United States Patent

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[72] Inventor **Henry J. Langlois**
Detroit, Mich.

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[73] Assignee **American Standard Inc.**
New York, N.Y.

[54] **OIL MIST ELIMINATOR FOR A FLUID DRIVE**
9 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **55/186,** 55/350, 55/423, 55/467, 55/482, 55/505, 55/DIG. 19, 55/25, 60/54, 210/DIG. 5
[51] **Int. Cl.** **B01d 19/00**
[50] **Field of Search** ..... 55/DIG. 25, 350, 482, 259, 423, 186, 467, 505, 521, DIG. 19; 60/54; 210/DIG. 5

[56] **References Cited**

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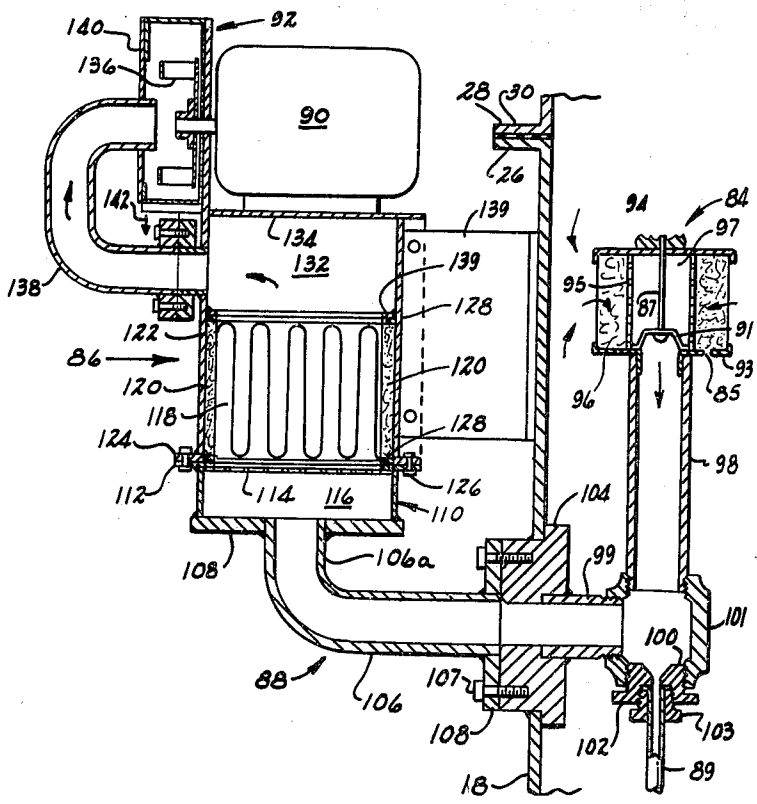
2,521,785 9/1950 Goodloe 55/482

Primary Examiner—S. Leon Bashore
Assistant Examiner—Saul R. Friedman
Attorneys—John E. McRae, Tennes I. Erstad and Robert G. Crooks

ABSTRACT: A fluid drive wherein the runner and impeller assemblies are disposed within a nominally closed tank which defines an oil sump. A fan-filter unit assembly is provided for drawing oil mist from the tank interior through the filter unit, whereby a partial vacuum is established within the tank interior which prevents the mist from leaking into the surrounding atmosphere through small joints in the housing and protruding shafts. The fan-filter unit comprises an oil coalescing device in an upstream portion of the fan-filter unit and a fine mesh filter for trapping fine oil mist droplets which pass through the coalescing device without undergoing coalescence. The coalescing device and fine mesh filter are interconnected by a conduit which has a drain line for draining the coalesced oil droplets into an oil sump.



