United States Patent [19]

Aronson et al.

[11] **3,860,364**

[45] **Jan. 14, 1975**

[54] **PUMP-COMPRESSOR SYSTEM**

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[22] Filed: **Aug. 22, 1973**

[21] Appl. No.: **390,575**

Related U.S. Application Data

[63] Continuation of Ser. No. 161,166, July 9, 1971, abandoned.

[52] **U.S. Cl.** **417/204,** 417/441, 418/97

[51] **Int. Cl.** **F04b 1/00**

[58] **Field of Search** 418/97, 15, 85; 417/441, 417/211.5, 26, 77, 204

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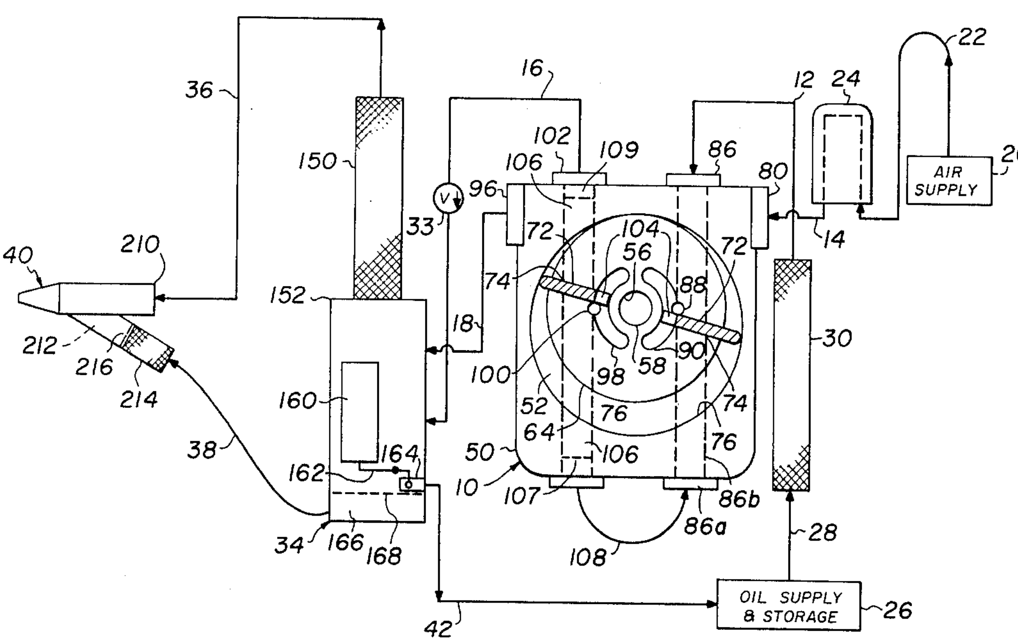
[57] **ABSTRACT**

A self priming pump-compressor system is provided which includes a pump-compressor combination which performs simultaneously as a gas compressor and as a hydraulic pump having separate inlets and outlets for gas being compressed and liquid being pumped, and liquid recycling means for effecting self-priming of the combination. In addition, a system is provided for atomizing a liquid in a gas, such as oil in air, employing the self-priming pump-compressor system in combination with gas-liquid separation means and atomizing means.

