Oct. 5, 1965 E. A. PRIJATEL 3,209,995

COMBINATION PUMP AND SEPARATOR

Filed Dec. 15, 1961

Fig. 1

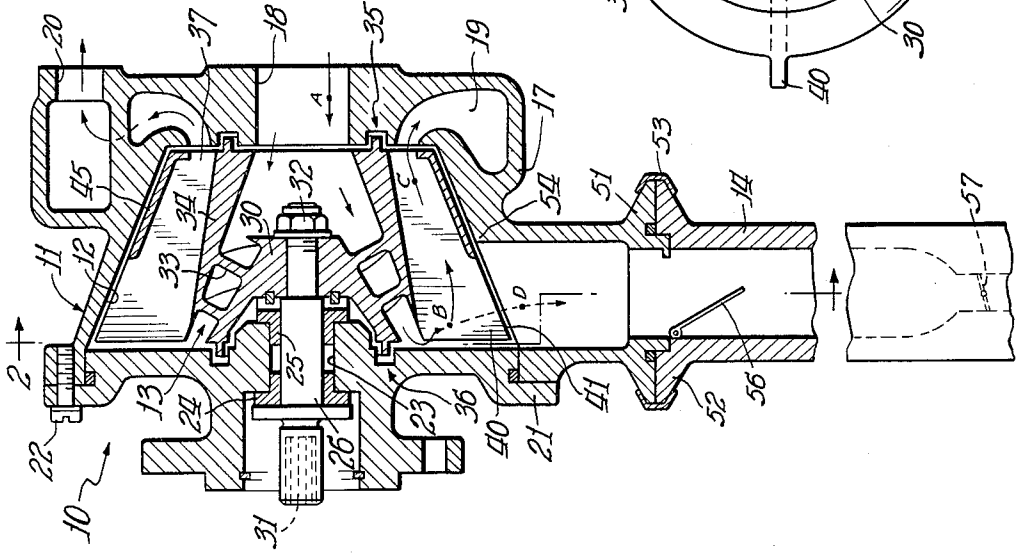


Fig. 3

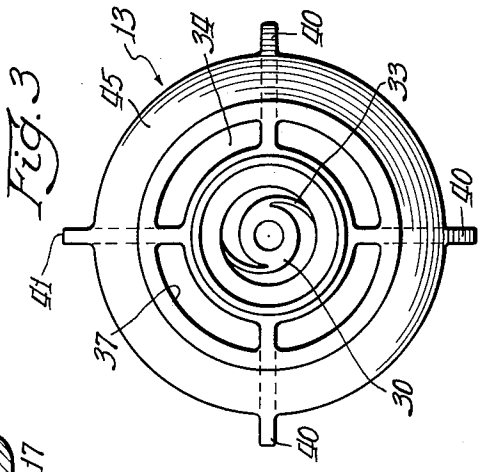
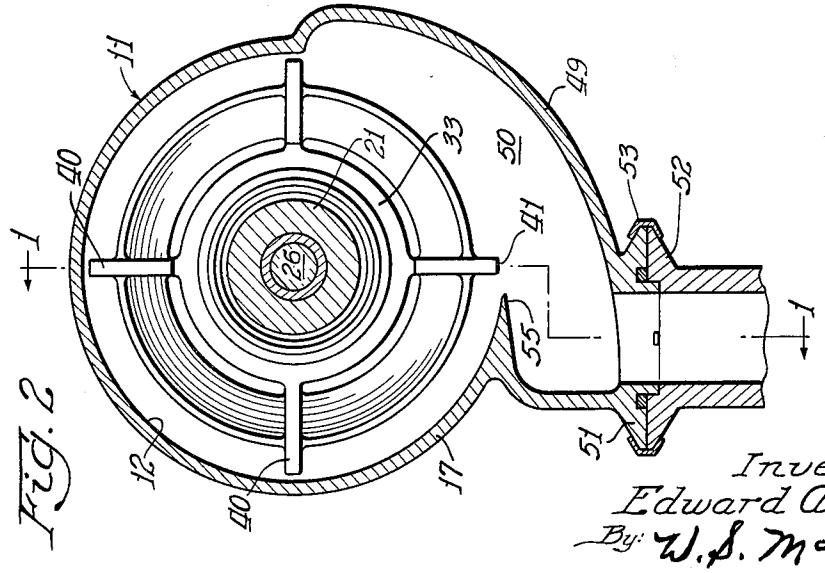


Fig. 2



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COMBINATION PUMP AND SEPARATOR

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This invention relates to a combination pump and separator. More specifically, this invention relates to a combined unit for pumping fuel containing both liquid and solid contaminants, and simultaneously separating the contaminants therefrom to provide a clean fuel supply.