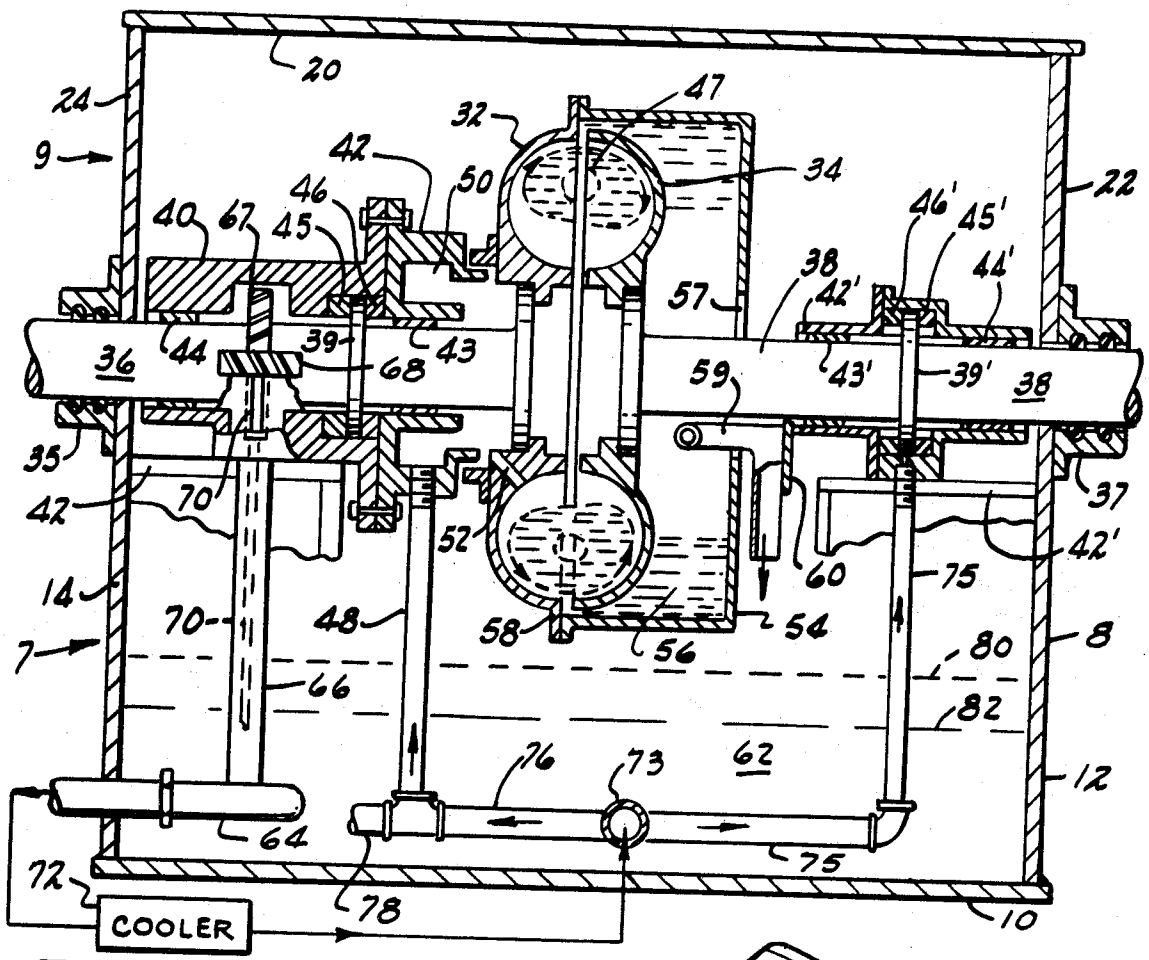


FIG_1

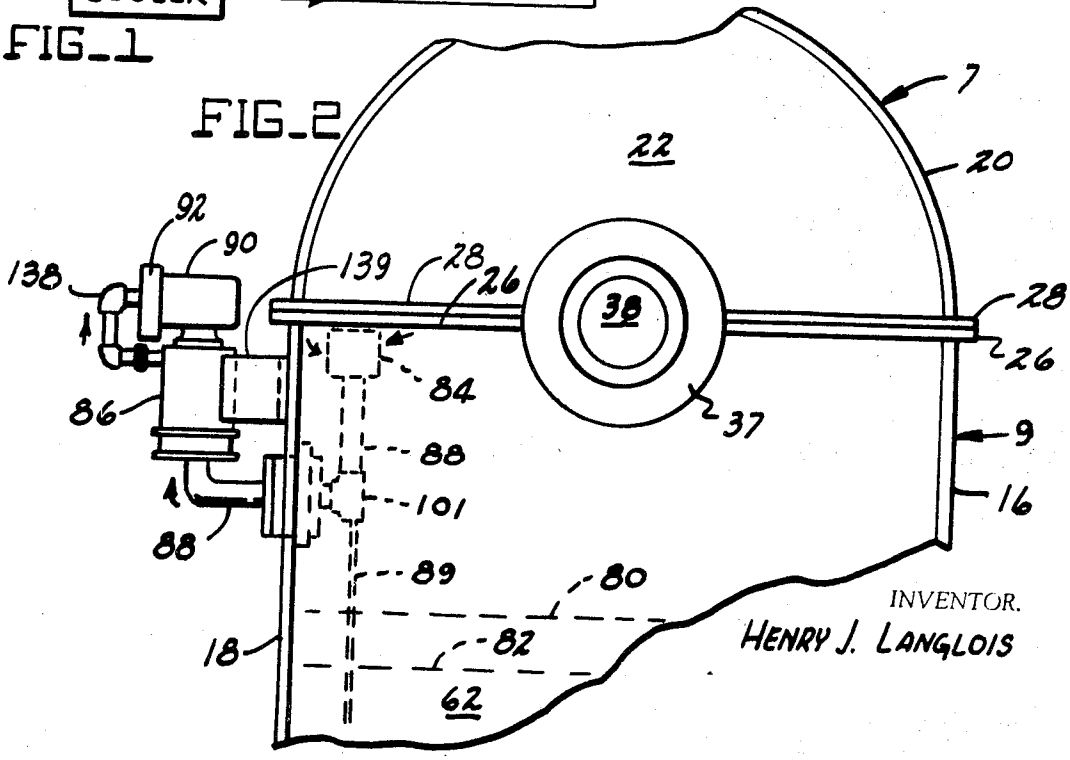


FIG_2

INVENTOR.
HENRY J. LANGLOIS

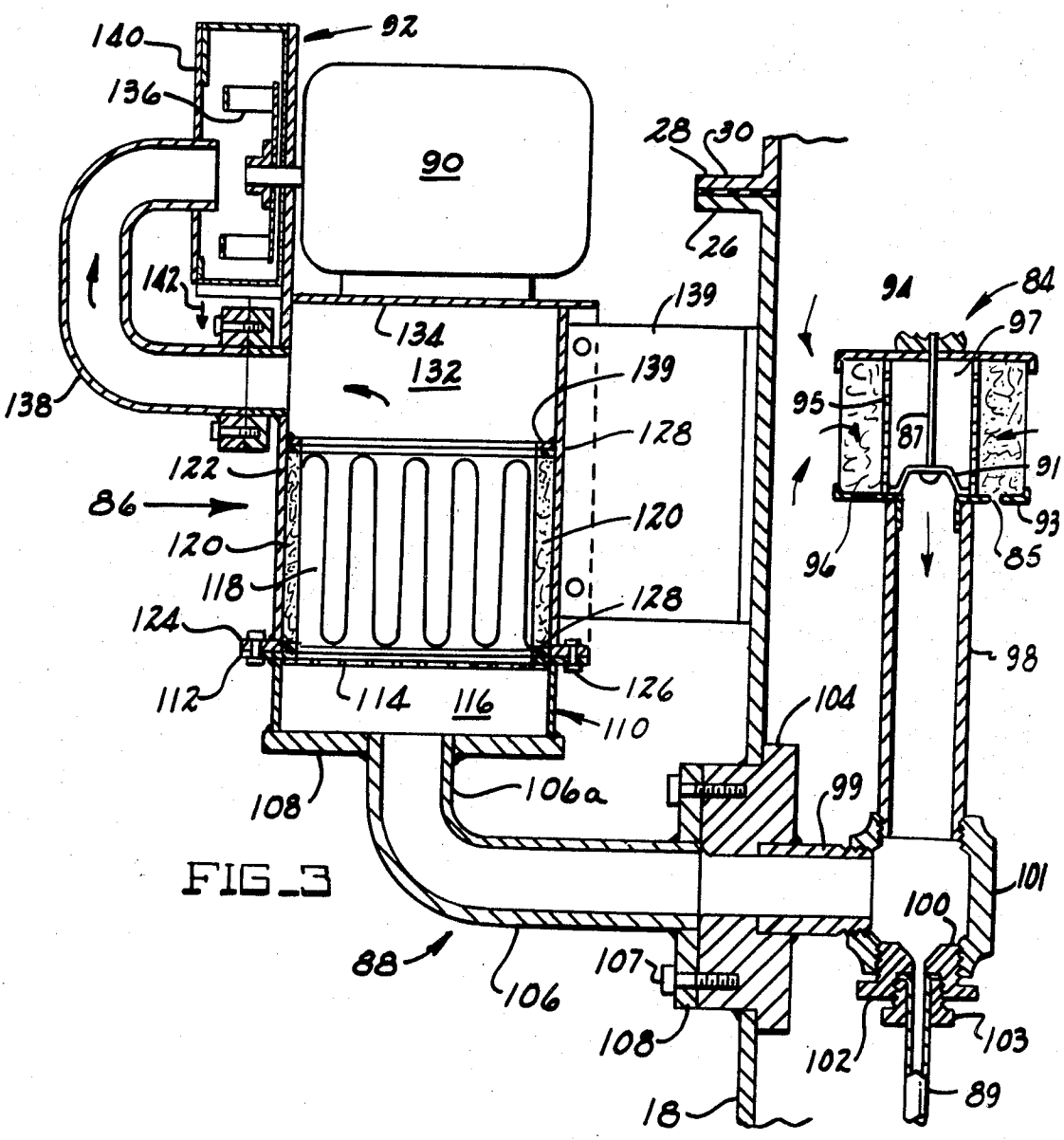


FIG_3

INVENTOR.
HENRY J. LANGLOIS

OIL MIST ELIMINATOR FOR A FLUID DRIVE

THE DRAWINGS

FIG. 1 is a semischematic sectional view taken through a conventional fluid drive adapted to utilize the present invention.

FIG. 2 is a right end view of the FIG. 1 fluid drive.

FIG. 3 is an enlarged sectional view of a novel fan-filter unit utilized on the FIG. 1 fluid drive.

THE DRAWINGS IN DETAIL

FIG. 1 illustrates a conventional fluid drive of the type commonly used in power stations, boilers, liquid pump stations, etc. to transmit a rotary drive from a power source, usually an electric motor, to a driven load such as a large fan, liquid pump, etc. The general operation of this type equipment is described for example in U.S. Pat. No. 3,200,594 issued in the name of E. R. Braun.

As shown in FIG. 1, the fluid drive includes a large tank formed by a lower tank sump secton 7 and an upper tank cover section 9. Section 7 comprises a bottom wall 10, two end walls 12 and 14, two sidewalls 16 and 