds, % mass		0,048
4.	Mechanical admixtures, % mass		0,007
5.	Water content % vol		0,05
6.	Ash content, % vol		lack
7.	Kinematic viscosity at 20°C, cSt		0,82
8.	Chlorous salt content, mg/l		3,7
9.	Water-soluble acid & alkali content		lack

Test volume - 800 ml
 Test weight - 589,6 gr

Table 2

№	Quality indices	Test results
1.	Density at 20°C, kg/m ³	0,731
2.	The Engler's fraction structure	Boil commencement °C
		57
		The boiled away up to 100 °C, %
		38
		The boiled away up to 150 °C, %
		86
		The boiled away up to 200 °C, %
		89
		The boiled away up to 210 °C, %
		95
		Ending of boiling °C
		216/98,5
3.	Content of sulphuric compounds, % mass	0,032
4.	Mechanical admixtures, % mass	0,006
5.	Water content % vol	0,04
6.	Ash content, % vol	lack
7.	Kinematic viscosity at 20°C, cSt	0,80
8.	Chlorous salt content, mg/l	3,5
9.	Water-soluble acid & alkali content	lack

Test volume - 800 ml
 Test weight - 589,6 gr

Table 3

№	Quality indices	Test results
1.	Density at 20°C, kg/m ³	0,729
2.	The Engler's fraction structure	Boil commencement °C
		63
		The boiled away up to 100 °C, %
		30
		The boiled away up to 150 °C, %
		71
		The boiled away up to 200 °C, %
		75
		The boiled away up to 210 °C, %
		96
		Ending of boiling °C
		216/98,5
3.	Content of sulphuric compounds, % mass	0,029
4.	Mechanical admixtures, % mass	0,007
5.	Water content % vol	0,04
6.	Ash content, % vol	lack
7.	Kinematic viscosity at 20°C, cSt	0,83
8.	Chlorous salt content, mg/l	3,8
9.	Water-soluble acid & alkali content	lack

Test volume - 800 ml
 Test weight - 589,6 gr

Claims

1. Method for cracking hydrocarbons whereby the hydrocarbon educt is fed to a reactor in which the hydrocarbon educt is provided with deuterium or with a deuterium compound or with the disintegration products thereof.

2. Method according to claim 1 wherein the hydrocarbon educt in the reactor passes a substance which emits deuterium or a deuterium compound when excited with an electromagnetic field.
- 5 3. Method according to claim 2, wherein the electromagnetic field is generated by heating the substance to a high temperature and by subsequent exciting of this heated substance by electric current pulses.
4. Method according to claim 2 or 3, wherein the electromagnetic field is an electromagnetic field of carbon.
- 10 5. Method according to claim 3 or 4, wherein the heating is performed up to the melted state of the substance.
6. Method according to anyone of claims 3 to 5, wherein the electric current pulses have a density ranging between 10^6 — 10^8 A/mm².
- 15 7. Method according to anyone of claims 3 to 6, wherein the electric current pulses have duration up to 0,01 μ s.
8. Method according to anyone of claims 2 to 7, wherein the substance is or comprises graphite or metals or carbides, sulfides, oxides and/or nitrides of graphite or of metals.
- 20 9. Method according to anyone of the preceding claims, wherein the efflux of the reactor is fed to an ultrasonic reactor.
10. Method according to claim 9, wherein the ultrasonic reactor is a spherical reactor comprising ultrasonic generators arranged such that the ultrasonic waves are focused in the centre of the reactor.
- 25 11. Method according to claim 9 or 10, wherein the ultrasonic treatment is performed at a static pressure ranging between 0,1 — 5,0 MPa or at a variable pressure.
12. Method according to anyone of claims 9 to 11, wherein the ultrasonic treatment is performed with a frequency ranging between 1 and 10^4 kHz.
- 30 13. Method according to anyone of claims 9 to 12, wherein the ultrasonic intensity ranges between 1 and 10^4 MW/m².
14. Method according to anyone of claims 1 to 13 wherein the reactor is a reactor according to anyone of claims 15 to 25 and/or wherein the ultrasonic reactor is an ultrasonic reactor according to any one of claims 26 to 29.
- 35 15. Reactor for cracking hydrocarbons having an inlet and an outlet as well as a substance which is adapted to release deuterium or a deuterium compound in the heated state when applying electric current pulses.
16. Reactor according to claim 15, wherein said substance is or comprises graphite or metals or carbide, sulfide, oxide and/or nitride of graphite or of metals.
- 40 17. Reactor according to claims 15 or 16, wherein said substance is electro-conductive and that the reactor further comprises an electrode which is arranged relative to the surface of said substance such that an arc may be established between the electrode and the surface of said substance.
- 45 18. Reactors according to claim 17, wherein the reactor further comprises a means adapted for changing the distance between the electrodes at the surface of said substance.
19. Reactor according to claim 18, wherein the reactor further comprises a solenoid which is adapted to remove the electrode from the surface of said substance if current is applied thereto and that the reactor further comprises a spring which exerts a force directed in the opposite direction and which is adapted to press the electrode to the surface of said substance if no current flows in the solenoid.
- 50 20. Reactor according to claim 19, wherein the reactor further comprises means for changing the tension of the spring.
- 55 21. Reactor according to anyone of claims 15 to 20, wherein the reactor comprises a cylindrical corpus.
22. Reactor according to claim 21, wherein the longitudinal axes from the inlet and from the outlet are arranged perpendicularly to the longitudinal axis of the corpus.

