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B01F 3/08

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(58) Field of search
UK CL (Edition J) B1C CAC CPJA CPJB
INT CL[4] B01F

(54) **Producing water-in-oil emulsions**

(57) Apparatus for producing water-in-oil emulsions on demand, comprises water supply means, oil supply means and mixing means, characterised in that the mixing means comprises a chamber (32) through which the oil can be forced in a stream, the chamber being provided with water inlet means (31) to allow water to be mixed with the oil stream.

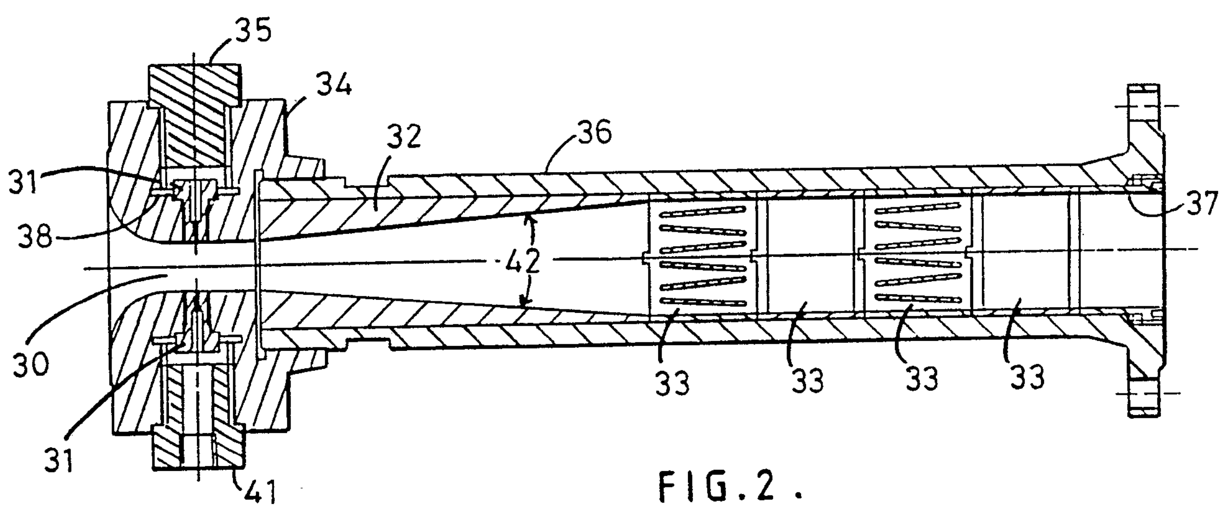

FIG.2.

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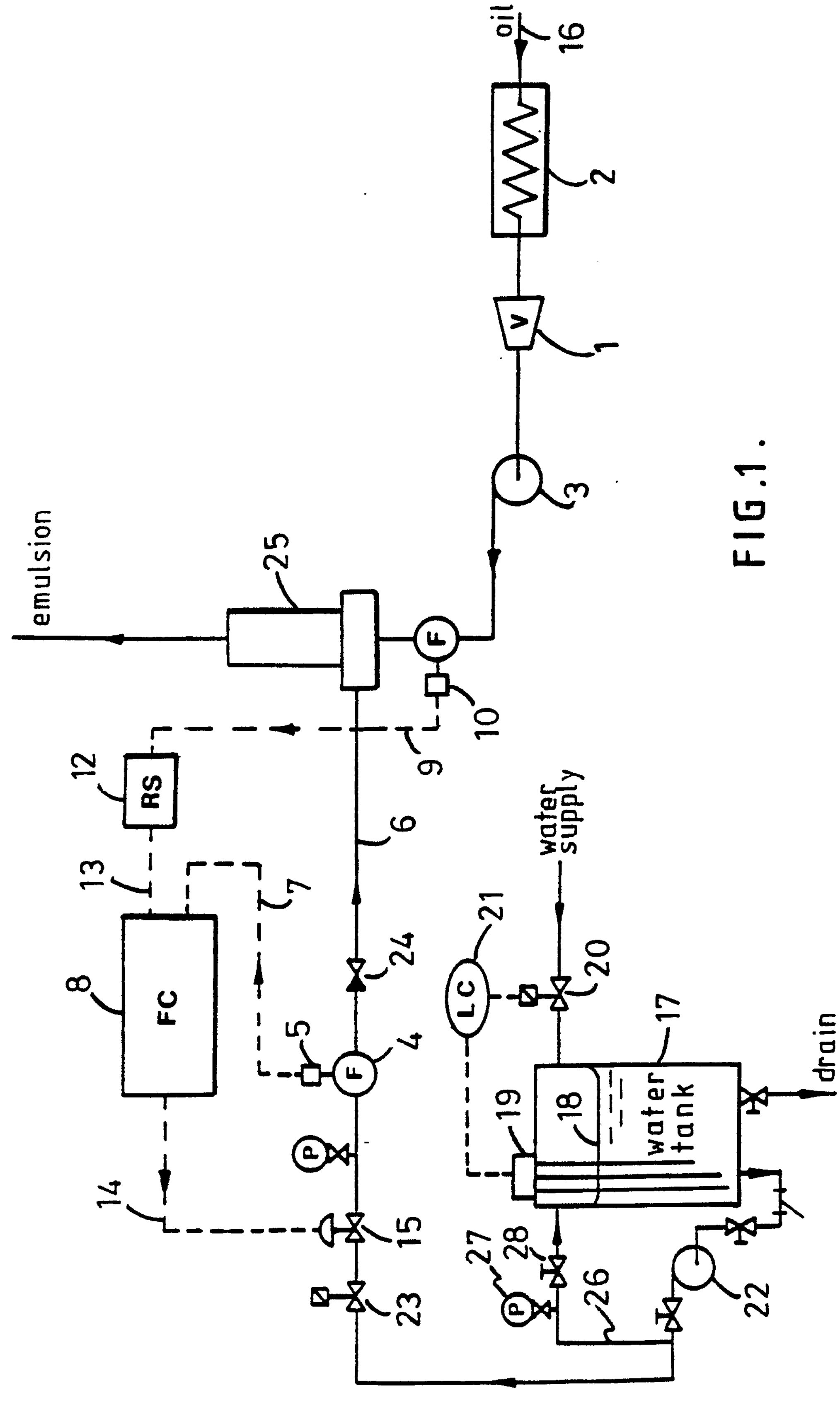
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy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2
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emulsion
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F
4
P
14
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water supply
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LC
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18
water tank
drain
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26
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FIG.1.

