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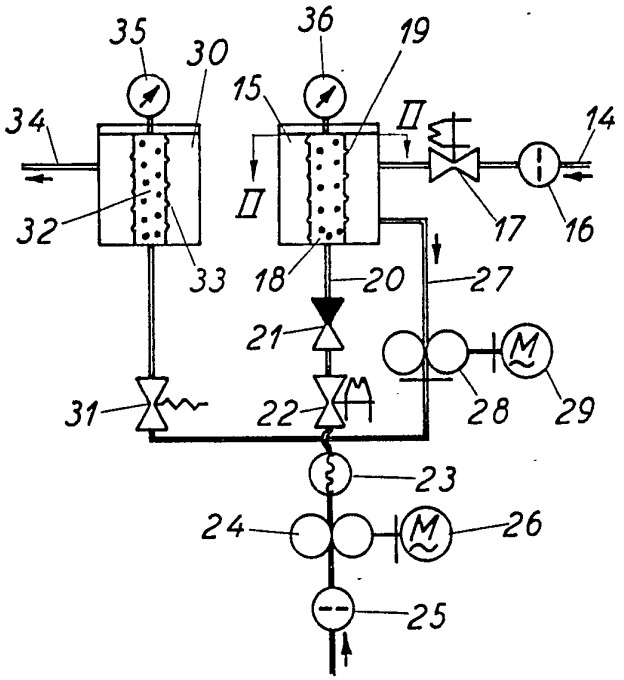
With international search report

In English translation (filed in Danish)

(54) Title: METHOD AND APPARATUS FOR THE PRODUCTION OF AN EMULSION OF WATER IN OIL

(57) Abstract

Method and apparatus for the production of an emulsion of water in oil whereby the production takes place in two stages: a first stage where water is pressed through nozzles (19) into an oil stream, and a second stage where the emulsion produced in the first stages is pressed through another set of nozzles (33).



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METHOD AND APPARATUS FOR THE PRODUCTION OF AN EMULSION OF WATER IN OIL

The invention relates to a method for the production of an emulsion of water in oil whereby water is sprayed into the oil through one or several nozzles.

It has gradually become generally known and recognized that an admixture of water in fuel oil gives an improved combustion of the oil and a heavy reduction in the emission of oil coke (also called cenospheres , carbon(coke)-particles, etc.). The predominant theory concerning the effect of the water is that this effect is physical as there is relative agreement that the small water drops in the oil drops make the oil drops burst (secondary atomization) when these are heated in the combustion chamber to a temperature above that of the boiling point of water.

The problem of obtaining a clean combustion by fuel oil firing is that the biggest oil drops, resulting from the atomization of the oil, will not have sufficient time for a complete burning, i.e. the time they stay in the combustion chamber is too short, and they will therefore be extinguished and form coke particles, normally called oil coke.

For many years it has been tried by means of all kinds of atomizing principles to obtain smaller oil drops, but without much success, and is is difficult to avoid drops of 200-500 µm (0.2-0.5 mm), especially if the plant is some years old, or if the oil has a high viscosity. Drops of this size are normally too big in relation to the time of stay available in modern boilers, and many of the drops will therefore leave the boiler plant as oil coke (emission).

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The easiest method available today for obtaining sufficiently small oil drops with low quality oil burners or/and low quality oil of high viscosity, is apparently the secondary atomization of the drops in the combustion chamber by the admixture of water. This is now generally recognized, but after the surprise at the extraordinarily heavy effect of the water has fallen off there is an awakening interest for the economy in the admixture of water in relation to the effect.

At the beginning 20-30% of water was normally used, but as it costs 1% extra oil per 12% of water in the oil there is an increasing interest in reducing the amount of water while maintaining the heavy reduction in the amount of oil coke. This can happen only if it is possible to obtain the right size and size distribution of the water drops in the oil (and later in the oil drops). The water drops may both be too big, which is a generally recognized problem, and the problem which all experiments try to solve, and too small, which is a new but very important realization.