2 Claims, 8 Drawing Figures



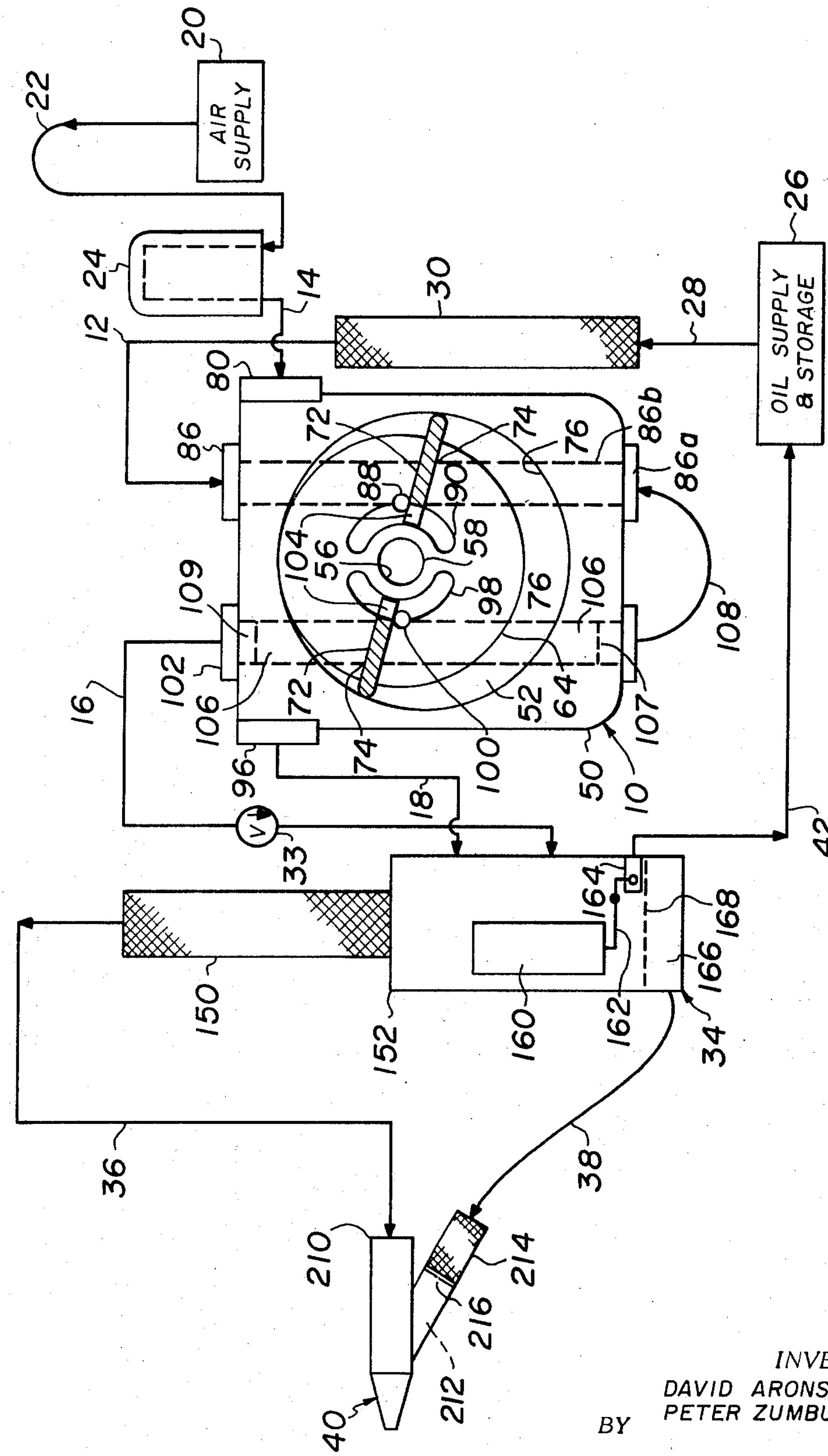


FIG. 1

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ATTORNEYS

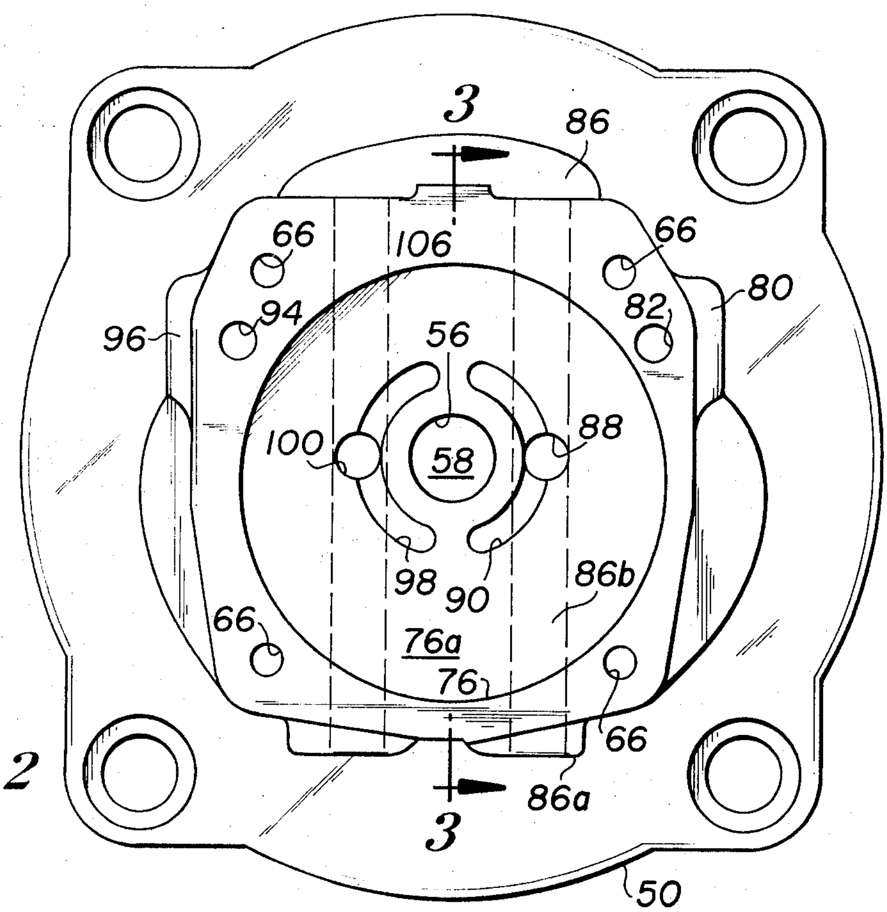

3
86
66
106
66
80
94
82