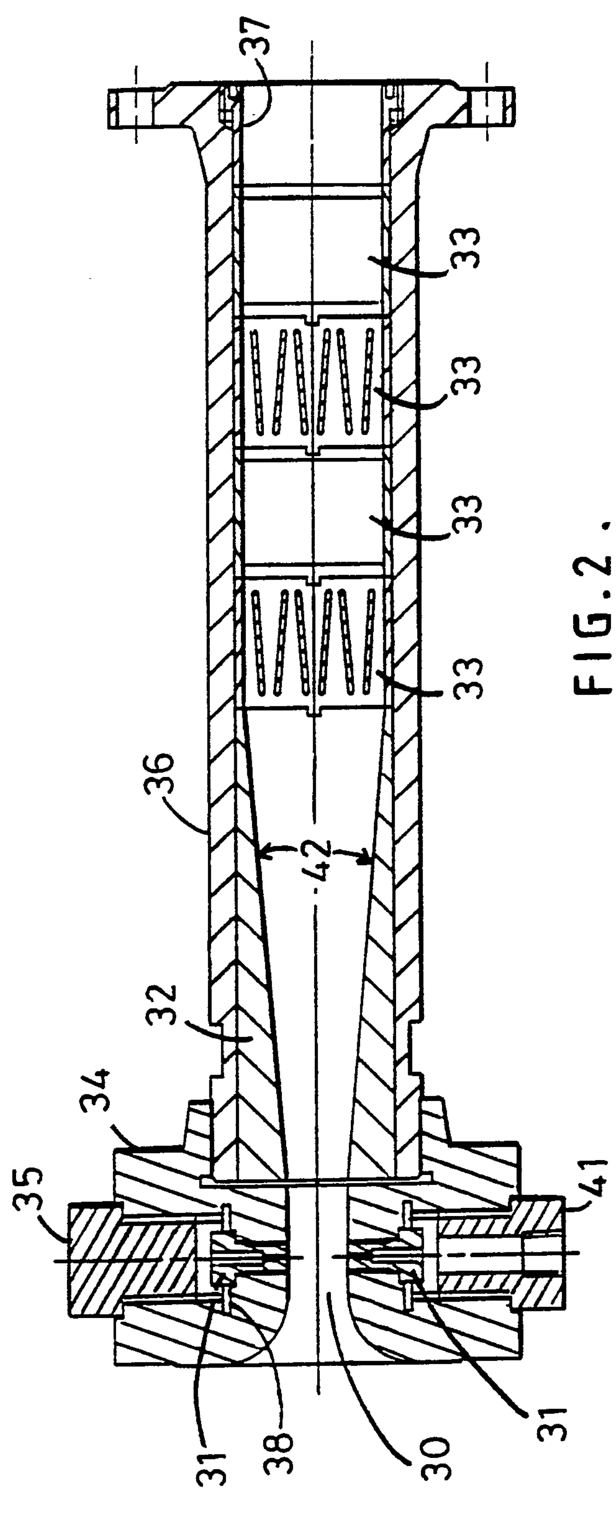

FIG.2.