To date, various devices have been employed for removing contaminants from fuel. Such prior art devices include, for example, the barrier or screen-type filter and the centrifugal revolving drum type separation unit, both of which exemplary devices have several disadvantages. First of all, these units are incapable of removing contaminants in immiscible liquid form, nor are they adapted to be purged of collected contaminants during continuous operation of said units. Moreover, it is often necessary to dissassemble these devices in their entirety in order to remove the contaminants accumulated therein.

Accordingly, this invention has as a major object to provide a combination pumping and separating unit which is effective in completely removing both solid and liquid contaminants and which may be purged of accumulated contaminants during operation. It is particularly useful for aircraft installations where in-flight dumping of the contaminants is particularly desirable.

Other objects of the invention will become apparent from the following specification and the drawings relating thereto, wherein:

FIGURE 1 is a sectional view of the combined pump and separator taken along line 1—1 of FIGURE 2;

FIGURE 2 is a sectional view taken on line 2—2 of FIGURE 1; and

FIGURE 3 is a top plan view of the impeller.

The combination pump and separator designated generally by numberal **10** includes a housing **11** providing a generally frusto-conical chamber **12**, an impeller **13** having the same general configuration of the chamber and a sump **14** for collecting contaminants separated from the fuel.

The housing **11** comprises a casing **17** having a central fuel inlet opening **18** at one end thereof, and a scroll-type fluid discharge passage **19** surrounding the inlet opening communicating with a discharge port **20**. At the oposite end of the housing **11** is a removable end closure **21** which is adapted to be secured to the housing by means of a plurality of bolts **22**. The closure **21**, which may be regarded as the base portion of the housing and together with the casing forms said housing, is provided with a central opening **23** to accommodate bearings **24**, **25** for the impeller shaft **26**.

The impeller **13** includes a central hub **30** of a generally conical shape, a shaft **26** connected to said hub and rotatably supported within the bearings **24**, **25**, and means associated with the shaft, preferably in the form of an internally splined section **31**, to connect the shaft with a suitable driving means (not shown). The impeller is shown as threaded onto the shaft and retained by a nut **32**. Associated with the hub are a set of spiral or helical vanes **33**. This portion of the impeller thus acts as a mixed flow pump which upon rotation draws the fluid into the housing. A central frusto-conical member **34**, integral with the vanes and carried thereby in surrounding relation, defines with said hub an inlet passage communicating with the central inlet and which may

be regarded as a first pumping stage to force fluid in a generally axial direction through the unit.

The seals shown at **35**, **36** serve to isolate the chamber from the other structure and may be of any well-known construction. Seal **35** prevents fluid from by-passing the separation area by flowing between the frusto-conical member **34** and the casing **17** directly out the discharge scroll. Seal **36** prevents leakage of fuel into the bearings **24**, **25**. A plurality of radial blades **40**, carried by said frusto-conical member **34**, extend generally axially and have straight edges **41** generally parallel to and adjacent the chamber wall **12**. This provides a fluid passage communicating with the scroll discharge outlet **19**.

The radial blades **40** are effective to increase the rotational velocity of the fluid pumped through the annular space between the frusto-conical member **34** and the hub **30** by the helical vanes **33**. As fluid is discharged through the annular space, the blades generate centrifugal force tending to impel the fluid against wall **12** of the chamber. The pumping effect from the axial flow impeller is sufficient to overcome the centrifugal force outwardly, forcing the fluid axially through the chamber into the discharge scroll or volute **19** through the annular space **37**. Since the outside diameter of the discharge outlet **37** is approximately equal to or slightly less than the outside diameter of the axial flow impeller, the denser materials can not overcome the centrifugal force imparted thereto and are effectively prevented from being carried along by the fluid stream into the discharge volute. This arrangement provides an efficient means for separating contaminants and assures a clean, contaminant-free effluent. It is preferred that a generally circular shroud member **45** be carried by the outer ends of said blades **40** to provide a rotatable inclined wall adjacent the scroll outlet for reasons which will be apparent in the following description.