18 (FIG. 2). Cover section 9 includes an arcuate top wall 20 and semicircular end walls 22 and 24 aligned with the end walls 12 and 14. The various walls on cover section 9 and tank section 7 are flanged, as at 26 and 28 (FIG. 2), so that suitable bolts (not shown) can be extended through holes in the flanges to connect the two tank sections together; a gasket 30 (FIG. 3) may be interposed between the mating flanges to better seal the flange joints.

Disposed within the tank are confronting vaned impeller and runner shells 32 and 34 carried on an impeller shaft 36 and runner shaft 38. As will be appreciated, shaft 36 extends through one end wall of the tank for connection to the power source, such as an electric motor, and shaft 38 extends through the other end wall of the tank for connection with a load device such as a large fan or pump.

Shaft 36 is supported and mounted in a baring cage 40 suitably secured to a stationary platform 42. Cage structure 40 comprises an annular liquid housing 42 which mounts a radial bearing 43; a second radial bearing 44 is carried in the main part of bearing cage 40. Axial thrust loads are carried by thrust bearings 45 and 46 engaged with the enlarged shaft flange 39. Shaft 38 is supported in generally the same manner as shaft 36, and corresponding numerals are therefore used where applicable.

During operation oil from the bearings and the tank atmosphere tends to collect on the shaft surfaces 36 and 38, and to escape into the atmosphere surrounding the tank. Conventional shaft seals 35 and 37 (O-ring, labyrinth, screw type, etc.) may be provided to minimize such oil escapage.

OIL CIRCULATION

In the illustrated arrangement oil is supplied to the impeller-runner work chamber 47 through an oil supply line 48. The oil is fed from line 48 into the immovable annular chamber 50, and ultimately through ports 52 in the impeller 32 for admission to the work chamber 47. Impeller 32 carries a scoop chamber casing 54 which defines a scoop chamber 56. During operation oil continually escapes from the work chamber 47 into the scoop chamber 56 through the space 58 between the impeller and runner elements; the radial thickness of the liquid ring in the scoop chamber 56 determines the quantity of liquid in chamber 47 and hence the power transmitted from shaft 36 to shaft 38.