Today it is assumed that water drops of a size of 2-5 µm have the right size as it is likely that several drops of this size will be able to make oil drops of 200-500 µm burst, taking into account the fact that the steam volume for water is 1700 times larger than the liquid volume. If drops of the size 2-5 µm are sufficient to make the oil drops burst this means that all water drops bigger than that result in a waste of water. Here it is worth considering that one 50 µm drop may give 1000 drops of a size of 5 µm.

On the other hand, it is something new today that the water drops may also become too small. Ever since firing with water/oil emulsions was started, everything has been

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done to make the drops as small as possible in order to avoid the above-mentioned waste of water. Supersonic waves, high pressure homogenizing, etc. have been used, and there have been no hesitations with regard to making the water drops too small. However, they may become too small, so small ($\leq$ 1-2 µm) that their steam volume by vaporization is not big enough to make the oil drops of 200-500 um burst. The water content of these water drops will consequently be wasted.

From the above-mentioned it can be concluded that if a really large reduction of the amount of oil coke is wanted with a minimum amount of water, it is necessary to have an even distribution of water drops, which shall moreover be of the right size and size distribution.

A method of the said type is known where at a first stage water and oil are atomized against each other by means of nozzles turning in opposite directions, and after that at a second stage a mechanical processing of the thus resulting emulsion is made by leading it through a cavity pump.

The purpose of the present invention is to show a simplified method which gives an optimal effect with reference to the above-mentioned.

This object is achieved by a method which according to the invention is special in that at least two stages are used, i.e.

1) one stage where the water is atomized into the oil through a nozzle or a set of nozzles, and

2) one stage where the emulsion from the first stage is homogenized by means of a nozzle or nozzles

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According to the invention the differential pressure above the nozzle or nozzles may be at least 3 bars, and this is very expedient, because the nozzles are generally designed to work by pressures which are not less than 5 bars.

One embodiment of the method is special in that there is a third stage, where the dispersing of the water into the oil is further improved and maintained by means of a pump with dispersing effect, for example a centrifugal pump. By such a method a buffer effect can be obtained, i.e. a reservoir can be built up for the produced emulsion and the quality of the emulsion can be maintained in this reservoir.

The invention also relates to an apparatus for using the method, and this apparatus is special in that it has a first and a second closed nozzle house with nozzles that open into the houses, and in that it is thus designed that there are means to carry the oil through the first nozzle house, means to press the water through the nozzle or nozzles in this house, and means to carry the mixture of oil and water flowing out from the first nozzle house under pressure to the pressure side of the nozzle or nozzles in the second nozzle house.

Hereby a very simple construction is provided.

The apparatus may furthermore be characteristic in that the outlet from the second nozzle house opens into the top of the house. Hereby it is ensured that the house is always filled with emulsion thus ensuring a homogeneous emulsion, since the outflow from the nozzles in the second nozzle house always leads to a room filled with liquid.

A preferred embodiment of the apparatus is characteristic in that the first nozzle house is cylindrically designed

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with a centrally placed pipe in which a number of nozzles are mounted mainly with a radial direction of outflow, as the pipe serves as an inlet for water, and in that the inlet for oil in the room between the outlet of the nozzles and the wall of the cylindrical nozzle house has a tangential component. This embodiment is extremely simple in construction.

The invention will be further described in the following with reference to the accompanying drawing where

fig. 1 illustrates the method according to the invention with reference to a principal construction of an apparatus according to the invention, which functions together with an oil burner,

fig. 2 shows 3 curves with reference to a table that illustrates the connection between the carbon reduction and the added water, calculated in per cent, and showing 3 different water admixtures, compare the table below,

fig. 3 shows an embodiment of an apparatus according to the invention in schematic form, and

fig. 4 shows a sectional view of the first nozzle house, line II-II, on an enlarged scale.

In fig. 1 a pipe 1 is shown, through which the fuel oil is carried to a first emulsification chamber 2. Water enters through a pipe 3 and through an atomizing nozzle 4. In practice a larger number of nozzles is used. In the emulsification chamber 2, at stage 1, the first emulsification of water into the oil takes place, and the emulsion thus

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resulting will be sufficiently good to give a large reduction of oil coke emission, since relatively large amounts of water are used. If a heavy reduction with a small amount of water is wanted, then it will be necessary to continue with stage 2. In stage 2 the emulsion is carried through a tube 5 from the first emulsification chamber into a pump 6 and from there to another emulsification chamber through a pipe 7 and an atomizing nozzle 8. In practice, also here a larger number of nozzles is used. In the second atomizing chamber there will be a better distribution of water in the oil, and the size of the water drops will become optimal. After the second stage the emulsion is so effective that a heavy reduction in the amount of oil coke is obtained with an amount of water as low as 4-6%. The emulsion will now be suitable and can be used direct through a pipe 9, but if further improvement is wanted, and if it is wanted to maintain the emulsion it is possible to continue through stage 3, as shown in fig. 1.