The housing **11** is formed with an enlarged peripheral wall portion **49** adjacent the base **21** providing a cavity **50** which is tangentially oriented with respect to the chamber. This cavity **50** forms a contaminant discharge outlet extending from said casing and communicating with the sump **14**. The terminal portion of said discharge outlet is provided with a flange **51** adapted to be connected to flange **52** on the sump **14** by a conventional collar **53**. Ordinarily the unit is disposed so that the cavity and the sump are below the pump and separator to facilitate separation. The contaminants are thus acted on by the force of gravity in addition to the centrifugal forces resulting from their rotation.

The width of the cavity is approximately half the axial length of the blades **40** and is preferably wide enough to allow the shroud to slightly overlap the shoulder **54**.

OPERATION

The contaminated fuel from tanks in an aircraft, for example, is pumped or fed by gravity to the central fuel inlet. The path of the fuel is shown in FIGURE 1 by arrows, and various points along the path are designated by the reference letters A, B, C, and D. As can be seen from FIGURE 1, fuel passes through the central fuel inlet to point A and thereafter through the inlet passage between the hub and the conical member. Contaminants in the fuel, which may be in solid and/or immiscible liquid form, begin to separate from the fuel during the passage from point A to point B inside the conical member. As the fuel reaches the point B, it moves radially outwardly and is subjected to even greater centrifugal force as the result of the higher rotational velocity of the blades **40**. The greater part of the separation takes place in the general vicinity of point B and the contaminants, being denser than the fuel, are carried tangentially by both

centrifugal force and gravity into the cavity 50 and finally into the sump 14. The separated contaminants are prevented from re-entering the chamber by the same forces which originally directed them to the sump. Because of the smooth inclined wall of the chamber 12 and the inclined shroud member 45, particles which are thrust thereagainst move outwardly and downwardly along the wall and shroud and are eventually discharged into the cavity 50. The fuel thus moves in a direction from B to C countercurrent to the contaminants deposited on the shroud and the wall and clean fuel is discharged through the annular space 37 between the shroud and the frusto-conical member 34 into the scroll discharge passage 19 where the rotational velocity of the fluid is transferred into pressure head for discharge through discharge port 20 in fluid communication with the scroll discharge passage. The passage of fluid from point B to point C is of relatively low velocity, thus offering little resistance to the contaminants moving in the opposite direction.

Under certain flight conditions, the unit may be subjected to inversion or negative *g* forces which would tend to force the contaminants, previously deposited in the sump, back into the chamber 12. Accordingly, a check valve 56 has been provided of any well-known construction, between the contaminants discharge port and the sump, which valve is adapted to close if the unit is subjected to such forces. This valve is optional since it is possible to design the unit so that the centrifugal force generated within the chamber 12 is of sufficient magnitude to overcome any tendency for the contaminants to re-enter the chamber.

It is possible to purge the pump by merely opening a dump valve 57 in the bottom of the sump and allowing the fuel head to force the contaminants out through the dump valve. In the case of an aircraft installation, the sump is replaced by a conduit leading outside the air frame. The dump valve is then controlled from some remote place, such as the cockpit, by any well-known operating means, thus permitting in-flight purging. This eliminates ground servicing as required by other contaminant-removal devices. In the event flight purging is not desirable, it is possible to purge the pump with the aircraft grounded and the engines idle by utilizing the fuel head which may be present, or the head produced by the tank-mounted boost pumps. Only a small head is required to purge the unit, and with proper design of the sump, only a minimum quantity of fuel is needed to completely purge the pump of the collected contaminants.

It may also be desirable to use a heater (not shown) associated with the sump and/or the housing. Since a large portion of the contaminants may comprise ice, it has been found desirable to melt the ice rather than leave the water in the solid state. It will be noted in FIGURE 2 that a projection 55 is provided within the housing adjacent the cavity 50. This projection assists in breaking up relatively large pieces of ice which are separated from the fuel. The blades 40 also promote the disintegration and comminution of large solid particles.

It is to be expressly understood that this invention, in its broadest interpretation, comprises an arrangement for the separation of denser materials from a fluid stream. While I have disclosed a specific embodiment of the invention, it is not to be so limited to the specific combination pump and separator described.