96
56
100
88
58
98
90
86b
66
76a
76
66
86a
3
50

FIG. 2

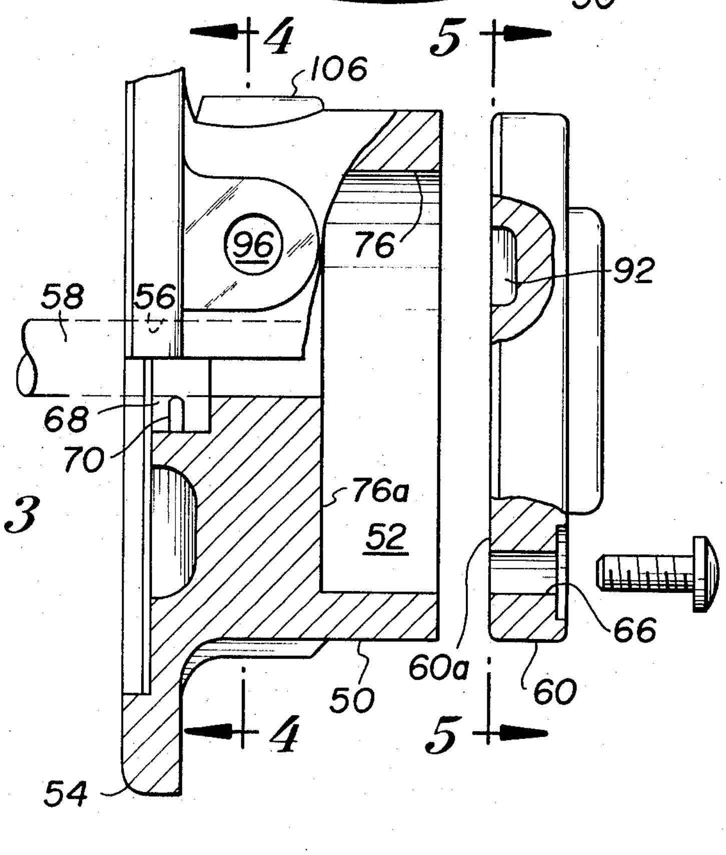

4
5
106
96
76
92
58
56
68
70
76a
52
66
60a
50
60
4
5
54

FIG. 3

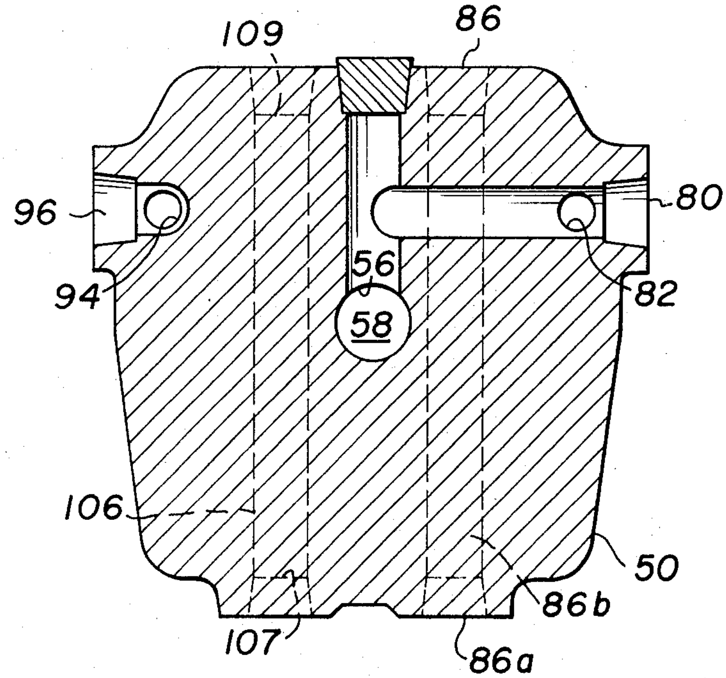