Control of the liquid ring thickness in chamber 56 is conventionally achieved by means of a scoop tube 59, shown mounted on a plate 60. In practice plate 60 is affixed to a control rod, not shown, that extends through one of walls 16 and 18. Horizontal movement of the control rod by an automatic controller responsive to some parameter such as flow, pressure, temperature, etc., effects movement of the scoop tube 59 horizontally, i.e. normal to the plane of the paper. The controller thereby causes the scoop tube to control the radial

thickness of the liquid ring in chamber 56, as by scooping variable liquid quantities from the inner skin of the liquid ring; the scooped liquid is discharged into the subjacent sump 62.

Disposed within sump 62 is a liquid pump housing 64 attached to a rigid tube 66 that depends from the stationary structure 42 or 40; and rotary shaft 70 extends vertically within tube 66. Impeller shaft 36 may be provided with a helical gear 67 that meshes with a similar gear 68 carried on the rotary shaft 70. The lower end of shaft 70 carries the pumping element (meshed gears or vaned rotor) disposed within pump housing 64. The pumping element is thus gear-driven by the impeller shaft 36 at a constant speed, or at whatever speed the shaft is operating. Pump 64 pumps oil from sump 62 through an external cooler 72 and back to a supply pipe 73 that extends through the wall of the tank. Pipe 73 distributes part of the oil to a pipe 75 which leads to the bearings for shaft 38. A second pipe 76 delivers oil to the aforementioned pipe 48 and another pipe 78; pipe 78 delivers lubricant to the bearings for shaft 36 in a somewhat similar fashion to pipe 75.

A typical fluid drive of about 4,000 hp. would require about 500 gallons of oil. Pump 64 would be pumping perhaps 300 gallons per minute, sufficient to keep the oil from overheating due to the heat generated in work chamber 47. Usually the oil temperature should be kept below about 180° F. The pump is therefore chosen on the basis of temperature and the cooling capacity of cooler 72(air or water-cooled). During operation the sump 62 oil level may vary between a high level designated by numeral 80, and a lower level designated by numeral 82. Some of the system oil is within work chamber 47 and scoop chamber 56, and some of the system oil is flowing through cooler 72. Pump 64 operates on a continuous basis.

FLUID DRIVE OPERATION

The power transmitted from shaft 36 to shaft 38 is dependent on the quantity of oil in work chamber 48, and that quantity is determined by the radial thickness of the liquid ring in scoop chamber. Conventional scoop tube 59 is movable radially within the scoop chamber to control the liquid ring thickness and consequently the scoop chamber fill. Adjustment of the scoop tube therefore varies the power transmission and hence the speed of output shaft 38 from zero up to approximately the input shaft speed (less about 3 or 4 percent slip at maximum work chamber filling).

Full acceleration or deceleration of the output shaft (between zero and maximum speed) usually takes something on the order of 15 seconds because the pump is supplying oil to line 48 at nearly the same rate as oil is being removed by the scoop tube. Partial speed change is accomplished in a shorter time span, but for every speed change required there is some time interval between initial movement of the scoop tube and attainment of the desired speed. During this time interval the mass oil flow through scoop tube 59 varies according as it is moving into or out of the liquid ring. During deceleration periods the scoop tube is discharging increased oil quantities into the sump, thereby tending to raise the sump level; during acceleration periods the scoop tube is discharging lesser oil quantities into the sump, thereby tending to lower the sump level. In a typical fluid drive the combined liquid capacity of work chamber 47 and scoop chamber 56 might be about 130 gallons. Full speed change (between zero runner speed and maximum runner speed) might vary the sump 62 level 4 or more inches (depending on the capacity of chambers 47 and 56).

The exterior surfaces on impeller 32 and scoop chamber housing 54 are not perfectly smooth. For example, these members may have projecting bolt heads, ribs, etc. that interrupt the surface contours. Such surface interruptions tend to act as small fan blades and to produce a beating action of the tank air on the sump liquid. The result is a certain amount of foaming on the sump oil surface and the formation of a fine oil mist in the space above the oil surface. The extreme oil turbulence in chambers 47 and 56, together with high oil temperatures,

also cause some oil mist that escapes through the eye **57** of housing **54**. Further mist apparently forms due to the splashing of liquid from scoop tube **59** into the sump liquid, and the escape of oil past the shaft bearings. The mist is objectionable in that it can under certain conditions escape through the shaft seals **35** and **37** or through other joints so as to pollute the surrounding atmosphere and form slippery unsafe films on walkways, etc. The sump foam is objectionable in that it interferes with proper mass flow through the oil system, and is not satisfactory for power transmission from the impeller to the runner.