Also, it will be understood that many changes and modifications will be made without departing from the spirit and scope of the invention and that the invention is designed to be comprehended within the scope of the appended claims which should be given a scope consistent with the prior art.

I claim:

1. A combined pump and separator for contaminated fluid comprising a housing having a generally frusto-conical shaped chamber therein, means defining a central fluid inlet in said housing communicating with said chamber, a scroll-type fluid discharge passage generally surrounding said inlet and communicating with said chamber, said chamber having a generally smooth peripheral wall diverging towards an enlarged base portion of said housing, an impeller, means in said base portion for rotatably supporting said impeller within said chamber, said impeller including a conically shaped hub member, the axis of which is generally aligned with said inlet, a frusto-conical member having its converged end in sealing relation with said inlet and spaced from and generally surrounding said conical hub, spiral vanes between said conical hub and said frusto-conical member providing a first stage pump means, and a plurality of blades extending radially outwardly from and carried by said frusto-conical member, said blades having edges adjacent to and generally parallel with said chamber wall, said blades providing a centrifugal separating means between said frusto-conical member and said chamber wall; means defining a peripheral cavity in said housing, said cavity being tangentially disposed to said chamber and adjacent to the base portion of said housing, a downwardly depending sump communicating with said cavity, whereby fluid is drawn through said inlet into said first stage pump means and discharged through said centrifugal separating means into said scroll-type discharge passage while contaminants are separated from the fluid and discharged tangentially outwardly into said cavity and sump.

2. A combined pump and separator for contaminated fluid comprising a housing having a generally frusto-conical shaped chamber therein, means defining a central fluid inlet in said housing communicating with said chamber, a scroll-type fluid discharge passage generally surrounding said inlet and communicating with said chamber, said chamber having a generally smooth peripheral wall diverging towards an enlarged base portion of said housing, an impeller, means in said base portion for rotatably supporting said impeller within said chamber, said impeller including a conically shaped hub member, the axis of which is generally aligned with said inlet, a frusto-conical member having its converged end in sealing relation with said inlet defining means and means spacing the same from and generally surrounding said conical hub, said spacing means comprising spiral vanes between said conical hub and said frusto-conical member providing a axial flow pump means, a plurality of blades extending radially outwardly from and carried by said frusto-conical member, said blades having edges adjacent to and generally parallel with said chamber wall, said blades providing a centrifugal separating means between said frusto-conical member and said chamber wall, and a shroud member carried by the edges of said blades adjacent the converged end of said chamber; means defining a peripheral cavity in said housing, said cavity being tangentially disposed to said chamber and adjacent to the base portion of said housing and a downwardly depending sump communicating with said cavity, whereby fluid is drawn through said inlet into said axial flow pump means and discharged through centrifugal separating means into said scroll-type discharge passage while contaminants are separated from the fluid and discharged tangentially outwardly into said cavity and sump.

3. A combined pump and separator for contaminated fluid comprising a housing having a generally frusto-conical shaped chamber therein, means defining a central fluid inlet in said housing communicating with said chamber, a scroll-type fluid discharge passage generally surrounding said inlet and communicating with said chamber, said chamber having a generally smooth peripheral wall diverging towards an enlarged base portion of said housing, an impeller, means in said base portion for rotatably supporting said impeller within said chamber, said impeller including a conically shaped hub member, the axis of which is generally aligned with said inlet, a frusto-conical member having its converged end in sealing relation with said inlet and spaced from and

generally surrounding said conical hub, spiral vanes between said conical hub and said frusto-conical member providing a axial flow pump means, and a plurality of blades extending radially outwardly from and carried by said frusto-conical member, said blades having edges adjacent to and generally parallel with said chamber wall, said blades providing a centrifugal separating means between said frusto-conical member and said chamber wall; means defining a peripheral cavity in said housing, said cavity being tangentially disposed to said chamber and adjacent to the base portion of said housing, a downwardly depending sump communicating with said cavity, and a dump valve in the bottom of said sump, whereby fluid is drawn through said inlet into said axial flow pump means and discharged through said centrifugal separating means into said scroll-type discharge passage

while contaminants are separated from the fluid and discharged tangentially outwardly said cavity and sump.

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