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Fuel-water separator.

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References cited:
CA-A-963 400
DE-A-2 436 080
FR-A-1 385 489
FR-A-2 181 045
US-A-1 468 906
US-A-3 508 658

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Description

This invention relates to a fuel-water separator, for example for use with a diesel-engine to separate water from the diesel fuel.

It is known that diesel fuel contains substantial amounts of water which will damage the fuel-injection system of an engine if it is not removed.

This problem has been recognised in the prior art and there is disclosed, in CA—A—963400, a separator for separating water from a fuel-water mixture which separator comprises a container having an entry port for the fuel-water mixture, an exit port for fuel and a discharge port for water separated from the fuel, means inside the container defining a succession of spaces through which the fuel-water mixture is constrained to flow in a sinusuous path to the exit port and in which the higher density water separates from the lower density fuel and flows downwardly in said spaces to the discharge port. Such a separator, however, has not proved wholly satisfactory in operation since it is unable to prevent significant quantities of the separated components of the mixture from remixing before the fuel reaches the exit port.

This problem is resolved, according to the invention, by making the internal space-defining means a cup-shaped member having a bottom provided with a drainage opening through which water, separated from the mixture, can flow downwardly towards the discharge port, said drainage opening forming the upper seat of the float valve ball of a first valve, said float valve ball having a density less than water and greater than the fuel such that the ball will move upwardly in separated water to close the drainage opening in said internal member to stop back flow of separated water through said drainage opening and providing a second valve for closing the discharge port to stop fuel flow through said discharge port, the second valve including a safety valve ball having a density less than water and greater than the fuel so as to move upwardly to allow discharge of water separated from the fuel and to move downwardly to close the drainage port when the separated water has been discharged from the container.

It is already known from FR—A—1385489 to install a float valve for controlling communication between two concentric cup-shaped compartments within a container and to provide a ball valve for controlling a discharge port at the bottom of the container. The float valve, however, does not control a drainage opening for water and the ball valve is movable downwardly against the action of a spring in order to permit water to drain from the container.

The separator of the present invention functions to separate the water from the fuel in a safe and reliable manner. The separator operates without servicing except to drain the excess water; it can provide an indication when water is to be drained, and can operate without priming with fuel after the water is drained. The present separator may be enclosed in a metal container and be crimped or otherwise sealed closed so that it becomes an inexpensive, disposable unit if it goes wrong or needs replacing. The inner components of the separator may be made from moulded plastics parts so that the unit can be lightweight, durable, and inexpensive.

Water is hydrophilic, whereas the fuel is hydrophobic, so that water and the fuel are generally immiscible. Water also has a greater density than the fuel, and therefore, has a higher specific gravity. Further, water has different surface tension properties than the fuel.

The separator of the present invention may utilize a combination of water separating and settling techniques arranged in such a manner as to provide effective water separation. For example, the fuel/water mixture may be initially introduced into the separator through an entry port and directed about a circular passageway at a relatively high velocity to apply centrifugal force to the mixture. The centrifugal force separates the higher density water from the lower density fuel. The radially outer wall of the passageway may have openings through which separated water moves to drain downwardly to the bottom of the container.

Fuel moves through the progression of spaces, through which it moves upwardly and then downwardly. Because of its higher density, the water tends to move downwardly and stay down while the lighter density fuel tends to move upwardly in the spaces.

In one of the spaces, a medium may be provided having a downwardly directed surface upon which the water coalesces to move downwardly and through which the fuel moves to progress to the next space. This medium may be, for instance, an untreated fibreglass sleeve. In another space, a medium may be provided having a surface tension-discriminating surface through which the fuel will move and down which separated water will move. This surface tension-discriminator may be fabricated from, for instance, a polyester cloth material.

In one embodiment, the spaces may be defined by an outer container, an outer cup, and an inner cup. The container has a drainage opening at its bottom, and a petcock may be provided for closing the drainage opening to control removal of separated water. As a safety feature, a float valve ball having a density greater than that of the fuel and less than that of the water is seated in the drainage opening. When water is present, the ball floats above its seat in the drainage opening to allow the water to flow therethrough. When the water has been drained, the ball drops and seats in the drainage opening to stop flow of liquid so that fuel does not drain if the petcock is inadvertently left open.

In a somewhat similar fashion, the outer cup also has a drainage opening closed by a valve ball which floats upwardly in water to permit drainage from the outer cup and which seats in the opening to prevent drainage of fuel from the outer cup.
after the water has drained. This valve ball is arranged to float upwardly in the presence of excess water in the bottom of the container, to close off a drainage opening in the inner cup. This valve ball also holds fuel in the last stages of the separator so that engine fuel is present to start an engine without the need to prime the system or refill the separator, as is required with present filter systems.

The invention will now be described by way of example, with reference to the drawings, in which:

Fig. 1 is a section of one embodiment of separator in accordance with the invention, taken generally along the axis of the separator;

Fig. 2 is a section, partly broken away, on the line 2—2 in Fig. 1;

Fig. 3 is a section on the line 3—3 in Fig. 1;

Fig. 4 is a section of a portion of the separator embodying an electric heating element;

Fig. 5 is a section of a portion of the separator embodying a plastics draincock;

Fig. 6 is a section of a portion of the separator embodying a water level probe;

Fig. 7 is a section of a portion of the separator embodying another drain valve; and

Fig. 8 is a diagrammatical view, partly cross-sectional and broken away, of another embodiment of the separator of the present invention.