23. Reactor according to claims anyone of claims 15 to 22, wherein said substance is arranged in an end portion of the reactor.
24. Reactor according to anyone of claims 15 to 23, wherein the surface of said substance is arranged essentially in the same plane as one of the walls of the inlet and/or outlet of the reactor.
25. Reactor according to anyone of claims 21 to 24, wherein the cylindrical corpus of the reactor is closed at both end portions with flanges, which flanges are provided with electrical contacts.
26. Ultrasonic reactor having a spherical reactor wall in which at least two ultrasonic generators are provided at opposite portions of the reactor such that the ultrasonic waves are focused in the centre of the reactor.
27. Ultrasonic reactor according to claim 26, wherein the reactor wall is composed of two hemispheres which are linked, especially welded to each other.
28. Ultrasonic reactor according to claims 26 or 27, wherein the ultrasonic generators are oriented radially directed to the centre of the ultrasonic reactor.
29. Ultrasonic reactor according to anyone of claims 26 to 28, wherein the ultrasonic reactor has an inlet and an outlet which are both oriented radially and which align with each other.
30. Use of a reactor according to anyone of claims 15 to 25 or to anyone of claims 26 to 29 or a combination thereof for cracking hydrocarbons.

Amended claims in accordance with Rule 86(2) EPC.

1. Method for cracking hydrocarbons including the following steps:

- feeding the hydrocarbon educt to a reactor,
- whereupon the hydrocarbon educt passes a substance in the reactor which substance is adapted to emit deuterium or a deuterium compound when excited with an electromagnetic field,
- exciting said substance with an electromagnetic field which causes the substance to emit deuterium or a deuterium compound and
- providing the hydrocarbon educt in the reactor with said deuterium or deuterium compound or with the disintegration products thereof.

2. Method according to claim 1, wherein the electromagnetic field is generated by heating the substance to a high temperature and by subsequent exciting of this heated substance by electric current pulses.

3. Method according to claim 1 or 2, wherein the electromagnetic field is an electromagnetic field of carbon.

4. Method according to claim 2 or 3, wherein the heating is performed up to the melted state of the substance.

5. Method according to anyone of claims 2 to 4, wherein the electric current pulses have a density ranging between 10^6 - 10^8 A/mm².

6. Method according to anyone of claims 2 to 5, wherein the electric current pulses have duration up to 0,01 μ s.

7. Method according to anyone of claims 1 to 6, wherein the substance is or comprises graphite or metals or carbides, sulfides, oxides and/or nitrides of graphite or of metals.

8. Method according to anyone of the preceding claims, wherein the efflux of the reactor is fed to an ultrasonic reactor.

9. Method according to claim 8, wherein the ultrasonic reactor is a spherical reactor comprising ultrasonic generators arranged such that the ultrasonic waves are focused in the centre of the reactor.

10. Method according to claim 8 or 9, wherein the ultrasonic treatment is performed at a static pressure ranging

between 0,1 - 5,0 MPa or at a variable pressure.

11. Method according to anyone of claims 8 to 10, wherein the ultrasonic treatment is performed with a frequency ranging between 1 and 10^4 kHz.

12. Method according to anyone of claims 8 to 11, wherein the ultrasonic intensity ranges between 1 and 10^4 MW/m².

13. Method according to anyone of claims 1 to 12 wherein the reactor is a reactor according to anyone of claims 14 to 24.

14. Reactor for cracking hydrocarbons having an inlet and an outlet and comprising a source of deuterium or a deuterium compound as well as means for applying electric current pulses to said source, whereby said source is formed by a substance which is adapted to release deuterium or a deuterium compound in the heated state when applying electric current pulses by said means for applying electric pulses.

15. Reactor according to claim 14, wherein said substance is or comprises graphite or metals or carbide, sulfide, oxide and/or nitride of graphite or of metals.

16. Reactor according to claims 14 or 15, wherein said substance is electroconductive and that the reactor further comprises an electrode which is arranged relative to the surface of said substance such that an arc may be established between the electrode and the surface of said substance.

17. Reactors according to claim 16, wherein the reactor further comprises a means adapted for changing the distance between the electrodes at the surface of said substance.

18. Reactor according to claim 17, wherein the reactor further comprises a solenoid which is adapted to remove the electrode from the surface of said substance if current is applied thereto and that the reactor further comprises a spring which exerts a force directed in the opposite direction and which is adapted to press the electrode to the surface of said substance if no current flows in the solenoid.