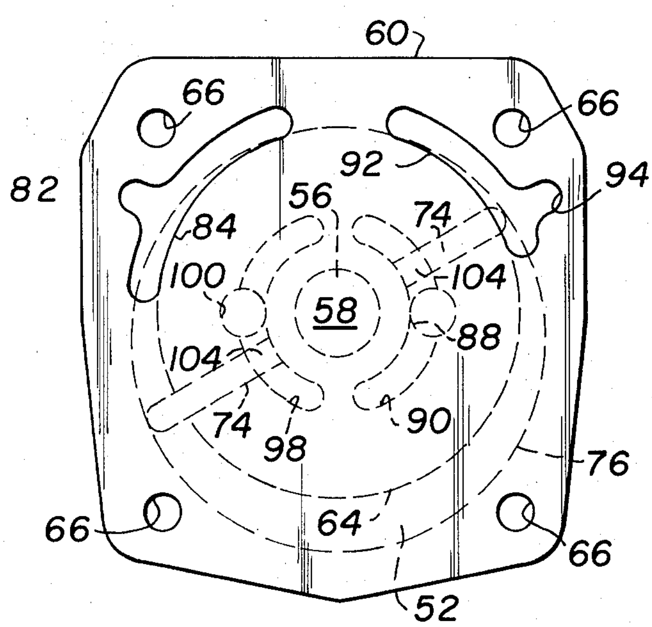

109
86
96
80
94
56
58
82
106
50
86b
107
86a

FIG. 4


60
66
66
82
92
94
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84
74
100
104
58
104
88
74
98
90
76
66
64
66
52