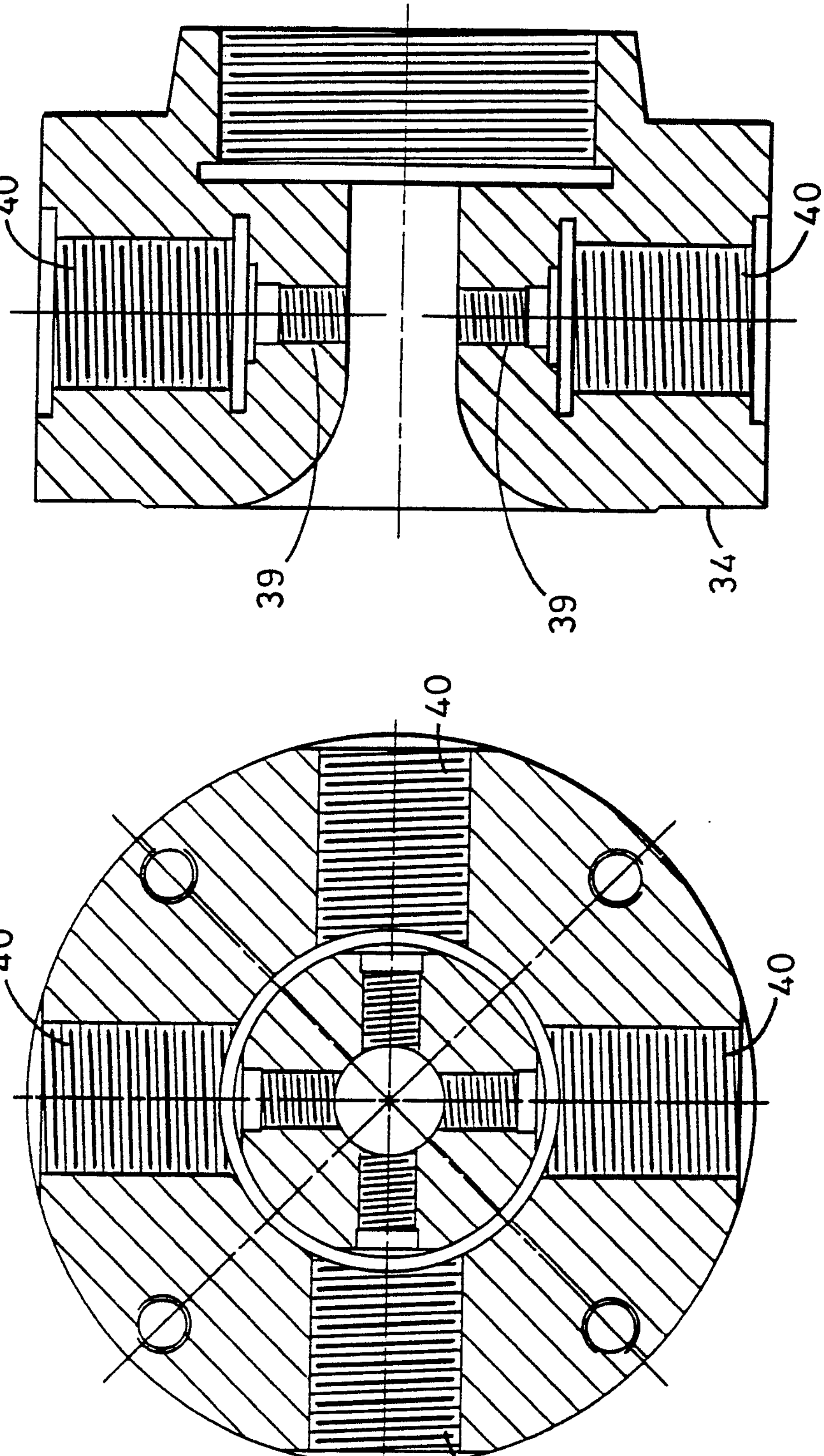

FIG.3.