A pipe 10 then carries the emulsion from the second stage to a reservoir from where a centrifugal pump takes the emulsion and sends it round to the oil burners in a ring system and back again to the reservoir. At this third stage there will be some improvement of the emulsion, but the most important thing is that the emulsion will all the time be maintained, and it is very rational that this takes place with the same pump as the one circulating oil to the oil burners.

The effect of emulsifying water into oil is always so that by the correct emulsification and a little water, or by a less correct emulsification and more water a weighted emission of particles can be obtained, only slightly higher than that corresponding to the ash content in the oil.

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Usually it is not carried as far as that, as it is normally not necessary to remove 100% of the carbon. On the other hand, it is a question of obtaining the optimal reduction with the minimum amount of water, and here the emulsification method is of great importance which we shall see from the experiments described in the following.

EXAMPLE

Experiments with combustion of water/oil emulsions where the variables are the water per cent and the number of emulsification stages according to the above description.

The experiments were made with an oil fired boiler with the below specifications:

Type of oil burner: Danstoker (fire-tube boiler) 20 Gcal/h-

Oil burner: Saacke rotation oil burner.

Oil: Fuel oil with a viscosity of 1500 Redwood secs. at $100^{o}F$

Load: Full load during all tests.

The water per cent in the emulsion was fixed at 3%, 5% and 10% by changing the nozzle capacity at stage 1 (see fig. 1). The water per cent was determined for each experiment.

The carbon content in the flue gas was determined by means of the quartz wool filter method. According to this a certain amount of flue gas is sucked through a quartz wool filter. The filter is weighed before and after the sucking through of flue gas, and if the weight increase is then compared with the sucked through volume of flue gas, the particle emission concentration in mg/m^3 is obtained.

From the emission of particles it will then be possible to

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find the carbon emission either by determining the carbon content in the quartz wool or, on the basis of the known ash content in the oil by deducting the amount of particles on the quartz wool filters, corresponding to the ash content in the oil.

Both methods gave the same result in the experiments made.

In order to study the effect of the individual stages an experiment was made with an emulsion, taken out must after stage 1 (see fig. 1), and emulsion taken out just after stage 2, and an emulsion taken out from stage 3 which is a ring system.

The figures in the following table are all average figures from the three tests.

In all tests the fuel oil came from the same delivery and the analysis was as follows:

Type: Heavy fuel oil
Viscosity:
by 100°F: 1480 Redwood secs.
by 50°C: 172 cS
Density: 0.955 g/ml by 15°C
Carbon, C: 87.0%
Hydrogen, H: 10.7%
Nitrogen, N: 0.4%
Sulphur, S: 1.8%
Ash: 0.023%

During the experiments the load was constant (full load), calculated on the basis of combusted kg oil per hour (and thus not on kg emulsion per hour).

The excess air was automatically regulated and correspond-

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ed to 1.6% $O_2 \pm 0.2\%$ O_2.

The carbon emission with water/oil emulsion after:

Fuel	stage 1		stage 2		stage 3	
	g/kg oil	% red.	g/kg oil	% red.	g/kg oil	% red.
Fuel oil without water	2.32		2.32		2.32	
- + 3.1% w	1.65	71.1	1.94	83.6	2.02	87.0
- + 4.8% w	1.94	83.6	2.11	90.9	2.16	93.1
- + 10.3% w	2.15	92.7	2.26	97.4	2.28	98.3

From the table, and especially the diagram, it is seen that by sufficiently large amounts of water () 10%) a simple emulsification of water into the oil will be adequate, corresponding to stage 1, but if the same reduction in particle emission by smaller amounts of water - 3-5% water - is wanted, several stages must be used, and at least 2 stages.