FIG. 5

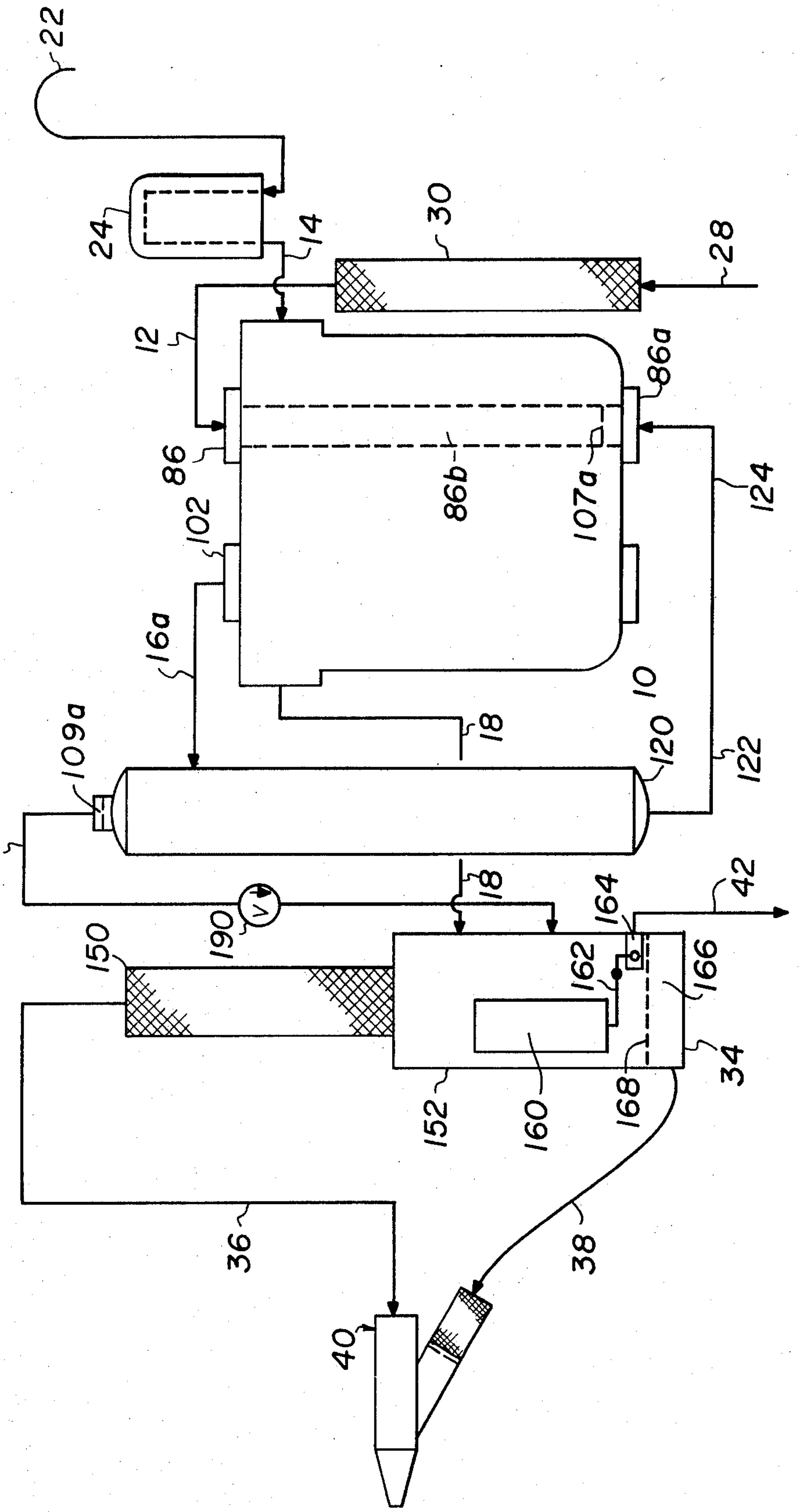