Referring to the drawings, Fig. 1 shows the fuel-water separator of the present invention, comprising an upright cylindrical housing 10 having a lower can or can portion 12 and an upper cover or cover portion 14 joined together by crimping as indicated at 16 with a gasket 18 captured in the crimp joint to provide a seal between the cover 14 and can 12. Fuel enters the separator 10 through a tube 20 which is brazed to an entry port 22 in the cover 14. The fuel exits through a tube 24 which is brazed into a central exit port 26 in the cover 14.

A central opening 34 is formed at the bottom of the can portion 12 of the housing 10 to provide a drainage port for water accumulated at the bottom of the can 12. A petcock 28 is threaded, as indicated at 30, into a threaded tube 32 brazed into the central opening 34. By opening and closing petcock 28, drainage of the water from can 12 can be controlled.

Inside the housing 10 is a circular plate 36 having a plurality of holes or openings 38 and an outer peripheral edge 40. The diameter of the plate 36 is less than the diameter of the can 12 so that a circumferential space 43 is provided between the outer peripheral edge 40 of the plate 36 and the can 12 for channeling water to the bottom of the can 12.

The plate 36 is provided with an opening 42 concentric with a downwardly extending sleeve 44. The lower edge 46 of the sleeve 44 rests upon a retainer 48 for a ball 50. This ball 50 can move upwardly and downwardly in the retainer 46 in a space defined by peripheral spaced-apart, vertically extending legs 51. Legs 51 define a plurality of drainage opening spaces 52 therebetween.

The ball 50 rests upon a seat 54 formed at the bottom central opening 34 of the can 12.

A drainage tube 56 extends downwardly through the opening 42 in sleeve 44. The lower end 58 of tube 56 provides an upper stop for the ball 50. The lower end 58 includes a plurality of reliefs or notches 60 which provide drainage relief and which prevent the ball 50 from sealing off the bottom of the tube 56.

Mounted on or connected to the top of the plate 36 is a semicircular fuel passageway or raceway 80 which may have a cross-sectional inverted U-shape, as best indicated at 82 in Fig. 1. This passageway 80 is designed to apply centrifugal force to the fuel-water mixture passing therethrough. The fuel enters the passageway 80 as indicated at 84 from the tube 20 and moves clockwise (Fig. 2) through the passageway 80 as indicated by the arrow 86. About the last one-third of the radially outer peripheral wall of the passageway 80 is provided with openings 88. The centrifugal force involved in the flow of the fuel-water liquid mixture through the passageway 80 pushes the high density water to the outer wall so that the water is separated from the fuel, forced through the openings 88, and drains downwardly over the outer peripheral edge 40 of the plate 36 through the space 43 between the edge 40 and the can 12. Once water is separated from the fuel, it tends to drain away and not to mix with the fuel. The fuel-water mixture continues to move through the passageway 80 and exits through end 81.

Referring to Figs. 1 and 2, the plate 36 and passageway 80 provide a centrifugal section 89 of the separator 10 which is isolated by an upper cover 90. The centrifugal section 89 is also formed in part by circular flange portion 118 of the tube 56 which provides support for the connection between the tube 56 and the sleeve 44 of the plate 36. Cover 90 is generally circular in shape and includes a gradually downwardly sloping upper wall 91 which extends radially outwardly slightly beyond the outer peripheral edge 40 of the plate 36 and a downwardly extending peripheral skirt 92. Skirt 92 extends far enough downwardly so that its end is at least even with the bottom surface of the plate 36, and it serves to deflect water separated by the centrifugal action downwardly into the bottom of the can 12.

The upper wall 91 of the cover 90 includes a central opening 93 for receiving the drainage tube 56. The upper wall 91 further includes a plurality of smaller openings 94 formed around and in proximity to the larger central opening 93. Openings 94 provide exits for the fuel-water mixture after it has passed through passageway 80. The liquid mixture passes through the openings 94 and moves into a first space 96 above the cover 90. Separated water, which is still entrained in the liquid mixture after the centrifugal action, may fall by gravity along the downwardly sloping upper wall 91 of the cover 90 and over the skirt 92 into the bottom of the can 12.
The first space 96 into which the liquid moves after leaving the centrifugal sector 89 is illustratively defined by the upper wall 91 of the cover 90, conical flange portion 110 of the tube 56, as well as by the bottom 112 and side 114 of an outer cup 116. The space 96 is also, as shown in Fig. 1, defined by the inner surface of the can 12. It will be seen that the conical flange 110 provides a seat or support for the rather slender conically shaped bottom 112 of the cup 116.

A mounting and support plate 130 is provided at the upper end of the assembly 10, just under the cover 14. This circular plate 130 has a central opening 132 through which the exit tube 24 extends. A plurality of mounting openings 134 are peripherally spaced about the radially outer peripheral edge of the plate 130, and snap fingers 136 provided on the outer cup 116 extend into these openings 134 to make a snap connection between the cup 116 and the plate 130 as indicated at 138. This is only one of several ways the cup 116 can be connected to the mounting plate 130.

The plate 130 and the cup 116 define a second space 139 within the cup 116, and the liquid mixture flows into that space 139 through a plurality of openings 140 peripherally spaced about the upper edge of the cup 116.

A surface tension separator 150, to be described in more detail hereinafter, is pressed upon a downwardly extending central shoulder 152 on the plate 130 which defines the opening 132 through which the exit tube 24 extends. This separator 150 is a generally cylindrical separator having an outer cylindrical wall 154, a lower end 156, and an upper end 158 provided with a socket portion 160 receiving the shoulder 152.