If stage 3 should after all be used because of the supply to the oil burners from a rign system and in order to maintain the emulsion, it is definitely an improvement to use a third stage, as appears from the diagram.

Fig. 3 and 4 show an inlet pipe 14 for oil to a first nozzle house 15 of a cylindrical shape. The inlet is tangentially directed as appears from fig. 4. In the inlet pipe 14 a filter 16 and a magnet valve 17 are inserted. In the nozzle house 15 a central tube 18 is placed in which a number of nozzles 19 are inserted, which are connected with an inlet pipe 20 for water. In this pipe 20 a non-return valve 21, a solenois valve 22, a volume indicator 23, a pump 24 and a filter 25 are inserted. The pump 24 is driven by a motor 26.

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The nozzle house 15 is designed with an outlet pipe 27 which via a pumpe 28, driven by a motor 29,leads to another nozzle house 30 via a pressure control valve 31. The nozzle house 30 is fitted with a centrally placed pipe 32 with nozzles 33 in the same way as the first nozzle house 15, and the pipe 27 is connected to the inside of pipe 32. The nozzle house 30 has an outlet pipe 34. In the nozzle houses 15 and 30 there are moreover fitted manometers 25 and 26.

The apparatus now works in the following manner.

When water and oil are pressed into the first nozzle house as indicated, the oil will stream out of the nozzle or nozzles in atomized form and will at the same time be well distributed in the water stream brought in rotation around the central pipe. When the thus produced emulsion is then atomized in the other nozzle house, the emulsion will have a very fine quality.

EXAMPLE

A preferred embodiment of the invention operates with a differential pressure of 7 bars above both sets of nozzles in the first and second nozzle house respectively. In this way it is possible to operate with an 0-12% water content in the finished emulsion, preferably 5% water. Hereby a reduction in the content of solid matter in the flue gas of 2 - 3 mg per kg fired oil is obtained.

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C L A I M S

1. Method for the production of an emulsion of water in oil whereby water is sprayed into the oil through one or several nozzles, c h a r a c t e r i z e d i n that at least two stages are used, i.e.

1) one stage where the water is atomized into the oil through a nozzle or a set of nozzles, and

2) one stage where the emulsion from the first stage is homogenized by means of a nozzle or nozzles.

2. Method according to claim 1, c h a r a c t e r i z e d i n that the differential pressure above the nozzle or nozzles, that is between water and oil, in first stage is at least 3 bars.

3. Method according to claim 1 or 2, c h a r a c t e r i z e d i n that the differential pressure above the nozzle or nozzles in the second stage is at least 3 bars.

4. Method according to claim 1, 2 or 3, c h a r a c t e r i z e d i n that there is a third stage where the dispersing of water into the oil is further improved and maintained by means of a pump with a dispersing effect, for example a centrifugal pump.

5. Apparatus for using the method according to claim 1, 2 or 3, c h a r a c t e r i z e d i n that there is a first and a second closed nozzle house with nozzles that open into the houses, and in that there are means to carry the oil through the first nozzle house, and means to press the water through the nozzle or nozzles in this house, and means to carry the mixture of oil and water

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flowing out from the first nozzle house under pressure to the pressure side of the nozzle or nozzles in the second nozzle house.

6. Apparatus according to claim 5, c h a r a c t e r i z e d i n that the outlet from the second nozzle house opens into the top of the house.

7. Apparatus according to claim 5 or 6, c h a r a c t i z e d i n that the first nozzle house is cylindrically shaped with a centrally placed pipe in which a number of nozzles are mounted mainly with a radial direction of outflow, as the pipe serves as an inlet for water, and in that the inlet for oil in the room between the outlet of the nozzles and the wall of the cylindrical nozzle house has a tangential component.