19. Reactor according to claim 18, wherein the reactor further comprises means for changing the tension of the spring.

20. Reactor according to anyone of claims 14 to 19, wherein the reactor comprises a cylindrical corpus.

21. Reactor according to claim 20, wherein the longitudinal axes from the inlet and from the outlet are arranged perpendicularly to the longitudinal axis of the corpus.

22. Reactor according to claims anyone of claims 14 to 21, wherein said substance is arranged in an end portion of the reactor.

23. Reactor according to anyone of claims 14 to 22, wherein the surface of said substance is arranged essentially in the same plane as one of the walls of the inlet and/or outlet of the reactor.

24. Reactor according to anyone of claims 20 to 23, wherein the cylindrical corpus of the reactor is closed at both end portions with flanges, which flanges are provided with electrical contacts.

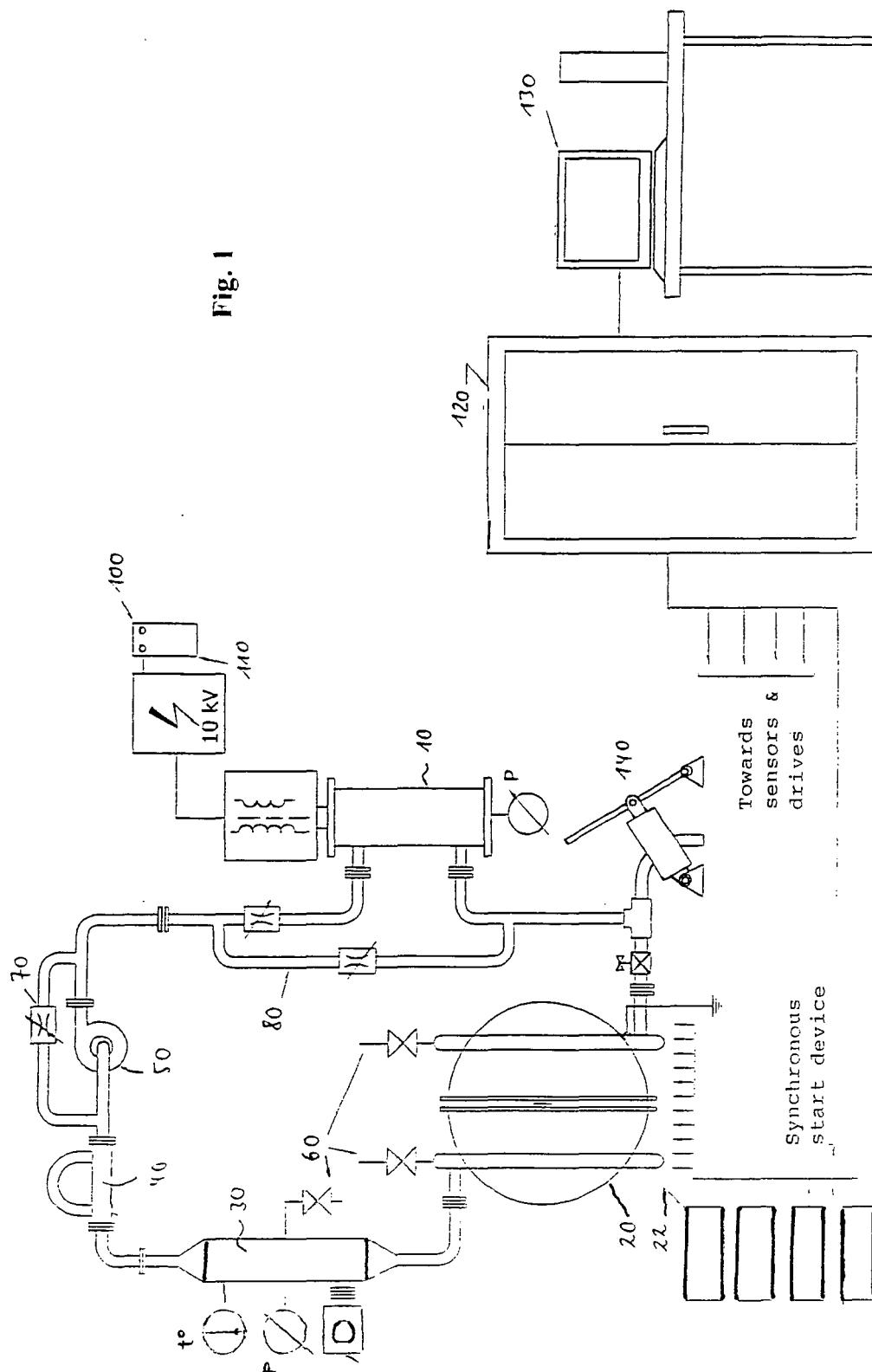


Fig. 1

Fig. 2

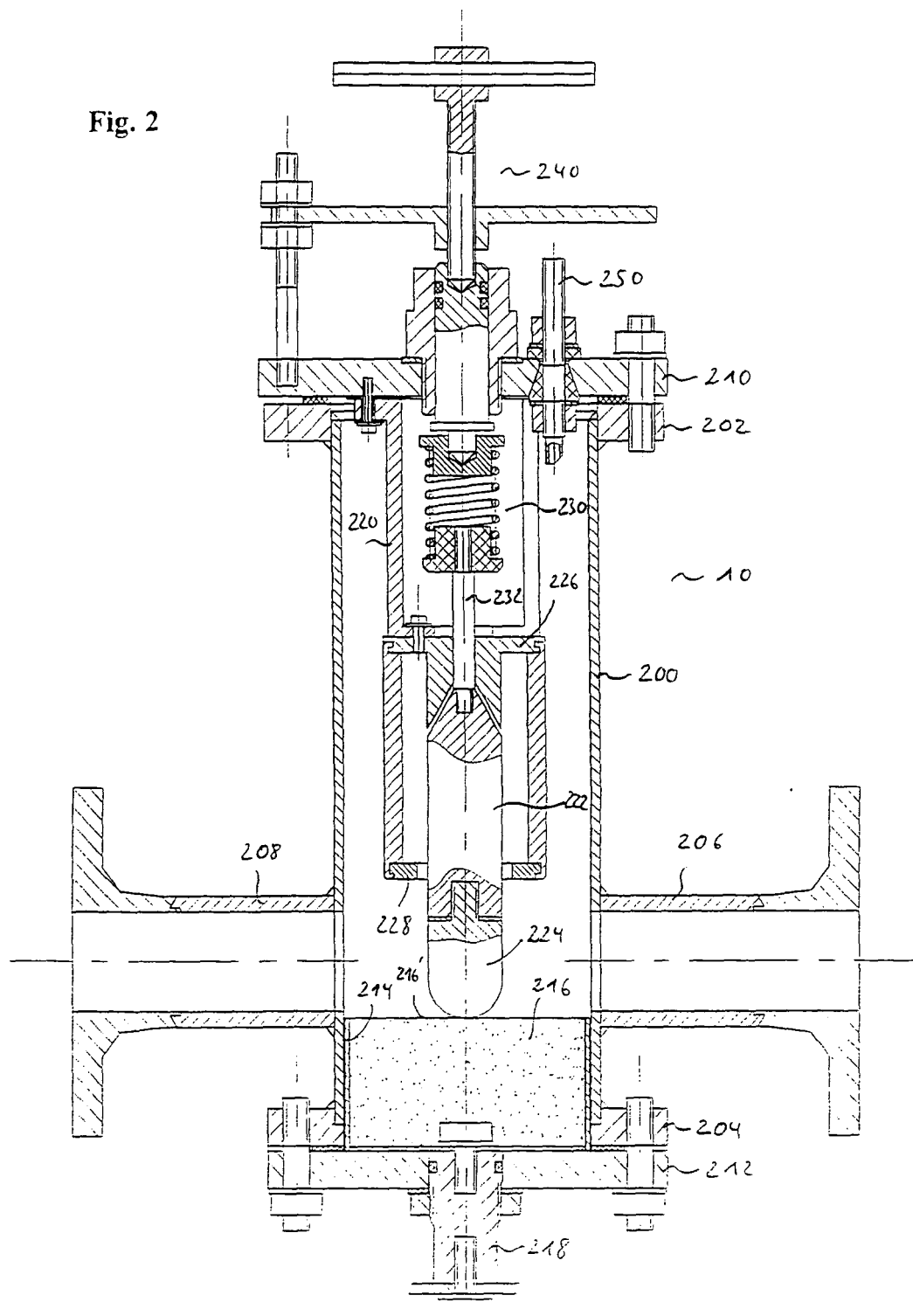


Fig. 3

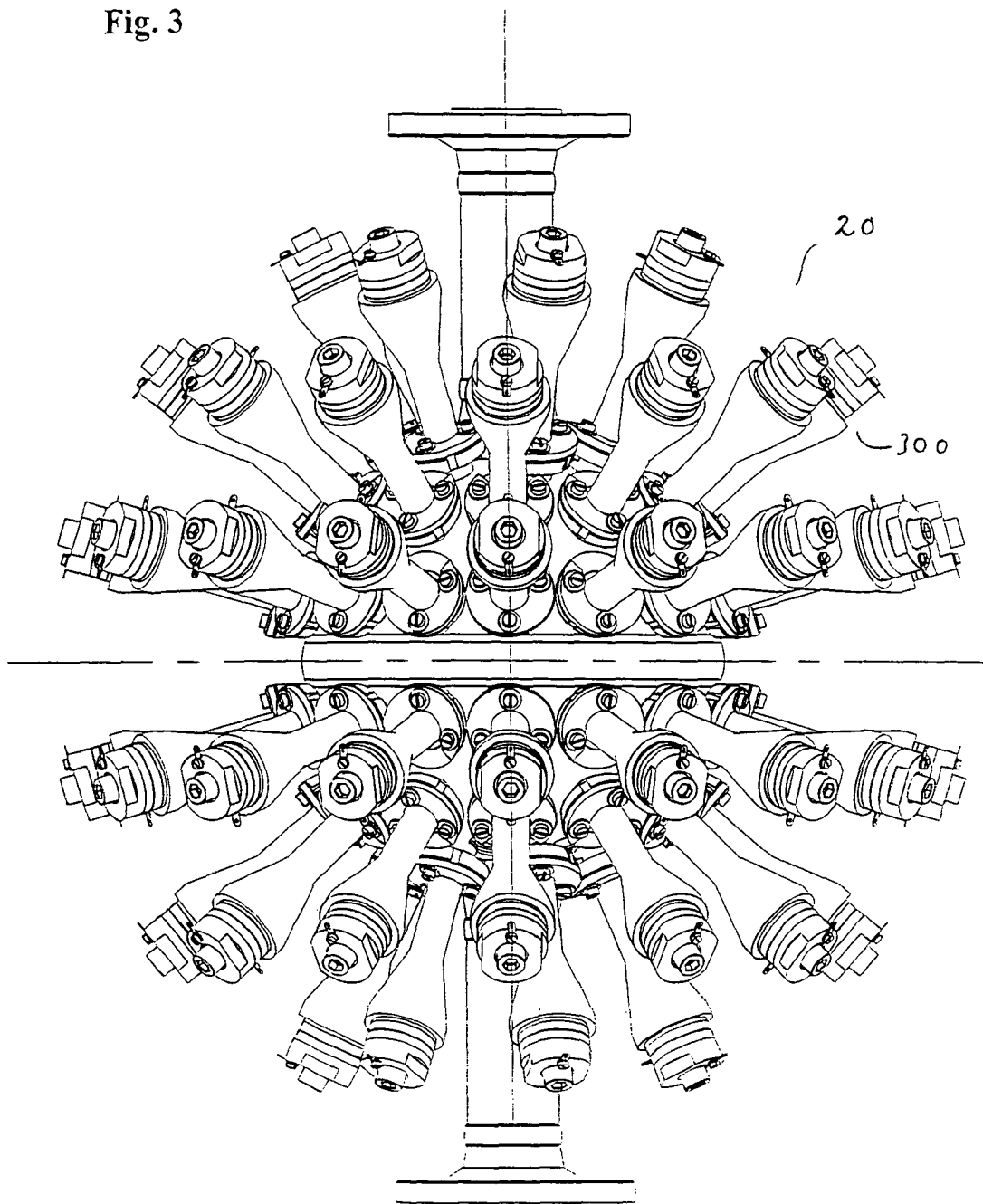
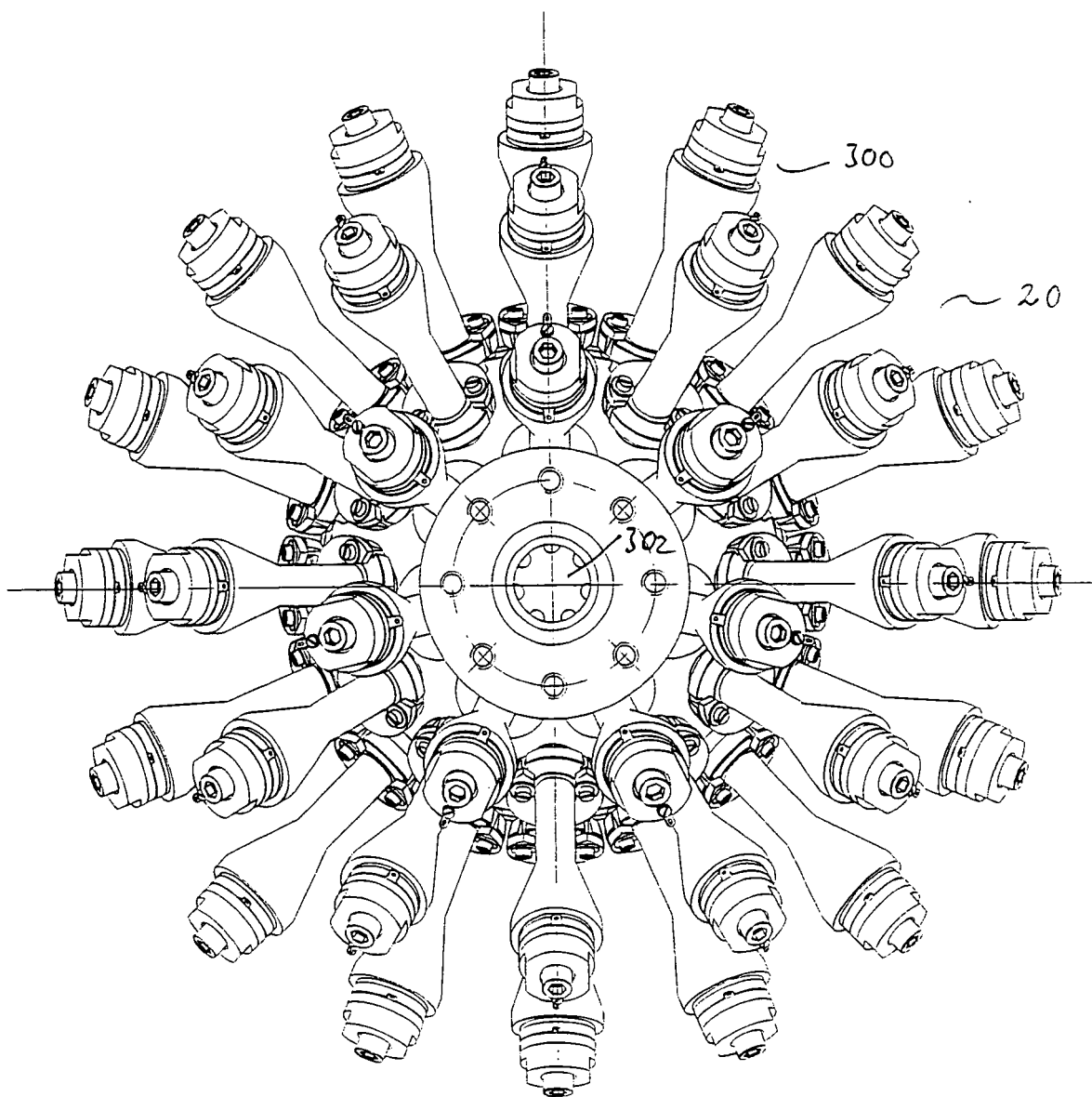