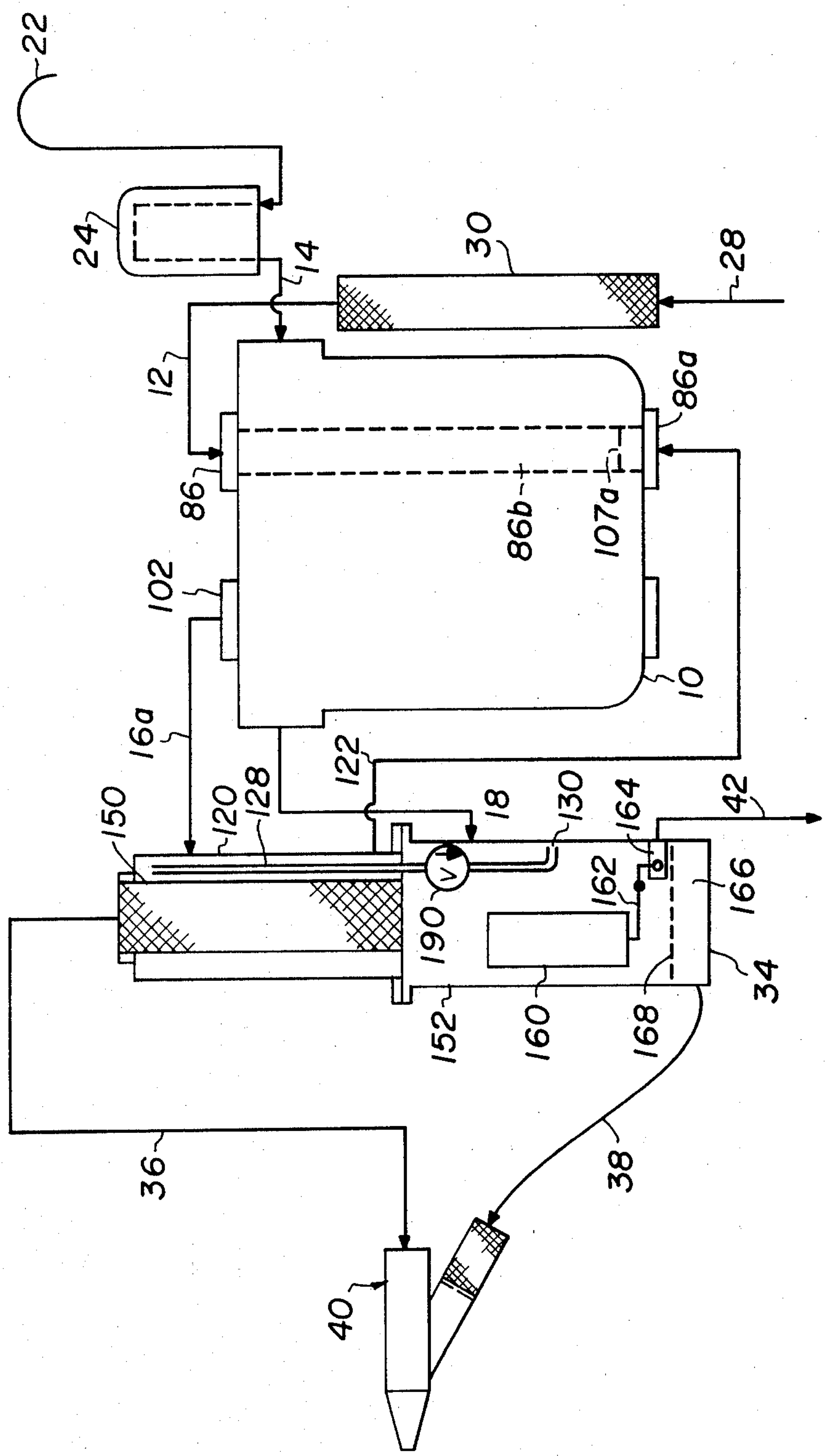