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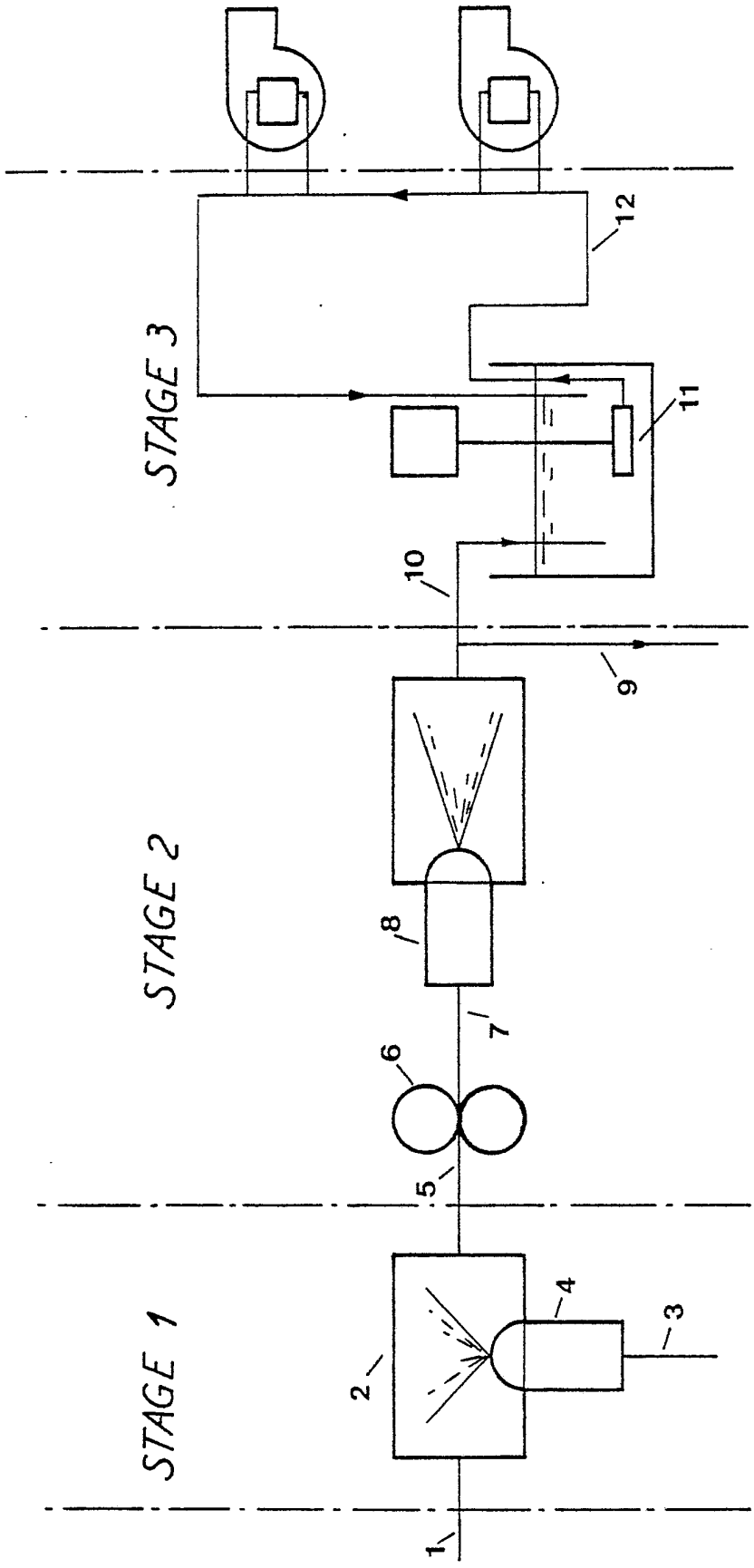