Fig. 4



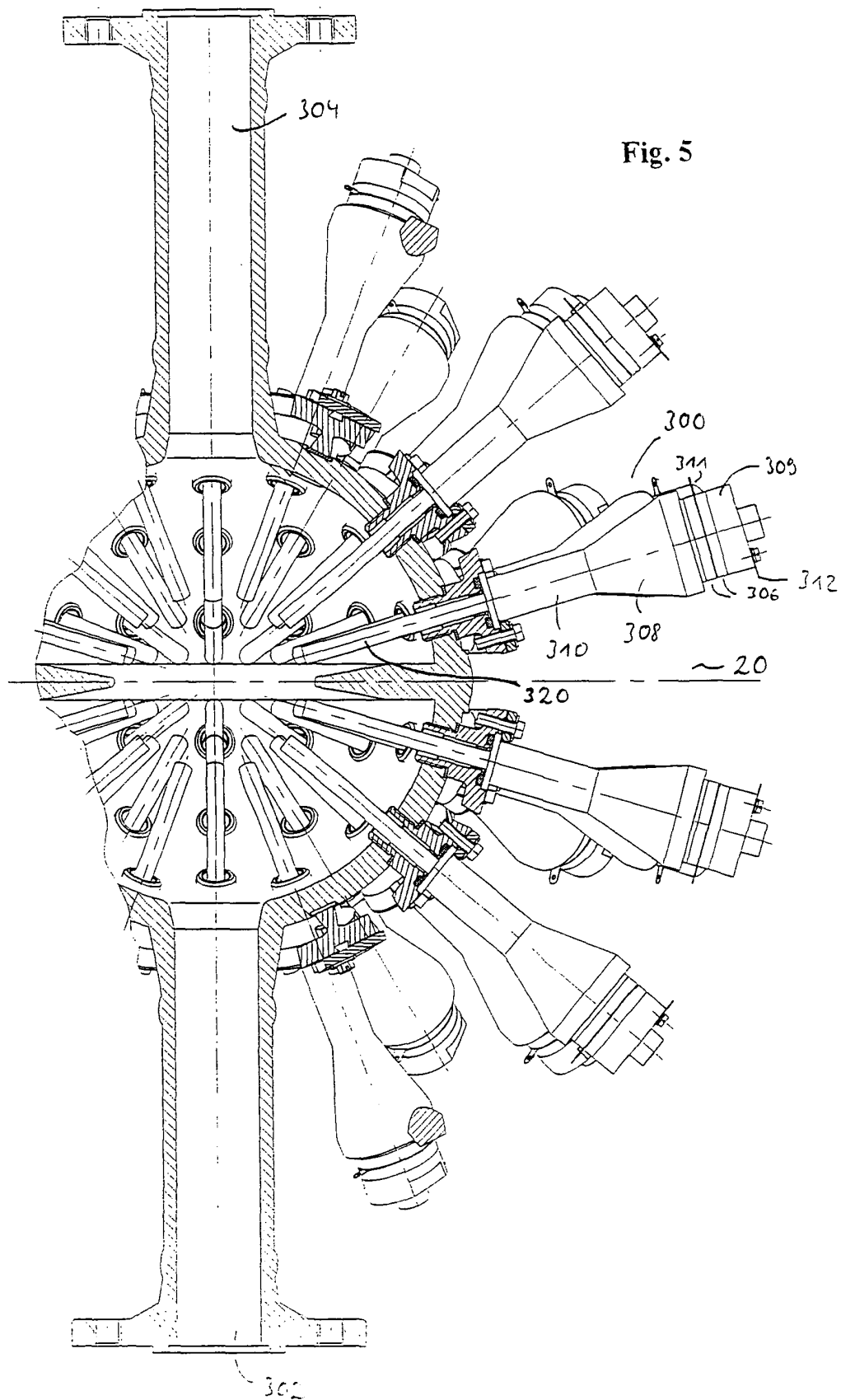


Fig. 6