Escape of oil mist from the tank is promoted by the fact that variation in sump **62** level tends to produce a breathing action of the tank with respect to the surrounding atmosphere. Thus, when the sump **62** level is rising the air-oil vapor atmosphere above the sump liquid tends to be exhausted or vented through any cracks or joints in the housing; when the sump **62** level is falling the various joints tend to draw ambient air into the tank. The sump oil tends to act as a giant piston for alternately exhausting oil mist and taking in fresh air, thus producing a net outflow of objectionable oil mist and an increased foaming on the sump oil surface.

The principle joints or escape paths occur between the two shafts **36** and **38** and their respective shaft seals **37** and **39**. These shaft seals can be of any construction, as for example O-ring seals, labyrinth seals, or screw seals, or screw seals, but with known seal constructions there is usually some possibility of oil mist leakage from the tank interior to the ambient atmosphere. It is believed that oil mist can also penetrate the gasket **30** (FIG. 3) between the upper and lower tank sections; pressure differential between the atmosphere within and without the tank can promote a migration of minute oil droplets through the gasket to the surrounding ambient. At least some of the droplets are very minute, on the order of 1 micron or less.

THE INVENTION

The invention comprises a fan-filter unit connected to the tank for drawing oil mist from the tank interior and passing the mist through two filtering devices. These filtering devices remove the oil particles from the air being drawn out of the tank interior, and thus tend to reduce the quantity of oil mist in the upper portion of the tank. The fan-induced flow also tends to set up a partial vacuum within the tank interior which opposes the outward breathing action that would otherwise take place; thus the slight negative pressure in the tank interior prevents the vapor from escaping through the shaft seals **35** and **37** so as to pollute the surrounding atmosphere and/or form slippery surfaces in surrounding areas. Such oil films have been found to contaminate nearby machinery such as the windings of electrical motors and have created nuisances making them slippery under foot and a fire hazard. By using the present invention it is believed that escape of oil mists from the fluid drive tank will be minimized or eliminated.

As shown in FIG. **2**, the invention embodies an oil-filtering and coalescing device **84** within the tank, a fine mesh filter unit **86** outside the tank, and an interconnecting conduit **88** extending through the tank wall **18**. Positioned above the filter device **86** is a small electric motor **90** which powers the bladed rotor wheel of a centrifugal fan **92**. The fan action draws vapor from the tank interior through the coalescing device **84**, conduit **88**, fine mesh filter device **86** and conduit **138**. Very fine oil particles are trapped in filter device **86**; larger oil particles drain back into the sump **62** through a small drain line **89**.

FILTER—COALESCER 84

FIG. **3** illustrates in somewhat greater detail the construction shown in outline in FIG. **2**. As shown in FIG. **3**, the combination filter-coalescing device **84** comprises a small housing having a bottom wall **93**, a top wall **94**, and an intervening porous cylinder or tube **95**; a strap **91** is welded to wall **93** for reception of a hold-down bolt **87**. Surrounding the cylinder **95** is a mass of porous material **96**. This material may be formed of porous sintered metal as described for example in U.S. Pat. NO. 3,460,612 issued in the name of E. I. Valyi or U.S. Pat. NO. 3,439,739 issued in the name of U. R. Jacqer. Alternately the porous media can be formed by a strip of porous wire cloth or screen spirally wound on tube **95**, as shown for example in U.S. Pat. No. 1,729,135 issued in the name of H. Slauson. The material can additionally take the form of steelwool or crinkled wire as described for example in U.S. Pat. No. 1,896,640 issued in the name of T. G. Moulding.

Preferably the porous media **96** has a pore size somewhat in excess of 1 micron. Small oil droplets are thereby enabled to pass through the media into the central space **97** within tube **95**. During their passage through media **96** the small particles strike the cell walls thereby tending to decelerate. The next-following oil particles impinge against the decelerating particles so that particles coalesce or agglomerate into oil films on the cell wall surfaces. Eventually some of the large droplets of oil tear away from the films and pass into the central space **97**; some droplets pass back into the sump through drain holes **85**.