An inner cup 170 is provided over the surface tension separator 150. The illustrative inner cup 170 is concentrically connected to the plate 130 by snap fingers 172 which engage openings 174 peripherally spaced about the plate 130. This inner cup 170 defines a third space 175. The third space 175 also has a plurality of openings 176 peripherally spaced about its upper edge for movement of the liquid mixture into the inner cup 170, and a plurality of openings 170 peripherally spaced about its bottom 178 for movement of water toward the bottom of can 12. The shallow conical bottom 178 of the cup 170 is provided with a concentric opening 180 forming an upper seat for a float valve ball 182 captured in a ball retainer defined by a plurality of peripherally spaced-apart fingers 184 extending upwardly from the flange portion 110 of the drainage tube 56. The drainage tube 56 is formed to provide a lower seat 186 for the ball 182 with the seat 186 being below and concentric with the upper seat 180. The ball 182, therefore, can move between the upper seat 180 and the lower seat 186 in the vertical space defined by the fingers 184.

Mounted concentrically about the inner cup 170 is a support cage 200 providing a plurality of peripherally spaced-apart, axially extending openings 202. This cage 200 is illustratively connected to the plate 130 by being engaged in a peripherally extending slot 203. The bottom edge of the cage 200 is supported in a circular, channel-like retainer 204 which, in turn, is supported by a plurality of studs 206 extending upwardly from the bottom 112 of the outer cup 116. This retainer ring 204 has a plurality of peripherally spaced-apart openings 208 in the bottom web portion of the channel. The radially inner peripheral edge of ring 204 engages the outer peripheral surface of the inner cup 170 just below the openings 210 in the cup 170. A sleeve 212 of untreated fiberglass media is placed on the cage 200 and supported by the channel 214 in the retainer ring 204. Another surface tension separator 216, to be described in more detail hereinafter, is provided around the outer periphery of the sleeve 212.

In the illustrative embodiment, the surface tension separators 150, 216 separate fine water particles having a diameter of about 130—140 microns from the liquid mixture. These are water particles which are too small to be separated by centrifugal or gravity action. The separator media may be either a monofilament polyester fiber woven into a cloth having a pore size of about 130—140 microns or a monofilament Teflon® screen having a similar pore size with approximately 100 fibers both horizontally and vertically per inch (1 inch = 2.54 cm), i.e., 10,000 fibers/square inch. Each of these separator media will separate water particles of the diameter indicated and pass fuel in response to widely varying surface tensions between the two liquids. The separated water will flow down the outer surfaces of the separator media.

Further, in the illustrative embodiment, sleeve 212 is a mat of untreated random length fiberglass fibers, commercially referred to as Class 5A fiberglass.

Preferably, all of the elements of the separator housed within the can 12 are constructed of materials which will collapse or crush so that an impact which deforms the can 12 will not cause the internal elements of the separator to pierce the can 12. This feature prevents leakage of the can 12 if it should be deformed by an impact. Since all connections to and from the housing 10 are at the top or bottom, there are no seals on the sides of the can 12 which could break upon impact. Furthermore, the crimp 16 is a roll seam which will deform slightly without leaking. These features are intended to prevent hazardous fuel leakage if the housing 10 is deformed.

Diesel fuel, which often contains some water, enters the entry tube 20 and moves downwardly to the point 84 at which the fuel-water mixture enters the passageway 80. Movement of the fuel-water mixture through the passageway 80 imparts a centrifugal force on the mixture. Because the water is of a higher density than the diesel fuel, some of the water will start to separate by moving to the outer wall of the passageway 80 and exit through the openings 88. The separated water moves through space 43 and falls to the bottom of the can 12. The fuel leaves the rather tight confines of the passageway 80 in which it is
moving at a relatively high speed into the centrifugal section 89 beneath the cover 90 such that its velocity is drastically reduced. This reduction of the velocity causes separated water entrained in the liquid mixture to move downwardly against the plate 36 and out through the openings 38 in the plate 36. As the heavier water moves downwardly through the openings 38, it will displace the lighter weight oil and force it upwardly through the openings 94 in the upper wall 91 of the cover 90 into the relatively larger first space 96 in the upper portion of the can 12. Separated water still entrained in the mixture after passing through openings 94 may run along the outer surface of the upper wall 91 of cover 90 and fall by gravity to the bottom of the can 12.

The first space 96, at this stage in the separation, provides residence time for the fuel-water mixture so that the water separated from the mixture by the centrifugal force can drain downwardly through space 43. The residence time itself will provide additional separation because of the difference in specific gravity between the water and the oil.

In the space 96, i.e., outside the outer cup 116, the oil will tend to move upwardly and the water will tend to move downwardly. The only communication between the space 96, outside the outer cup 116, and inside of the cup 116 is through the openings 140 at the upper peripheral edge of the cup 116. It is contemplated that oil with less water in it will be at the upper peripheral edge of the outer cup 116 to move through the openings 140 into the second space 139 between the outer cup 116 and the fiberglass media sleeve 212. Finely particulated or emulsified water particles will pass through the surface tension separator 216, coalesce, and form larger particles of water along the strands throughout the fiberglass sleeve 212. The larger water particles will tend to run downwardly and through the strads of the sleeve 212. The surface tension separator 216 prevents larger water particles which do not require coalescing from overloading the fiberglass strands of the sleeve 212. It is known that a fuel oil and water mixture will act in this manner with the finely particulated water coalescing on and moving down the fiberglass strands. The fuel oil itself will penetrate through the fiberglass and move radially inwardly through the passages 202 in the cage 200. Further, separated water particles will pass through openings 210 and drain through opening 180 in the inner cup 170.