FIGURE 1

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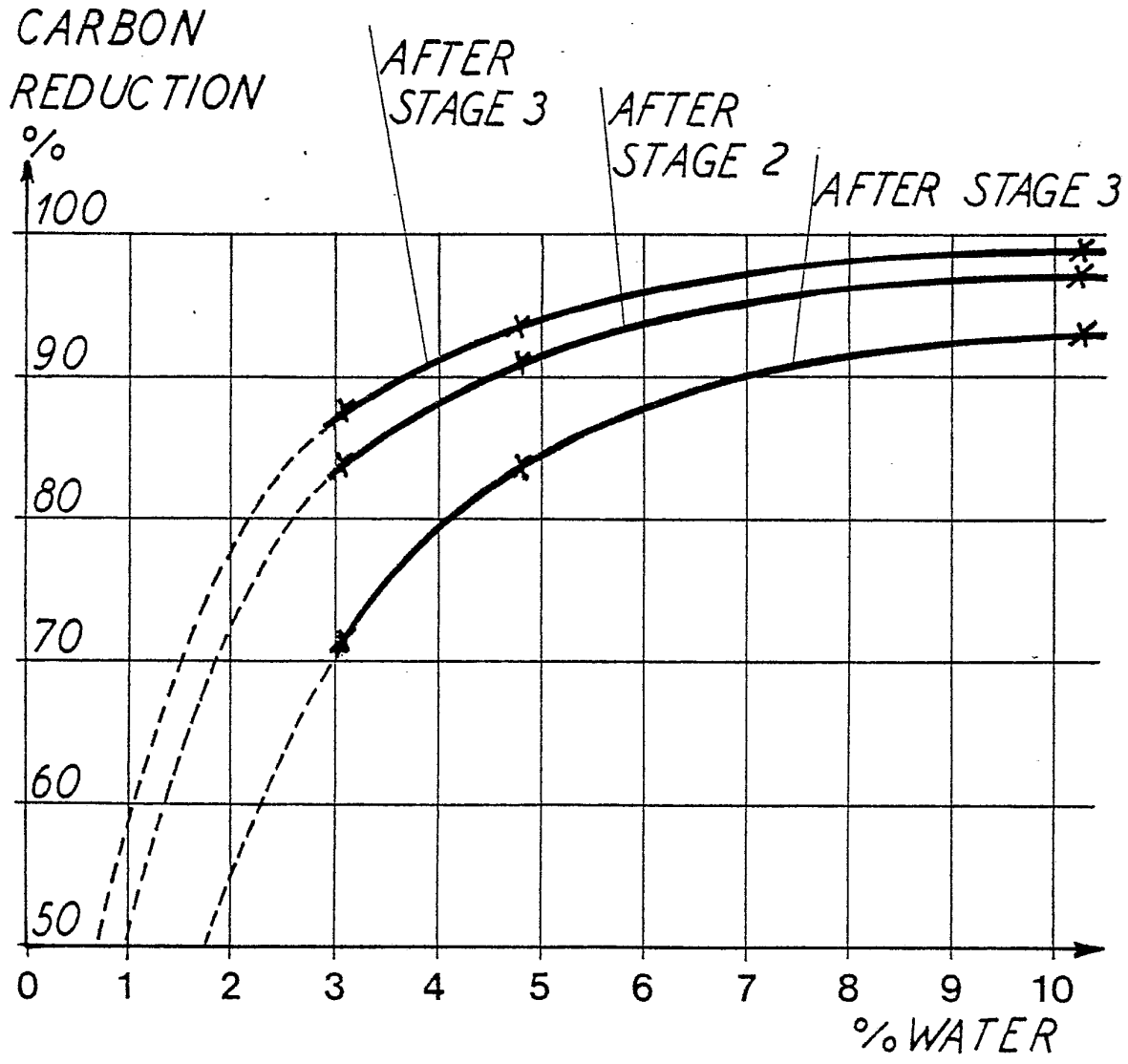