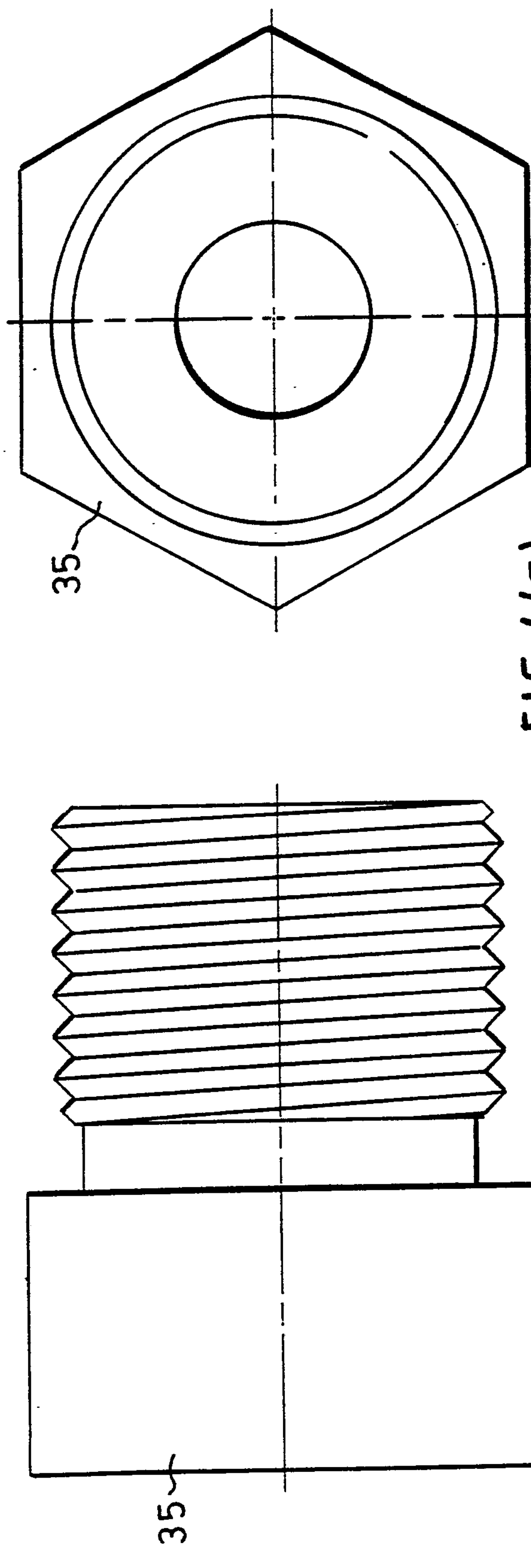

FIG 4(a)

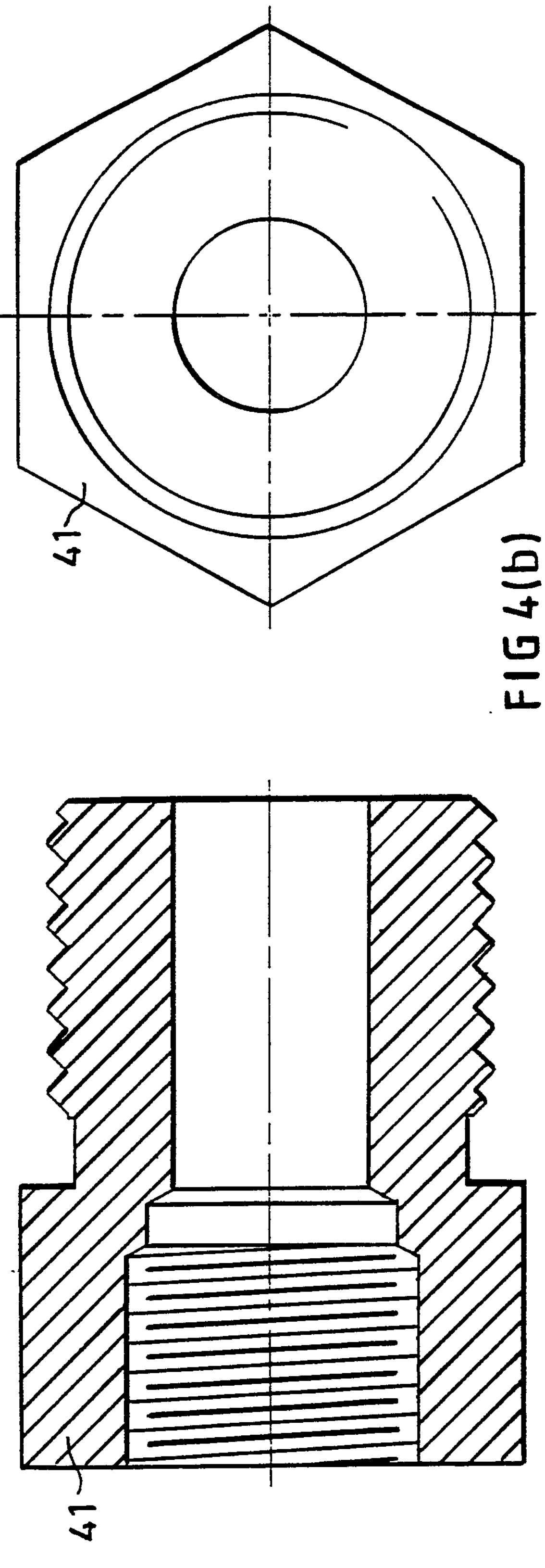

FIG 4(b)

FIG.5.