The water that separates or coalesces off the fiberglass strands of the sleeve 212 will move downwardly through openings 208 and displace the ball 182 upwardly to allow water to move downwardly through the drainage tube 56. The ball 182 is selected to have a density less than that of water and greater than that of diesel fuel. When the water level in the housing 12 gets up to the point that the ball 182 is supported by the water, the ball 182 will rise against the upper seat 180 to prevent any back flow upwardly into the inner cup 170.

Looking at the drainage function through the petcock 28 and noting the function of the ball 50, the ball 50 also has a density greater than that of diesel fuel and less than that of water. When the lower portion of the housing 10 contains water, the ball will float upwardly, allowing drainage out through the petcock 28. Even if the petcock 28 is left open, once the water is drained out of the housing 10, the ball 50, because it is heavier than the oil, will move downwardly to close off the opening 34. This ball 50, therefore, constitutes a safety check valve to prevent drainage of oil out of the can 12 if the petcock 28 is inadvertently left open too long.

When the water drains out of the outer cup 116 past the ball 182 and through the drainage tube 56, the ball 182 will seat on the lower seat 186 to close off the drainage tube 56 to prevent drainage of oil out of the cup 116. This feature eliminates the need to refill the cup 116 with fuel before the engine can be started. The engine can run on the fuel trapped in the inner cup 170 until the fuel pump starts pumping fuel through the separator.

The fuel-water mixture that moves through the fiberglass sleeve 212 will move against the outer surface of the inner cup 170. There again, the coalesced particles of water will tend to move downwardly to exit out through the openings 208 in the retainer ring 204. At higher flow rates, some coalesced particles of water may be carried by the fuel through the sleeve 212. The fuel will move upwardly through the spaces 176 about the upper edge of the inner cup 170, and the coalesced water will move downwardly through openings 210 into the inner cup 170. The fuel entering the inner cup 170 through spaces 176 should not have any heavy particulate water left. However, if finer water particles are in the fuel, those particles will separate at the face of the outer surface of the surface tension separator 150 and move downwardly through the central opening 180 in the bottom of the cup 170.

As previously described, the separator 150 may be fabricated by molding a polyester fabric outer cylindrical wall to the lower and upper end walls 156, 158. This polyester fabric is known to separate fuel and water by the widely varying surface tensions between the two liquids. The oil will move through the fabric to the interior of the separator, and the water particles will move downwardly on the outside of the fabric. The water-free fuel will leave the separator 150 and exit the assembly 10 upwardly through the exit tube 24.

Referring to Fig. 4, it will be seen that a metal outer cup 116a is shown having a bottom 112a and a shoulder 206a that serves the same function as the stud 206 in Fig. 1. A plate 130a provides a mounting plate for the same purpose as the plate 130 in Fig. 1. The illustrative outer cup 116a in Fig. 4 is metal so that it can be heated with a heating element 220. The illustrative heating element 220 is an annular ceramic ring which may be brazed or soldered to the bottom 112a of the cup 116a. This type of heating element 220, commonly
referred to as a PTC Element, is well known and, generally speaking, includes an annular ceramic heating element which is metallized on its outer surface so that it can be soldered or brazed to an item to be heated. An electrical service wire is indicated at 224.

The embodiment of Fig. 4, therefore, comprises a heating element 220 built into the basic water separator to heat the outer cup 116a and in turn to heat the fuel to prevent the water from freezing and to prevent the fuel from becoming gell-like due to paraffin in the fuel. It will be appreciated that automatic thermostat means may be embodied for applying current to the heater 220 as required to obtain the desired fuel and water condition.

Referring to Fig. 5, it will be seen that an alternative petcock 28a is shown. In the Fig. 5 structure, the ball retainer 48a is provided with seal 54. The ball retainer 48a is molded to provide the seat 54. The retainer 48a is also molded to provide a downwardly extending threaded sleeve 230. The retainer 48a is attached to the bottom of the housing by means of a compression nut 232 which captures a gasket 234 as illustrated. The petcock 28a includes handle 236 threaded on the sleeve 230. The handle 236 has a stem 238 extending upwardly through the opening in the sleeve 230 to carry an O-ring 240 to seal against a seat 242 formed within the sleeve 230. In the illustrative embodiment, the stem 238 includes an upwardly projecting tip 244 which forces the ball 50 off the seat 54 when the petcock is closed. The projecting tip 244 prevents the weight of the fuel-water mixture from forcing the ball 50 into engagement with seat 54 when the separator is filled with fresh fuel. Without the tip 244, the weight of the fresh fuel would prevent the desired floating action of the ball and thereby prevent drainage of the separator. When it is desired to drain the can 12, the handle 236 is rotated to lower the O-ring 240 away from the seat 242 so that the liquid can drain as indicated by the arrows 246, 248 down through the petcock 248a.

One embodiment of the invention may include a water sensor probe in 280, as best seen in Figs. 3 and 6. If a water sensor probe is desired, the upper cover 14 may be provided with an opening 262 (Fig. 6) for receiving a threaded sleeve 264. The probe 266 itself may be a commercially available liquid level probe adapted to either capacitive or resistive circuitry to sense water in the bottom of the housing 12. The probe 266, as illustrated in Fig. 6, is elongate having a diameter generally corresponding to the diameter of the fuel chamber 10 and a length sufficient to extend downwardly into the sleeve 264 to extend downwardly to the level indicated, for instance, at 268. The liquid level probe, of course, may be hooked to a light indicator on the dashboard of the vehicle or, for instance, to a solenoid valve drive as illustrated in Fig. 7.