FIGURE 2

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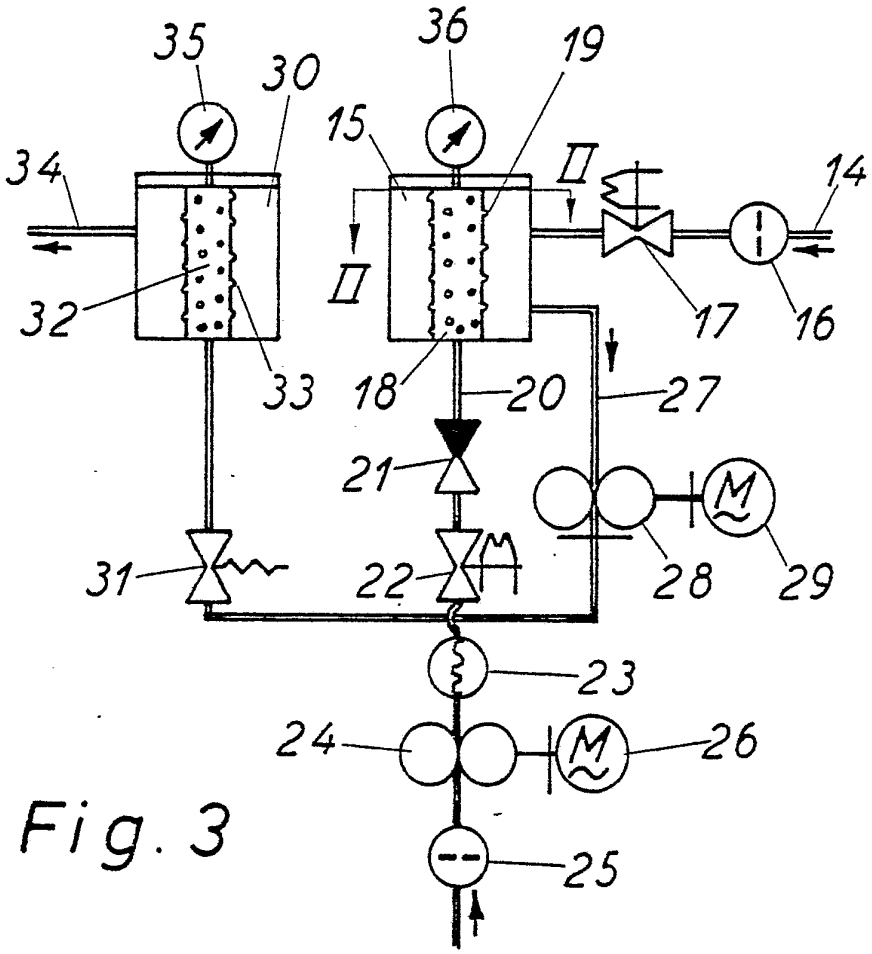


Fig. 3

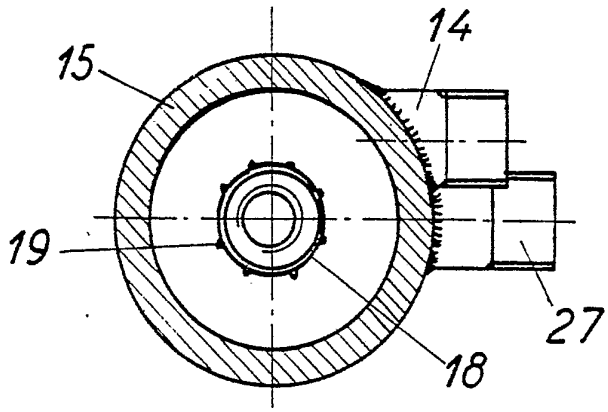


Fig. 4

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INTERNATIONAL SEARCH REPORT

International Application No PCT/DK80/00035

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC 3

B 01 F 3/08, 5/00, 5/08// C 10 L 1/32; F 23 D 11/16

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC 3	B 01 D 1/16; B 01 F 3/00, 3/08, 3/10, 3/22, 5/00-5/08, 5/18, 5/20; B 01 J 1/00, 14/00; C 10 L 1/32; F 23 D 11/16
National Cl	12e:4/50 .../...

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [5]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	DE, C, 614 701 published 1935, June 15, August Jacobi Akt.-Ges. in Darmstadt	1, 5
A	SE, A, 7809369-7 published 1979, March 8, Cleanodan AS	1, 4, 5

* Special categories of cited documents: [15]

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"P" document published prior to the international filing date but on or after the priority date claimed

"T" later document published on or after the international filing date or priority date and not in conflict with the application, but cited to understand the principle or theory underlying the invention

"X" document of particular relevance

IV. CERTIFICATION

Date of the Actual Completion of the International Search [3]	Date of Mailing of this International Search Report [3]
1980-09-11	1980 -09- 15
International Searching Authority [1]	Signature of Authorized Officer [20]
Swedish Patent Office	Wiva Asplund Wiva Asplund

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

II Fields Searched (cont.)

US Cl 137/3; 159/4, 48; 259/2, 11, 18, 60, 95

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This International search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers _____, because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers _____, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.