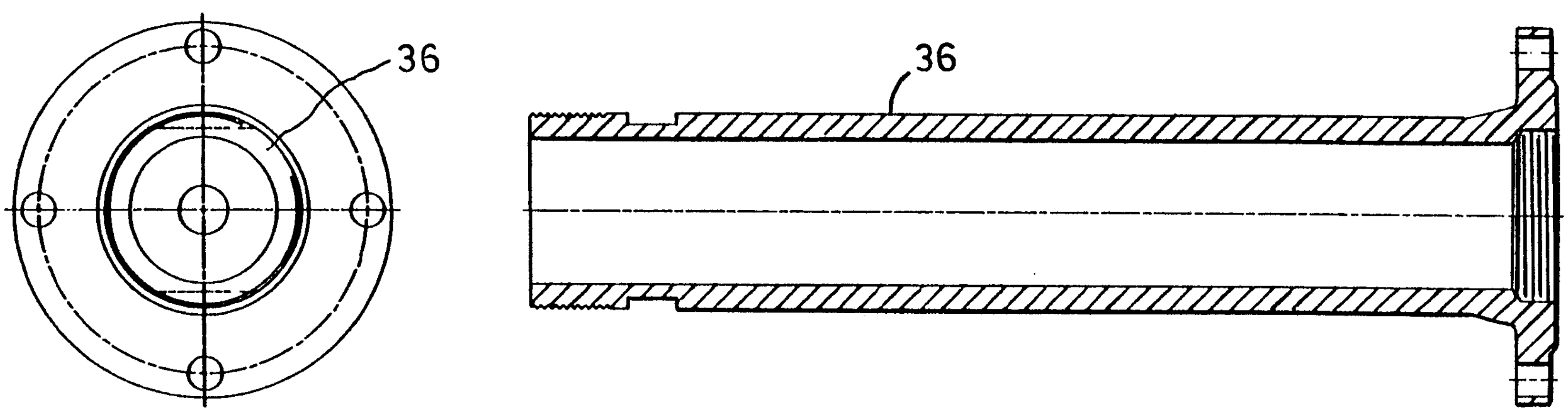

FIG.6.

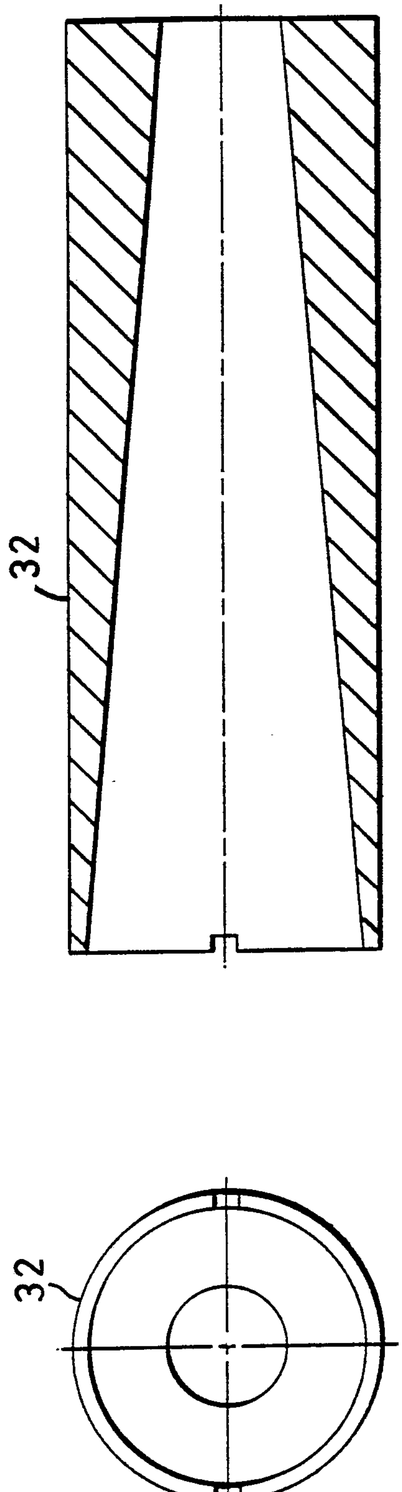

FIG.7.