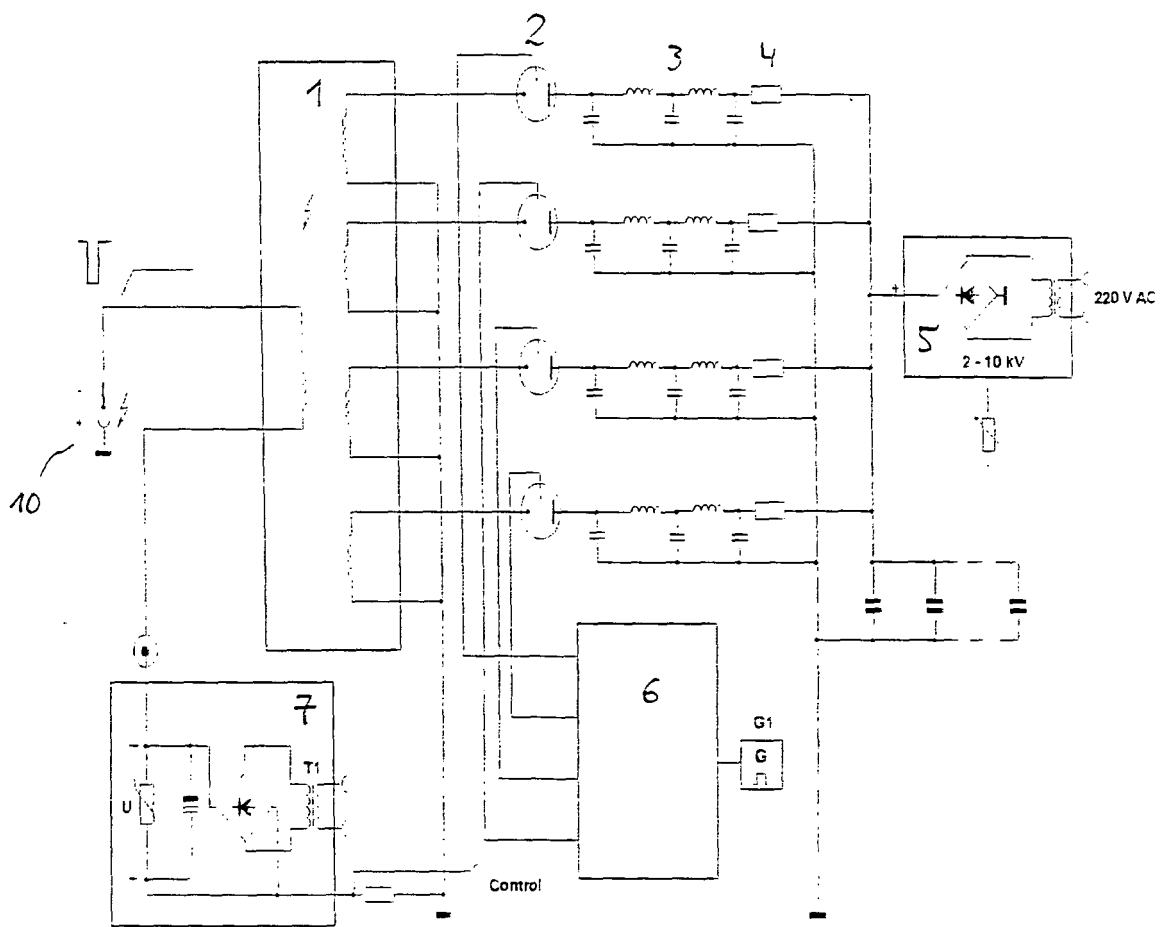
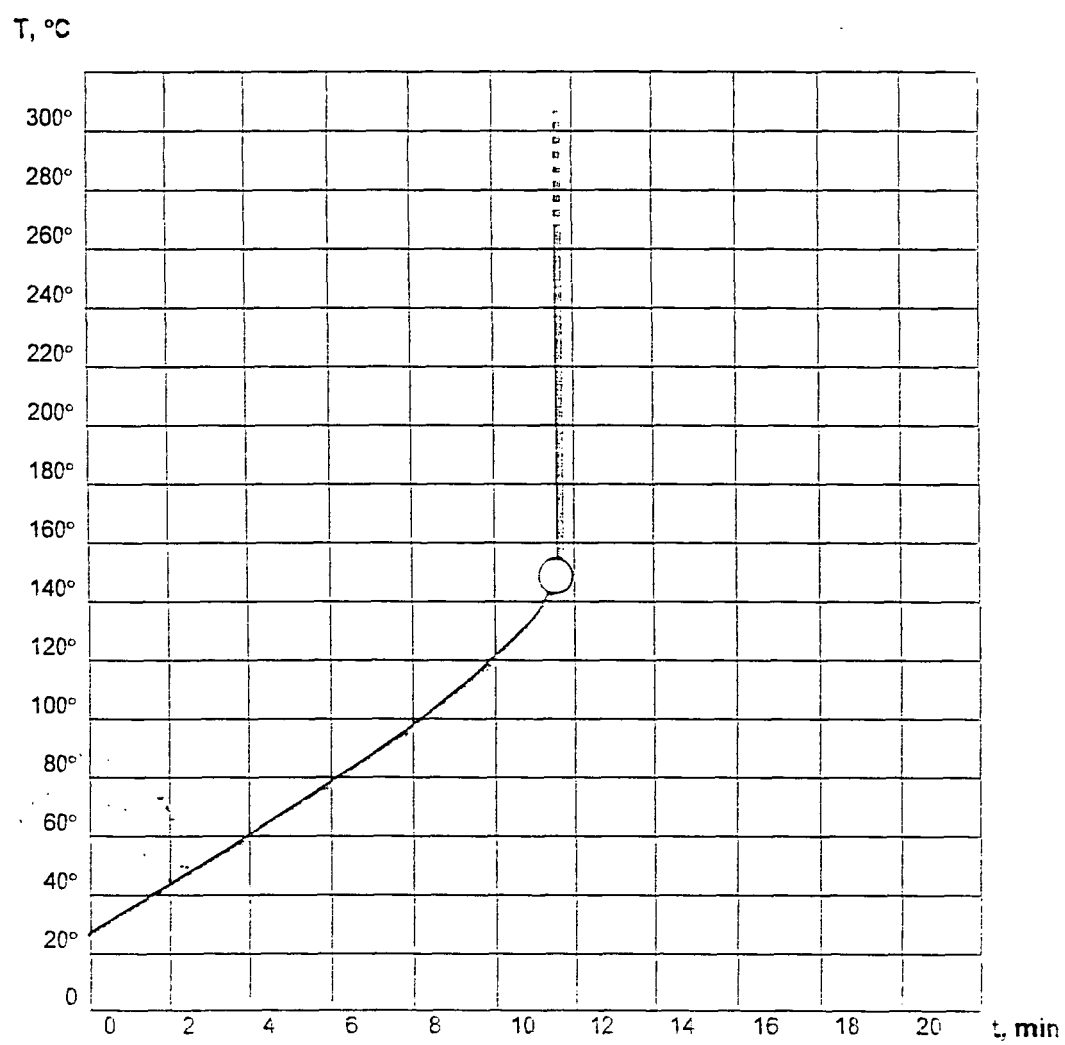