In Fig. 7, a petcock indicated at 28b is shown threaded into the sleeve 32. A solenoid-operated petcock valve member 280 is actuated to pull a plunger 282 from a seat 284 to drain the can 12. The valve member 280 is electrically connected to a power supply source (not shown) by wires 286. A switch (not shown), actuable by either the driver of the vehicle or the liquid level probe 266, may be connected in series with the valve member 280 for controlling its operation. It will also be understood that valve member 280 may be either pneumatically or hydraulically controlled without departing from the scope of the present invention.

Referring to Fig. 8, sleeve 212 of untreated fiberglass media may be located within the inner cup 170, either replacing or being used in conjunction with the surface tension separator 150. In this embodiment, the sleeve 212 and cage 200 in the outer cup 116 are removed, leaving only the surface tension separator 216 retained by the channel-like retainer 204. In operation, fine water particles are removed by the separator media 216 in the outer cup 116. The separated water will flow down the outer surface of the separator media 216, as indicated by the broken arrow in Fig. 8. Any finely particulated or emulsified water particles which pass through the separator 216 will coalesce and form larger particles of water along the strands throughout the fiberglass sleeve 212 in the inner cup 170. The larger water particles will tend to run downwardly and through the strands of the sleeve 212 and drain through opening 190 in the inner cup 170.

Claims

1. A separator for separating water from a fuel-water mixture, comprising a container (10) having an entry port (22) for the fuel-water mixture, an exit port (28) for the fuel and a discharge port (34), located at the lower end of the container, for the water separated from the fuel, said container being provided with an internal member (170) interposed between the entry port (22) and the exit and discharge ports (26, 34) and defining at least two generally concentric spaces (139, 175), each containing means (150, 212, 216) for separating water from fuel, the arrangement being such that fuel-water mixture entering the container at the entry port is constrained to flow through said spaces in a series of downwardly and upwardly directed paths towards the exit port and the higher density water is separated from the lower density fuel and flows downwardly in said spaces, characterised in that the internal member (170) is cup-shaped having a bottom (178) provided with a drainage opening (180) through which water, separated from the mixture, can flow downwardly towards the discharge port (34), said drainage opening (180) forming the upper seat of the float valve ball (102) of a first valve, said float valve ball (182) having a density less than water and greater than the fuel such that the ball will move upwardly in separated water to close the drainage opening (180) in said internal member (170) to stop back flow of separated water through said drainage opening (180) and a second valve is provided for closing the discharge
port (34) to stop fuel flow through said discharge port, the second valve including a safety valve ball (50) having a density less than water and greater than the fuel so as to move upwardly to allow discharge of water separated from the fuel and to move downwardly to close the discharge port (34) when the separated water has been discharged from the container.

2. A separator according to claim 1, including means (36, 90) defining a semi-circular passageway (80) through which the fuel-water mixture moves after passing through the entry port (22), the path defining means (36, 90) including a radially outer wall against which the water is centrifugally forced.

3. A separator according to claim 2, wherein said means (36, 90) provides a centrifugal section (88) having at least one opening (94) through which fuel leaving the semi-circular passageway (80) can move into a third space (96) upstream of said other spaces (139, 175).

4. A separator according to claim 2 or 3, wherein said means (36, 90) defines the semi-circular passageway (80) includes a plate (38) concentrically disposed in the lower part of the container (10) and having at least one drain opening (38) therein through which separated water moves downwardly.

5. A separator according to claim 2, 3 or 4, wherein said semi-circular passageway (80) is of relatively narrow cross section to induce high velocity flow therethrough.

6. A separator according to claim 3, wherein said centrifugal section (88) defines a flowpath area substantially greater than the semi-circular passageway (80) so that fuel-water mixture flowing from said passageway (80) through said centrifugal section has its velocity reduced and the water entrained in the fuel-water mixture can settle downwardly.

7. A separator according to claim 2, 3, 4 or 5, wherein said passageway (80) includes means defining openings (88) for the escape of water, spaced intermittently along the length thereof.

8. A separator according to any preceding claim, wherein the separating means (212, 216) in the space (139) surrounding the cup-shaped internal member (170) includes an annular medium (212) concentrically disposed in said space (139) to extend downwardly and provide a downwardly extending outer surface against which the water coalesces and moves downwardly and through which the fuel moves radially inwardly.

9. A separator according to claim 8, wherein the separating means (212, 216) in the outer (139) of said spaces (139, 175) includes a surface tension discriminator (216) disposed circumferentially around the outer surface of the annular medium (212), through which discriminator the fuel moves radially inward to said medium and along which the water moves to collect at the bottom of the outer space (139).

10. A separator according to claim 8 or 9, wherein the separating means (150) in the inner (175) of said spaces (139, 175) includes a surface tension discriminator through which the fuel moves to the exit port (24) and along which the water moves to collect at the bottom of said inner space (175).

11. A separator according to claim 10, wherein the container (10) is a closed, sealed container except for the entry and exit ports (22, 26) and the discharge port (34), the container being a metal can having a generally cylindrical side wall, and a top and a bottom, the entry and exit ports (22, 26) being provided in the top such that the side wall can collapse inwardly in a crash without breaking the container open at the ports.