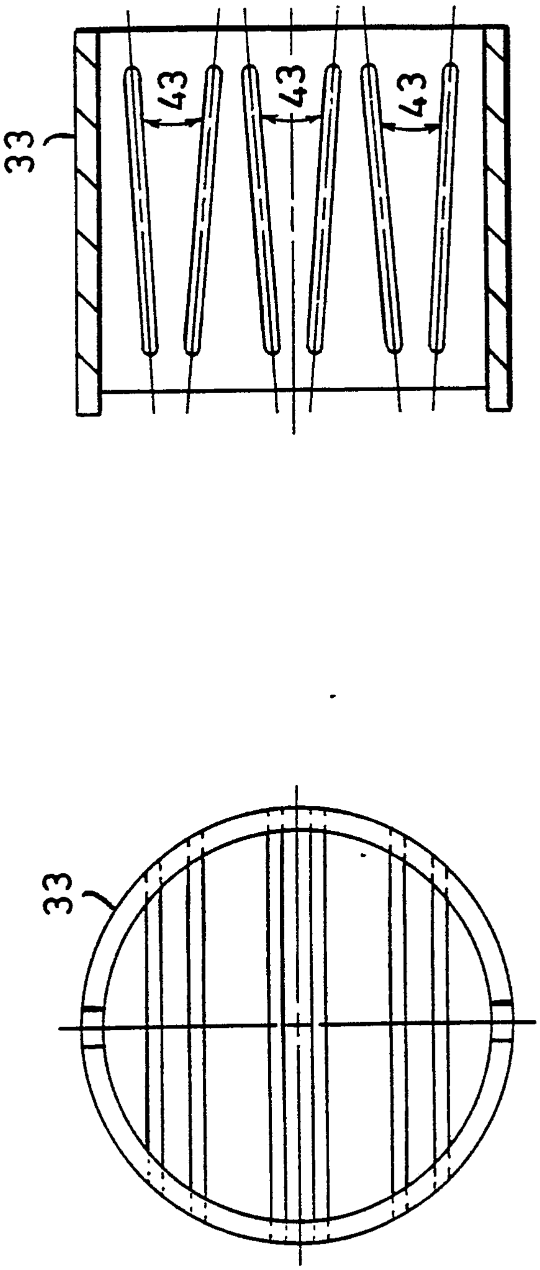

FIG 8

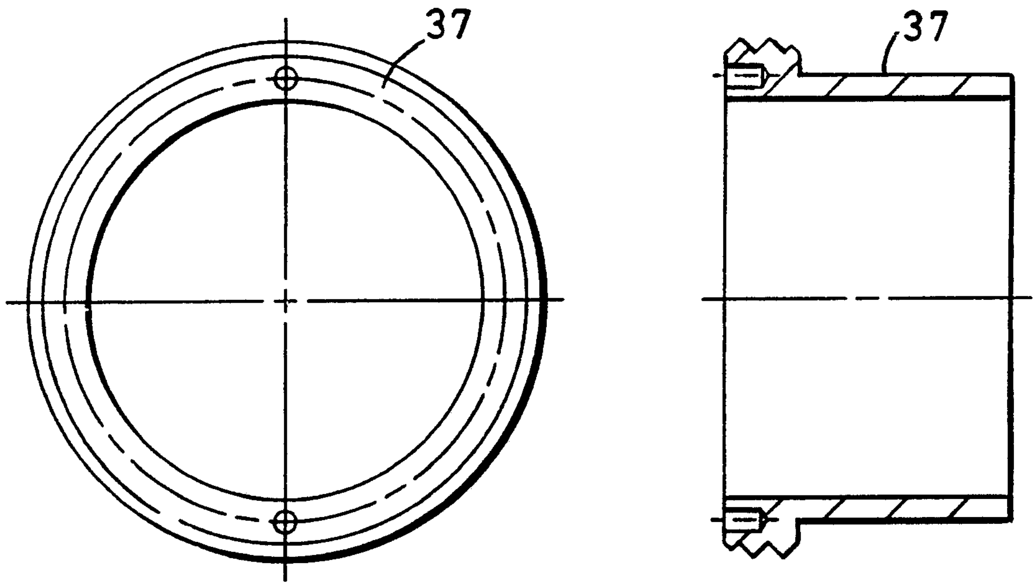

FIG.9.

M&C FOLIO: 230P59048 WANGDOC: 0192D

Method and Apparatus for Producing Water-in-Oil Emulsions

The present invention relates to processes for the production of water-in-oil emulsions, and apparatus therefor.

The benefits of burning water-in-oil emulsions are well known. Emulsions of water-in-fuel can be successfully burned in boiler and internal combustion engines. The established benefits of burning emulsions of water-in-oil include improved combustion efficiency leading to reduced fuel comsumption, reduced polluting emissions and reduced particulate emission. It has also been established that the optimum characteristics of water-in-oil emulsions for maximum benefits include a water content of 6 to 12 percent by volume and a uniform distribution of water particles of sizes between 2 and 10 µm.

Various methods and apparatus for producing such emulsions have been devised. These include ultrasonic, mechanical and centrifugal homogenising apparatus. In most methods and apparatus, surfactants and stabilising agents are required to produce a stable emulsion which can be stored in a reservoir for some period before use. Oil flowrate must be kept constant to allow water to be added at a fixed rate to achieve the required percentage content of water, in the absence of a proper water flow controller. Accordingly, a reservoir is needed as a buffer, because the consumption rate of the boiler or internal combustion engine is generally different from the constant oil supply rate.

The present invention provides a method of producing emulsions as, and at the rate, required. No storage is necessary, which thereby eliminates the need for storage space and the problems associated with emulsion storage, such as the separation of water from oil, and corrosion associated with bacteria. The invention also provides apparatus with no moving parts and which, therefore, consumes little energy and requires little or no maintenance after installation.