22
24
14
30
28
12
86a
86
86b
107a
124
102
16a
10
18
109a
120
122
126
18
42
164
190
150
162
166
34
152
160
168
36
38
40

FIG. 6


22
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86a
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107a
102
10
16a
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128
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34
152
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168
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36
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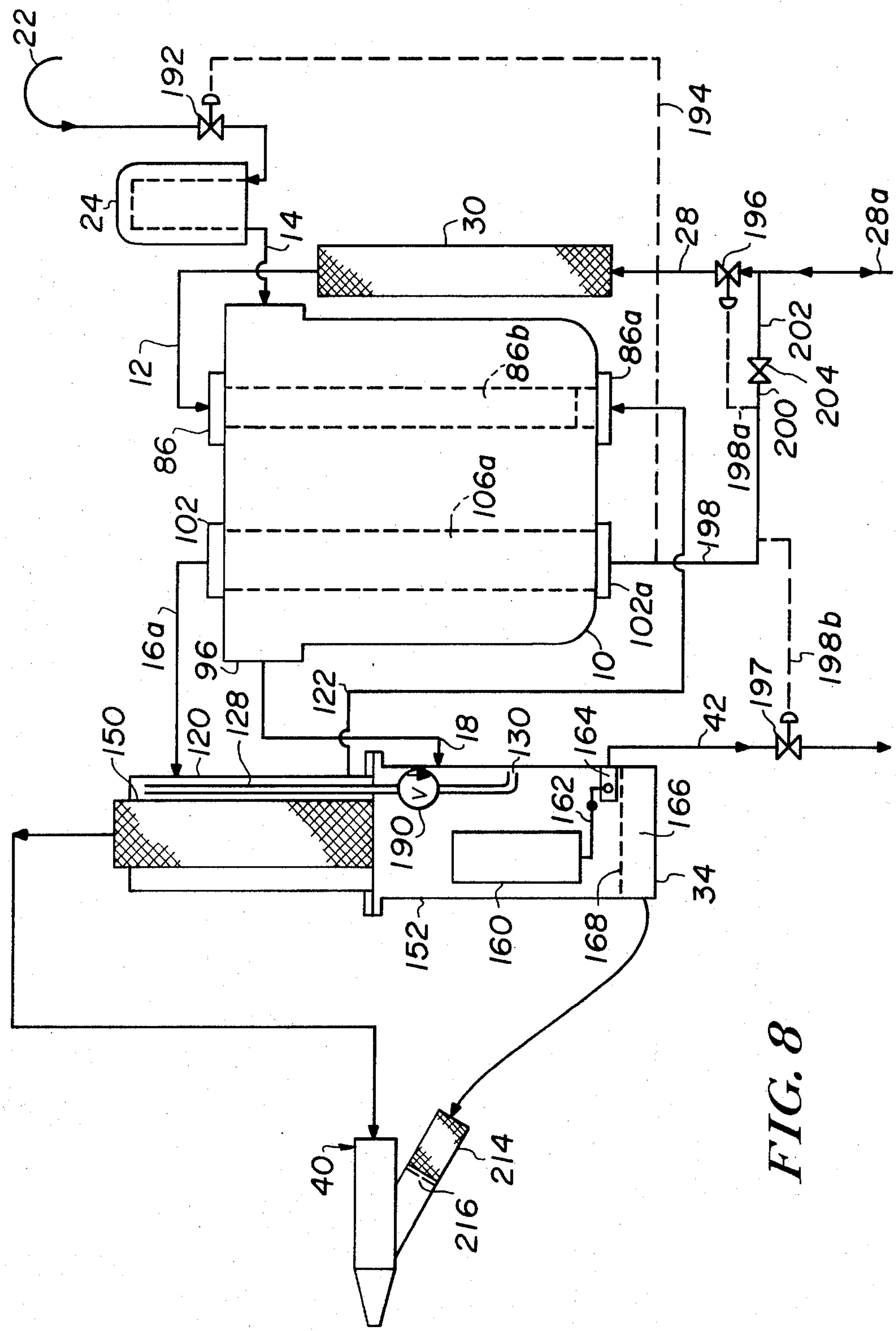
FIG. 7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192
194
24
14
30
28
196
28a
12
202
86b
86a
204
86
198a
200
106a
102
198
16a
102a
96
10
198b
122
150
120
128
18
130
164
42
197
162
166
190
34
152
160
168
40
214
216

FIG. 8

PUMP-COMPRESSOR SYSTEM

This application is a continuation of Ser. No. 161,166 filed July 9, 1971, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to a self-priming pump-compressor system for simultaneously compressing gas and pumping liquids, and to a gas-liquid atomizing system, such as an air-fuel oil atomizing system, for supplying fuel to oil burners, employing the self-priming pump-compressor system.

Until now, the compressing of gas and the pumping of liquid was primarily a two-step operation employing a compressor and a separate pump. Conventional compressors require a make-up supply of lubricant to keep moving components, such as metal fluid moving means, operational; alternatively, fluid moving means in the form of carbon vanes or blades could be employed which would not require lubricant, but, on the other hand, have a notoriously short life. Furthermore, carbon blades give off carbon dust which under most operating conditions must be filtered out of the compressed gas before the gas can be used.

U.S. Pat. No. 3,565,550 to Bellmer discloses a compressor and pump combination which overcomes the above-mentioned problems encountered where conventional and separate compressors and pumps are employed. In the Bellmer combination, a gas compressor and liquid pump are provided in a single unit employing inlet and outlet flow passages for gas and liquid within the unit. Inasmuch as the Bellmer combination pumps liquid, a ready supply of lubricant is thus available thereby obviating the need for using carbon blades.