12. A separator according to claim 11, wherein the exit port (24) is defined by a tube extending concentrically axially through the top of the container (10) downwardly into the inner space (175) downstream of the other space, the tube having an open lower end surrounded by the surface tension discriminator (150) in said inner space (175).

13. A separator according to any preceding claim, wherein the container (10) defines a water collection area and a fuel separation area above the water-collection area, the drainage opening (180) in the cup-shaped internal member (170) being located in the lower portion of the fuel separation area and retaining means (184) being provided for retaining the float valve ball (182) between the drainage opening (180) in said internal member (170) and a second drainage opening (66) in the lower end of a second cup-shaped internal member (116) closing the lower end of the outer (139) of said spaces (139, 175).

14. A separator according to any preceding claim including a device (260) for sensing the level of water in the container and for providing an indication of that level.

15. A separator according to any preceding claim, wherein the discharge port (34) includes a petcock (28, 28a, 28b) operable when actuated to discharge separated water from the container.

16. A separator according to claim 15, including means (280) for automatically actuating the petcock (28b) when a predetermined water level (268) is reached in the container and means for responsively connecting the actuating means (280) to sensing means (260).

17. A separator according to any preceding claim, including means (220) for heating fuel in the container.

Patentansprüche

1. Separator zur Trennung von Wasser aus einem Kraftstoff-Wasser-Gemisch mit einem Behälter (10) mit einer Eintrittsöffnung (22) für das Kraftstoff-Wasser-Gemisch, einer Austrittsöffnung (26) für den Kraftstoff und einer an der Unterseite des Behälters angeordneten Ausstoßöffnung (34) für das vom Kraftstoff abgetrennte Wasser, wobei der Behälter mit einem inneren Teil (170) versehen ist, das zwischen der Eintrittsöffnung (22) und den Austritts- und Ausstoßöffnungen (26, 34) angeordnet ist und wenigstens
zwei im wesentlichen konzentrische Räume (139, 175) aufweist, deren jeder eine Einrichtung (150, 212, 216) zur Trennung von Wasser und Kraftstoff enthält, wobei die Anordnung von der Art ist, daß das an der Eintrittsoffnung in den Behälter eintretende Kraftstoff-Wasser-Gemisch zum Hindurchfließen durch die Räume in einer Reihe von unten nach oben und von oben gerichteten Wegen zur Austrittsoffnung hin gezwungen wird und das Wasser mit höherer Dichte von dem Kraftstoff mit geringerer Dichte getrennt wird und in den Räumen nach unten fließt, dadurch gekennzeichnet, daß das innere Teil (170) topfförmig ausgebildet ist mit einem Boden (178), der mit einer Dränageöffnung (180) versehen ist, durch die von dem Gemisch abgetrenntes Wasser nach unten zur Ausstoßöffnung (34) hin fließen kann, wobei die Dränageöffnung (180) den oberen Sitz eines Ventil-Schwimmballes (182) eines ersten Ventils bildet, wobei der Ventil-Schwimmball (182) eine Dichte hat, die geringer als die von Wasser und größer als die von Kraftstoff ist, so daß der Ball sich in dem abgetrennten Wasser nach oben bewegen wird, um die Dränageöffnung (180) in dem inneren Teil (170) zu schließen und eine Rückfluß des abgetrennten Wassers durch die Dränageöffnung (180) zu unterbinden, und daß ein zweites, d.h. zentrales Ventil zum Schließen der Ausstoßöffnung (34) vorgesehen ist, um einen Kraftstofffluß durch die Ausstoßöffnung zu unterbinden, wobei das zweite Ventil einen Sicherheitsventilball (50) aufweist, dessen Dichte geringer als die von Wasser und größer als die von Kraftstoff ist, so daß der Ball sich nach oben bewegen kann, um den Ausstoß des vom Kraftstoff abgetrennten Wassers zu gestatten, und sich nach unten bewegen kann, um die Ausstoßöffnung (34) zu schließen, wenn das abgetrennte Wasser aus dem Behälter ausge- stoßen worden ist.

2. Separator nach Anspruch 1, mit einer Einrichtung (36, 90) zur Bildung eines halbrunden Durchgangs (80), durch den sich das Kraftstoff-Wasser-Gemisch nach Durchlaufen der Eintrittsoffnung (22) bewegt, wobei die Einrichtung (36, 90) zur Bildung des Durchgangs eine radial außenliegende Wand aufweist, gegen die das Wasser zentrifugal getrieben wird.

3. Separator nach Anspruch 2, worin die Einrichtung (36, 90) zur Bildung des Durchgangs einen Zentrifugalbereich (89) aufweist, der wenigstens eine Öffnung (94) hat, durch die den halbrunden Durchgang (80) verlassender Kraftstoff sich in einen stromaufwärts von den anderen Räumen (139, 175) angeordneten dritten Raum (96) bewegen kann.

4. Separator nach Anspruch 2 oder 3, worin die Einrichtung (36, 90) zur Bildung des halbrunden Durchgangs (80) eine konzentrisch im unteren Teil des Behälters (10) angeordnete Platte (36) aufweist, in der wenigstens eine Dränageöffnung (38), durch die abgetrenntes Wasser sich nach unten bewegt, ausgebildet ist.

5. Separator nach Anspruch 2, 3 oder 4, worin der halbrunde Durchgang (80) zur Bewirkung einer hohen Durchflußgeschwindigkeit einen relativ engen Querschnitt hat.