CONDUIT 88

Entraining air and oil droplets flow downwardly through pipe section **98** into a horizontal pipe section **99**, at which point some of the entrained oil droplets separate out of the stream by inertia separator action. Such separated droplets collect on the upper interior surface **100** of a plug **102**, which threads into a pipe coupling **101**. Eventually the droplets gravitate downwardly through a drain line **89** and into the subjacent sump **62**, as better shown in FIG. **2**. A second plug **103** may be provided to removably position the drain line in place, and to permit disassembly for cleaning.

Pipe section **99** is welded to a mounting plate **104** that is in turn welded to the tank wall **18**. Plate **104** thus supports the pipe **99**, pipe **98**, and filter-coalescing device **84**. Plate **104** releasably mounts an attachment plate **108** for a conduit **106** which is fixedly connected to the bottom wall **108** of a boxlike housing section **110**.

FILTER DEVICE 86

Housing section **110** includes a horizontal flat picture frame **112** having a diffuser plate **114** welded to its under face. Housing section **110** forms a plenum chamber **116** that reduces the linear velocity of the air-mist mixture that emerges from conduit **106**. Diffuser plate **114** exerts a resistance on the individual streams flowing through the diffuser plate openings and thereby tends to equalize the vapor flow from the plenum chamber into the sinuous filter media designated by numeral **118**. The purpose in thus equalizing the flow is to allow the various surface areas of the media to each perform a filtering action without early plug-up of some media areas and without possible reentrainment of collected particles due to high localized supply pressures.

Filter media **118** is preferably a conventional filter material obtainable from American Air Filter Company of Louisville, Ky. under the trade name "Astrocell." One suitable material is believed to be fine mesh woven fiber glass or gauze having a pore size less than 1 micron. The filter media is preferably disposed in a rectangular frame comprised of four vertical sidewalls **120**, constructed as shown for example in U.S. Pat. No. 2,415,579 issued to V. Dahlman or U.S. Pat. No. 2,907,407 issued to P. Engle or U.S. Pat. No. 3,183,286 issued to J. Harms.

Frame **120** is removably disposed within a vertical housing **122** having four flat vertical sidewalls suitably welded together to form a vertical tube of rectangular cross section. The lower edges of the housing walls are welded to a horizontal frame **124** that mates with aforementioned frame **112** of housing **110**; suitable bolts **126** may be extended through the mating frame walls to secure housing **110** and **122** together. Filter frame **120** is provided with gaskets **128** at its lower and upper edges for engagement with housing wall **112** and upper ledge

wall **130**. Thus, the gaskets **128** prevent the upflowing vapor from bypassing filter media **118**.

During passage through media **118** fine oil mist particles are captured by the media, while the cleaned air is drawn into an upper chamber **132** having an imperforate top wall **134** which mount conventional hub means, and is arranged within a scroll-shaped fan housing **92** so as to draw air from the U-tube **138**. As shown in the drawing, the U-tube may be attached to the housing **122** through conventional bolt-flange mounting devices. Preferably the fan housing is provided with a removable face plate **140** on its inlet face to seal the fan housing and thus insure that the fan draws air only from chamber **132**, not the surrounding atmosphere. The fan discharge is not shown in the drawing, but the direction of discharge is indicated by numeral **142**. Fan housing **92** can be mounted in any suitable fashion; in the illustrated arrangement the left sidewall of housing **122** is extended vertically upwardly to form a mounting surface for the fan housing. The assembly comprising housing **120**, motor **90**, fan **92**, and tube **138**, may be supported by a bracket **139** welded to tank wall **18**.

GENERAL FILTER OPERATION

Fan rotor **136** draws air from the fluid drive tank via a passage system that includes coalescing device **84**, U-tube **88**, and filter media **118**. This action produces a slight negative pressure in the tank which prevents the tank vapor from being forced past the shaft seals **35** and **37** or other joints. The negative pressure also helps reduce oil foaming in the sump.

Device **84** functions to filter out very large solid particles and liquid droplets. Additionally the pores of device **84** act as fluid drag surfaces for changing the finer oil mist particles into oil films; oil droplets tear off these films but as relatively large size droplets which eventually drain into line **89**.

Any fine droplets that escape the coalescing action in device **84** are trapped by media **118**.