In a first aspect, the present invention provides apparatus for producing water-in-oil emulsions comprising water supply means, oil supply means and mixing means, characterised in that the mixing means comprises a chamber through which the oil can be forced in a stream, the chamber being provided with water inlet means to allow water to be mixed with the oil stream.

The present invention also provides a method for producing water-in-oil emulsions comprising injecting water into a stream of oil while maintaining the relative flowrates.

In an alternative aspect, the invention provides a method and apparatus for producing an emulsion of evenly distributed particles of water-in-oil whereby water is injected into a jet of oil through one or more nozzles and the amount of water injected is controlled by a flow controller which adjusts a water flow control valve which in turn regulates the water flowrate so as to maintain the set ratio of water flowrate to oil flowrate.

Thus, the invention provides a method for producing an emulsion of evenly distributed particles of water-in-oil, whereby the amount of water injected is controlled by a feedback mechanism;

apparatus for use with such method which has no mechanically moving parts;
apparatus for producing an emulsion of water-in-oil instantaneously at the rate at which the emulsion produced needs to be used;
apparatus for producing an emulsion of water-in-oil which, through a water control system, ensures that the correct amount of water is injected even with constantly varying oil flowrate over a wide range;
apparatus for producing emulsions with fine and evenly distributed particles of water-in-oil of size of 2-10 µm diameter with set water content of between 6 to 12 % by volume;
apparatus for producing emulsions which are stable for more than three calendar weeks without deterioration in the size and distribution of the water-in-fuel particles, with oils having viscosities in the range of 1000 to 3000 Redwood No 1 sec at 50°C; and
apparatus for producing emulsions at a pressure of above 3 bar at the oil nozzle to prevent the injected water from boiling.

Tests on the invention have produced stable water-in-oil emulsions with set water contents of between 6 to 12 percent by volume. Investigations of emulsions with 6, 8, 10 and 12 % water content showed that evenly distributed water particles of 2 to 10 µm diameter were produced in the oil, and that the emulsions were capable of remaining stable for more than three weeks without showing any deterioration in the size and distribution of the water-in-fuel particles. Oils with viscosities of 1000 to 3600 Redwood No. 1 sec at a temperature of 50°C have been tested. The oil was heated to a viscosity of 50 to 60 Redwood No. 1 sec and pressurised to above 3 bar before water was injected into the oil.

A method of producing water-in-oil emulsions with a water content of 6 to 12 % by volume and uniformly distributed water particles of 2 to 10 μm diameter is described below. Apparatus for producing water-in- fuel emulsions is also referred to herein as an "emulsifier".

The invention will now be illustrated further with reference to the accompanying drawings in which:

Fig 1 shows a flow diagram of the method of this invention;

Fig 2 shows the structure of an emulsifier of the invention;

Fig 3 shows the structure of a mixing chamber housing of the invention;

Fig 4(a) & 4(b) show the structure of water chamber plugs of the invention;

Fig 5 shows the structure of water nozzles of the invention;

Fig 6 shows the structure of a mixing throat housing of the invention;

Fig 7 shows the structure of a diffuser of the invention;

Fig 8 shows the structure of mixing plates of the invention; and

Fig 9 shows the structure of a locking bush.

Fig 1 shows the flow diagram of the system for adding water to oil. The oil is first heated to the temperature required to maintain a viscosity of between 50 and 60 Redwood No. 1 sec. The viscosity of the oil is measured by a viscometer (1) which controls the heater (2). The heater and viscometer used may be off-the-shelf components which are commercially available as an integrated package for controlling oil viscosity. The pump (3) pressurises the oil at the oil nozzle (30) of the emulsifier to above 3 bar to prevent the water for injection into the oil from boiling, as the oil has to be heated to above 100°C for the necessary viscosity reduction.

Fig 2 shows a cross section of the emulsifier. Oil enters the emulsifier through the nozzle (30) which increases the oil viscosity to from 2 to 4 meters per sec. Water is injected into the oil jet in the oil nozzle (30) through one or more water nozzles (31) which are located on the peripheral wall of the fuel nozzle. The ratio of the water nozzle diameter to the fuel nozzle diameter is preferably between 0.02 and 0.10. The ratio of oil velocity to water velocity is preferably between 1.5 and 3.0, with water velocity between 3 to 6 metres per sec. The axis of the water nozzles (31) is preferably perpendicular to the axis of the oil nozzle (30). The difference in magnitude and direction of the oil jet and water jets causes an exchange of momentum between the oil jet and water jets and produces a uniform mixing effect. Dynamic shearing also occurs at the interface between the oil and water jets and causes the water to be sheared into fine and uniformly distributed water-in-fuel particles of 2 to 10 µm diameter. Downstream, the diffuser (32) converts the velocity energy of the emulsion back to pressure energy. The four sets of baffles, or mixing plates (33), after the diffuser, ensure further mixing to produce a uniform distribution of water-in-fuel particles.