Fig. 7





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 02 0893

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.7)
X	US 2 914 452 A (SCHUTZE HENRY G ET AL) 24 November 1959 (1959-11-24) * the whole document *	1,15	C10G15/08 C10G15/10 B01J19/10
X	WO 03/033129 A (PRIBYSHYN, VICTOR IVANOVICH) 24 April 2003 (2003-04-24) * the whole document *	26-30	
A	US 2 743 223 A (MCCLINTON LESLIE T ET AL) 24 April 1956 (1956-04-24) * the whole document *	1-25	
A	US 2 958 637 A (VOORHEES VANDERVEER) 1 November 1960 (1960-11-01) * the whole document *	1-25	
A	US 3 228 848 A (FELLOWS ALBERT T) 11 January 1966 (1966-01-11) * the whole document *	1-25	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			C10G B01J
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 27 April 2005	Examiner Cagnoli, M
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			

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EPO FORM 1503 03/02 (P04C01)

**CLAIMS INCURRING FEES**

The present European patent application comprised at the time of filing more than ten claims.

- ☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- ☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- ☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:



The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-25

Independent claim 1 is directed towards a method for cracking hydrocarbons by providing, within a reactor, the hydrocarbon educt with deuterium, with a deuterium compound or with the disintegration products thereof.

Dependent claims 2 to 14 are directed towards further embodiments of the said method.

Independent claim 15 is directed to a reactor which is adapted to release deuterium, deuterium compound or the disintegration products thereof.

Dependent claims 16 to 25 are only directed to further embodiments of the said reactor.

2. claims: 26-30

Independent claim 26 is directed towards an ultrasonic reactor having a spherical reactor wall having at least two ultrasonic generators at opposite portions of the reactor.

Dependent claims 27 to 30 are only directed towards further embodiments of the same ultrasonic reactor.

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 04 02 0893

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

27-04-2005

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