REMOVAL OF COALESCED DROPLETS

Conduit sections **98** and **106** have appreciably smaller flow areas than the flow area through filter device **84** or filter device **118**. The vapor stream therefore has a relatively slow velocity while passing through devices **84** and **118**, and a relatively high velocity while passing through the U-shaped conduit **88**. The high velocity in conduit **88** preferably provides sufficient turbulence to achieve some additional coalescing effect by impingement of droplets against one another.

Coalesced droplets produced in device **84** and/or the U-shaped conduit tend to impact against the walls of conduit sections **98**, **99** and **106**, especially at points where the stream changes direction. Such directional changes occur principally at the juncture between conduit sections **98** and **99**, and the juncture between the horizontal portion of conduit section **106** and the upflow portion **106*a***. During each of these directional changes the relatively heavy oil droplets tend to maintain their original directions and to thus separate out of the turning air stream by inertial separator action. The upflow section **106*a*** also tends to achieve some further droplet separation due to gravity effects.

Drain line **89** connects with the U-shaped conduit **88** at its lowest point. Therefore oil droplets impacting onto the conduit surfaces can gravitate into drain **89** and thence into sump **62**. Preferably drain line **89** is a fairly small diameter line, as for example ¼ inch. With a small diameter line the stagnant liquid film lining the inner surface of the drain tube tends to exert surface tension on the central tube liquid in a manner resisting upward lift of liquid by the suction action of fan **92**. The small diameter line also has a small volume of vapor therein so that the line does not contribute any appreciable numbers of droplets of submicron size to the stream flowing through conduit **88**. As a result the filter media **118** does not tend to clog with particles quite so quickly. In practice the aim is to achieve 1-year service life between each change of media **118**.

REPLACEMENT OF FILTER **86**

The assembly comprising plenum housing **110** and vapor supply conduit **106** is removably disposed between filter housing **122** and mount plate **104**. The assembly can be removed by removing the various bolts **107** and **126**. Thereafter the filter cartridge **120** can be removed from housing **122** by lowering same through the housing lower end. A new filter cartridge can be installed by the reverse process.

I claim:

1. In a fluid drive comprising a closed tank defining an oil sump; an impeller-runner assembly comprising confronting vaned impeller and runner shells disposed within the tank, an impeller shaft extending through one wall of the tank, and a runner shaft extending through another wall of the tank: the improvement comprising means for preventing oil mist from escaping from the tank into the surrounding space; said escape-prevention means comprising a filter unit connected to the tank, and fan means for moving oil mist from the tank interior through the filter unit; said filter unit comprising an oil coalescing device in the upstream portion of the unit, means for draining coalesced oil droplets into the oil sump, and a fine mesh filter device for trapping such fine mist droplets that pass through the coalescing device without undergoing coalescence.

2. The arrangement of claim **1** wherein the oil coalescing device and drain means are disposed within the tank, and the fine mesh filter device is disposed outside the tank.

3. The arrangement of claim **1** wherein the fine mesh filter device is an upflow unit whereby oil droplets can gravitate back toward the drain means without tending to plug the filter device.

4. The arrangement of claim **1** wherein the coalescing device and fine mesh filter device are interconnected by a conduit that has an appreciably smaller flow area than the flow area of either device, whereby the mist experiences increased turbulence while flowing through the conduit.

5. The arrangement of claim **4** wherein the interconnecting conduit includes a downflow section coming from the coalescing device and an upflow section leading to the fine mesh filter device.

6. The arrangement of claim **5** wherein the drain means comprises a drain line connected with the interconnecting conduit at a point between the downflow section and upflow section, whereby the drain line can receive oil droplets from both conduit sections.

7. The arrangement of claim **1** wherein the coalescing device and filter device are interconnected by a flow conduit having sufficient flow area to permit the fan to produce a partial vacuum within the closed tank; said drain means comprising a drain line extending downwardly from the conduit into the sump liquid, said drain line having a sufficiently small flow area that the fan is unable to produce any appreciable liquid lift action on the drain line liquid.

8. The arrangement of claim **1** wherein the fine mesh filter device comprises an upflow housing having an upper media-containment section, and a lower plenum-forming section; said lower housing section being detachable from the upper housing section to permit removal and replacement of the filter media.

9. The arrangement of claim **8** and further comprising a diffuser means arranged in the lower housing section to equalize vapor flow from the plenum chamber to different sections of the filter media.

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