7. Separator nach Anspruch 2, 3, 4 oder 6, worin der Durchgang (80) eine Einrichtung aufweist, die Löcher (88) zum Entweichen von Wasser festlegt, die intermittierend längs dieser angeordnet sind.

8. Separator nach jedem der vorangehenden Ansprüche, worin die Trenneinrichtung (212, 216) in dem das topfförmige innere Teil (170) umgebenden Raum (139) ein ringförmiges Medium (212) einschließt, das in diesem Raum (139) konzentrisch angeordnet ist, das sich nach unten erstreckt und eine sich nach unten erstreckende äußere Oberfläche aufweist, gegen die das Wasser koalesziert und sich nach unten bewegt und durch die von der Kraftstoff sich radial nach innen bewegt.

9. Separator nach Anspruch 8, worin die Trenneinrichtung (212, 216) in dem äußeren (139) der Räume (139, 175) einen Oberflächenspannungs-Diskriminator (216) aufweist, der umfänglich um die äußere Oberfläche des ringförmigen Mediums (212) angeordnet ist und durch den der Kraftstoff sich radial nach innen zu dem Medium hin bewegt und längs dessen das Wasser sich zum Sammeln am Boden des äußeren Raums (139) bewegt.

10. Separator nach Anspruch 8 oder 9, worin die Trenneinrichtung (150) im inneren (175) der Räume (139, 175) einen Oberflächenspannungs-Diskriminator aufweist, durch den der Kraftstoff sich zur Austrittsoffnung (24) hindurchbewegt und längs dessen das Wasser sich zum Sammeln am Boden des inneren Raums (175) bewegt.

11. Separator nach Anspruch 10, worin der Behälter (10) bis auf die Eintritts- und Austrittsoffnung (22, 26) und die Austrittsoffnung (34) ein geschlossener, abgedichteter Behälter ist, der als Metalltopf ausgebildet ist mit einer im allgemeinen zylindrischen Seitenwand, einem Obergang und einem Boden, wobei die Eintritts- und Austrittsoffnung (22, 26) in dem Obergang ausgebildet sind, so daß die Seitenwand bei einem Bruch nach innen kollabieren kann, ohne daß der Behälter an seinen Öffnungen aufgebrochen wird.

12. Separator nach Anspruch 11, worin die Austrittsoffnung (24) durch ein Rohr gebildet ist, das sich in axialer Richtung konzentrisch durch das Obergang des Behälters (10) nach unten in den inneren Raum (175) stromabwärts von dem anderen Raum erstreckt, worin das Rohr ein offenes unteres Ende hat, das von dem Oberflächenspannungs-Diskriminator (150) in dem inneren Raum (175) umgeben ist.


15. Separator nach jedem der vorangehenden Ansprüche, worin die Ausstoßöffnung (34) einen Abläßbahn (28, 28a, 28b) aufweist, der bei Betätigung den Ausstoß des abgetrennten Wassers aus dem Behälter bewirkt.


17. Separator nach jedem der vorangehenden Ansprüche, mit einer Einrichtung (220) zur Erwärmung des Kraftstoffes in dem Behälter.

Revendications

1. Séparateur pour séparer l’eau d’un mélange de combustible et d’eau comprenant un réservoir (10) ayant un passage d’entrée (22) pour le mélange de combustible et d’eau, un passage de sortie (26) pour le combustible et un passage de décharge (34) placé à l’extrémité inférieure du réservoir pour l’eau séparée du combustible, ledit réservoir étant muni d’un élément intérieur (170) interposé entre le passage d’entrée (22) et les passages de sortie et de décharge (26, 34) et délimitant au moins deux espaces de disposition générale concentrique (139, 175), chacun contenant un moyen (150, 212, 216) pour séparer l’eau du combustible, la disposition étant telle que le mélange de combustible et d’eau entrant dans le réservoir au passage d’entrée soit contraint de s’écouler à travers lesdits espaces en une série de parcours dirigés vers le bas et vers le haut en direction du passage de sortie et que l’eau de densité plus faible soit séparée du combustible de densité plus faible et s’écoule vers le bas dans lesdits espaces, caractérisé en ce que l’élément intérieur (170) est de forme de cuvette ayant un fond (178) présentant une ouverture de drainage (180) à travers laquelle l’eau, séparée du mélange, peut s’écouler en descendant vers le passage de décharge (34), ladite ouverture de drainage (180) formant le siège supérieur de la bille flottante de clapet (182) d’une première valve, ladite bille flottante de clapet (182) ayant une densité moindre que celle de l’eau et supérieure à celle du combustible de telle façon que la bille se déplace vers le haut dans l’eau séparée pour fermer l’ouverture de drainage (180) dans ledit élément intérieur (170) en arrêtant l’écoulement en retour de l’eau séparée à travers ladite ouverture de drainage (180) et une seconde valve est établie pour fermer le passage de décharge (34) en arrêtant l’écoulement du combustible à travers ledit passage de décharge, la seconde valve comprenant une bille (50) de valve de sûreté ayant une densité moindre que celle de l’eau et supérieure à celle du combustible de façon à se déplacer vers le haut pour permettre la décharge d’eau séparée du combustible et à se déplacer vers le bas pour fermer le passage de décharge (34) quand l’eau séparée a été déchargée du réservoir.

2. Séparateur selon la revendication 1, comprenant un moyen (36, 90) délimitant un parcours en demi-cercle (80) à travers lequel le mélange de combustible et d’eau se déplace après avoir passé par la passage d’entrée (22), le moyen délimitant le parcours (36, 90) comprenant une paroi radialement extérieure contre laquelle l’eau est refoulée par centrifugage.