A method for controlling the amount of water injected into the oil to produce the emulsion of the set water content is shown in Fig 1. Water flowmeter (4) measures the water flowrate (6) and the water flowmeter transmitter (5) transmits the electrical flowrate signal

(7) to the feedback input point of the flow controller (8). The flow controller may be a commercially available process controller. The electrical oil flowrate signal (9) from the oil flowmeter transmitter (10) is first scaled by a factor of (n/100) by an amplifier (12), where n is the set percentage water content of the emulsion, preferably between 6 and 12 %. The scaled output signal (13) from the amplifier is then the input to the remote set point input point of the flow controller. The output (14) from the flow controller is an electrical signal which adjusts the water flow control valve (15) position so as to maintain the set ratio (i.e. n %) of water flowrate to oil flowrate, even with oil flowrate (16) fluctuating over a wide range.

A water tank (17) is provided to act as a reservoir. The water level (18) in the water tank is monitored by low-level and high-level limit switches (19) which may suitably be of the float, floatless or probe type. The limit switches send the electrical signal to the level controller (21) which opens and closes the water supply solenoid valve (20) when water level is low and high respectively. The water tank (17) is preferably designed with a level watch glass for visual inspection of the water level. The high pressure water pump (22) takes its suction from the water tank (17) and pumps the water through the shut-down solenoid valve (23), water flow control valve (15), water flowmeter (4) and non-return valve (24) to the emulsifier (25). The function of the shut-down solenoid valve (23) is to shut off the water supply (6) immediately on shut down or in an emergency situation since the water flow control valve (15) requires some time to close completely. The non-return valve (24) ensures that no oil flows into the water tank (17). The return line (26) from the water pump (22) to the water tank (17) is used to regulate the water pump outlet pressure which is measured by the pressure gauge (27) by adjusting the return hand valve (28).

The illustrated emulsifier is a mixing apparatus which has no mechanically moving parts. Hence, it requires little or no maintenance once it is installed. Referring to Fig 2, the emulsifier consists of the following components:

(i) mixing chamber housing (34) (Fig 3);
(ii) water chamber plugs (35) (Fig 4);
(iii) water nozzles (31) (Fig 5);
(iv) mixing throat housing (36) (Fig 6);
(v) diffuser (32) (Fig 7);
(vi) four sets of mixing plates (33) (Fig 8); and
(vii) locking bush (37) (Fig 9).

The mixing chamber housing (34) has an annular water chamber space (38) which connects to the oil nozzle (30) through one or more holes (39) onto which the water nozzles (31) are screwed. The ratio of the length to the diameter of the oil nozzle (30) is preferably between 5 and 10. The water nozzles (31) are preferably designed with a nozzle length to nozzle diameter ratio of between 2 and 5. Access to the water nozzles (31) in the water chamber (38) is through the holes (40) on the outside of the mixing chamber housing (34) by unscrewing the water chamber plugs (35) from the holes (40). One of the water chamber plugs (41) has a hole through it which is connected to the water supply pipe. This mixing throat housing (36) houses diffuser (32) and four sets of mixing plates (33). The mixing throat housing (36) screws into mixing chamber housing (34) as shown in Fig 2 and the diffuser (32) and the four sets of mixing plates (33) are locked into place by the locking bush (37). The diffuser (32) is preferably designed with a total diffuser angle (42) of between 5 and 10 degrees. The four sets of mixing plates (33) are preferably arranged with alternative set of mixing plates at right angles. Each set of mixing plates is preferably designed with an angle between plates (43) of 5 to 10 degrees.

Claims

1. Apparatus for producing water-in-oil emulsions comprising water supply means, oil supply means and mixing means, characterised in that the mixing means comprises a chamber through which the oil can be forced in a stream, the chamber being provided with water inlet means to allow water to be mixed with the oil stream.

2. Apparatus according to claim 1 wherein the water inlet means comprises one or more nozzles.

3. Apparatus according to claim 1 or 2 wherein the water is injected into the oil stream.

4. Apparatus according to any preceding claim further comprising means to regulate the water supply according to the oil flowrate.

5. Apparatus according to any of claims 1 to 4 further comprising oil flowrate feedback regulatory means to control the water supply.

6. Apparatus according to any of claims 1 to 4 further comprising means to control the relative flowrates of water and oil.

7. Apparatus according to any preceding claim adapted to provide water-in-oil emulsions with particle sizes substantially between 2 and 10μm diameter and/or having a water content of between 6 and 12% v/v.

8. Apparatus according to any preceding claim adapted to effect the mixing of oil and water under pressure, preferably in excess of 3 bar.

9. A method for producing water-in-oil emulsions comprising injecting water into a stream of oil while maintaining the relative flowrates.

10. A method according to claim 9 having any or all suitable parameters defined in any of claims 1 to 8.

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