3. Séparateur selon la revendication 2, dans lequel ledit moyen (36, 90) établit une section centrifuge (88) ayant au moins une ouverture (34) à travers laquelle le combustible quittant le passage en demi-cercle (90) peut pénétrer dans un troisième espace (58) en amont desdits autres espaces (139, 175).

4. Séparateur selon la revendication 2 ou 3, dans lequel ledit moyen (36, 90) délimitant ledit passage en demi-cercle (80) comprend une plaque (36) disposée concentriquement dans la partie inférieure du réservoir (10) et ayant au moins une ouverture (34) à travers laquelle le combustible quittant le passage en demi-cercle (90) peut pénétrer dans un troisième espace (58) en amont desdits autres espaces (139, 175).

5. Séparateur selon la revendication 2, 3 ou 4, dans lequel ledit passage en demi-cercle (80) est d’une section transversale relativement étroite pour provoquer à travers lui un écoulement à grande vitesse.

6. Séparateur selon la revendication 3, dans lequel ladite section centrifuge (88) délimite un passage d’écoulement de section notablement plus grande que le passage en demi-cercle (80) de façon que le mélange de combustible et d’eau s’écoulant dudit passage (80) à travers ladite section centrifuge a sa vitesse réduite et que l’eau entraînée dans le mélange de combustible et d’eau puisse descendre.

7. Séparateur selon la revendication 2, 3, 4 ou 6, dans lequel ledit passage (90) comprend un moyen délimitant des ouvertures (88) pour l’échappement de l’eau, écartées les unes des autres sur la longueur de ce passage.

8. Séparateur selon l’une quelconque des revendications précédentes, dans lequel le moyen de séparation (212, 216) dans l’espace (139) entourant l’élément intérieur en forme de cuvette (170) comprend un moyen annulaire (212) dis-
posé concentriquement dans ledit espace (139) pour s'étendre vers le bas et établir une surface extérieure s'étendant vers le bas contre laquelle l'eau est en coalescence et se déplace vers le bas et à travers laquelle combustible se déplace radialement vers l'intérieur.

9. Séparateur selon la revendication 8, dans lequel le moyen de séparation (212, 216) dans celui (139) desdits espaces (139, 175) qui est à l'extérieur comprend un discriminateur (216) de tension superficielle disposé circonférentiellement autour de la surface extérieure du moyen annulaire (212) à travers lequel discriminateur le combustible se déplace radialement vers l'intérieur dudit moyen et le long duquel l'eau se déplace pour se rassembler au fond de l'espace extérieur (139).

10. Séparateur selon la revendication 8 ou 9, dans lequel le moyen séparateur (150) dans celui (175) desdits espaces (139, 175) qui est à l'intérieur comprend un discriminateur de tension superficielle à travers lequel le combustible se déplace vers le passage de sortie (24) et le long duquel l'eau se déplace pour se rassembler au fond dudit espace intérieur (175).

11. Séparateur selon la revendication 10, dans lequel le réservoir (10) est un réservoir fermé, scellé à l'exception de passages d'entrée et de sortie (22, 26) et du passage de décharge (34), le réservoir étant une cuve en métal ayant une paroi latérale de forme générale cylindrique, un dessus et un fond, les passages d'entrée et de sortie (22, 26) étant ménagés dans le dessus de telle façon que la paroi latérale puisse s'infléchir vers l'intérieur sans briser le réservoir ouvert aux passages.

12. Séparateur selon la revendication 11, dans lequel le passage de sortie (24) est délimité par un tube axial s'étendant concentriquement à travers le dessus du réservoir (10) vers le bas dans l'espace intérieur (175) en aval de l'autre espace, le tube ayant une extrémité inférieure ouverte entourée par le discriminateur de tension superficielle (150) dans ledit espace intérieur (175).

13. Séparateur selon l'une quelconque des revendications précédentes, dans lequel le réservoir (10) délimite une surface de réception de l'eau et une surface de séparation de combustible au-dessus de la surface de réception d'eau, l'ouverture de drainage (180) dans l'élément intérieur en forme de cuve (170) étant placé dans la partie inférieure de la surface de séparation de combustible et un moyen de retenue (194) étant prévu pour retenir la bille flottante de clapet (182) entre l'ouverture de drainage (180) dans ledit élément intérieur (170) et une seconde ouverture de drainage (56) dans l'extrémité inférieure d'un second élément intérieur en forme de cuve (116) fermant l'extrémité inférieure de celui (139) desdits espaces (139, 175) qui est à l'extérieur.

14. Séparateur selon l'une quelconque des revendications précédentes, comprenant un dispositif (260) pour capter le niveau d'eau dans le réservoir et pour établir une indication de ce niveau.

15. Séparateur selon l'une quelconque des revendications précédentes, dans lequel le passage de décharge (34) comprend un robinet de purge (28, 28a, 28b) pouvant être actionné pour décharger du réservoir l'eau séparée.

16. Séparateur selon la revendication 15, comprenant un moyen (280) pour actionner automatiquement le robinet de purge (28b) quand un niveau d'eau prédéterminé (288) est atteint dans le réservoir et un moyen pour ramener de façon convenable le moyen d'actionnement (280) au moyen de captage (260).

17. Séparateur selon l'une quelconque des revendications précédentes, comprenant un moyen (220) pour chauffer le combustible dans le réservoir.