A guard ring is required in the Bellmer compressor and pump combination to prevent any leakage of gas being compressed into the liquid being pumped so that the compressor-pump combination can be employed in a system where the unit is used to supply metered amounts of compressed air and fuel oil, such as in an oil combustion system. In order to obtain good combustion, the oil flow must be employed in requisite proportions to the compressed air flow; this necessitates a supply of oil without entrained air, and a supply of air free of oil so that the oil flow can be effectively controlled. Moreover, the use of the guard ring creates other problems and operational limitations. In order to function properly, the guard ring must operate at a pressure sufficiently low to be below the mean pressure of both the gas and liquid pumping streams. The two-phase mixture of gas and liquid, such as air and oil, collected by the guard ring presents a disposal problem inasmuch as it cannot be returned to an oil storage tank as such, that is as a two-phase mixture, because this might lead to build up of foam within the tank. If the fluids were separated into an oil stream and an air stream, then, for many installations, the oil would be at too low a pressure to permit is return to the oil storage tank.

SUMMARY OF THE INVENTION

In accordance with the present invention, a fluid handling system has been developed wherein a self-priming combination pump-compressor unit is employed which does not require the use of a guard ring as employed in the Bellmer unit, yet is able to supply liquid without entrained gas, such as oil without entrained air, and gas free of liquid such as air free of oil. The fluid handling system of the invention is thus able to supply streams of air and oil in controlled proportions, in atomized form or otherwise, as fuel for oil furnaces, such as used in single and multiple dwelling heating plants. Furthermore, the pump-compressor system of the invention can be modified to vary the performance of the compressor without changing the dimensions or operating speeds of the compressor, thus enabling a given compressor to operate over a wide range of operating conditions, such as in oil combustion systems requiring different firing rates and/or fuels of varying characteristics.

BRIEF DESCRIPTION OF THE FIGURES

The invention as well as the advantages thereof will be made apparent by the following description taken in conjunction with the accompanying drawings wherein:

FIG. **1** is a diagram of a fluid handling system including a schematic representation of a pump-compressor system of the invention, especially adapted for compressing air and pumping oil, wherein the pump-compressor system includes internal air-oil separation means, air-free oil recycling means, and a second air-oil separation means positioned externally to the pump-compressor unit.

FIG. **2** is a front elevation of the pump-compressor system shown in FIG. **1**, with the front cover thereof removed.

FIG. **3** illustrates a partial section of the pump-compressor system taken along lines **3—3** of FIG. **2**, including a view of the external cover plate of the pump-compressor system.

FIG. **4** is a section of the pump-compressor system taken along lines **4—4** of FIG. **3**, showing internal passages.

FIG. **5** is a section of the pump-compressor system taken along lines **5—5** of FIG. **3** and showing conduit grooves in the cover plate of the pump-compressor unit and suggesting in phantom the orientation of the conduit grooves, rotor, slots and vanes superimposed on the interior of the cover plate.

FIG. **6** is a diagram of the pump-compressor system of the invention incorporated in a fluid handling system especially adapted for delivering atomizing air and oil to an oil combustion system, wherein the pump-compressor unit includes first and second air-oil separation means each positioned externally to the pump-compressor unit, and air-free oil recycling means.

FIG. **7** is a diagram of yet another fluid handling system especially adapted for delivering atomized air and oil to an oil combustion system, wherein another type of air-oil separation means is positioned externally to the pump-compressor unit of the invention and including air-free oil recycling means.

FIG. **8** illustrates a flow diagram of the fluid handling system as shown in FIG. **7** including in addition, flow control means in communication with the oil inlet line, the air-oil separation means, and the air inlet line.

DETAILED DESCRIPTION OF THE INVENTION

In accordance with the present invention, a self-priming pump-compressor system is provided for simultaneously compressing gas and pumping liquid, such as compressing air and pumping oil. The system comprises (1) a rotary device or pump-compressor for simultaneously compressing gas and pumping liquids, comprising (*a*) a pump-compressor body, having a cylindrical pumping chamber formed therein, (*b*) first closure means operatively associated with one end of said body, having a bore therethrough for receiving a rotatable shaft, (*c*) a second closure means operatively associated with the other end of said body, (*d*) a shaft rotatably mounted in the pump-compressor body and extending through said first closure means into the pumping chamber, (*e*) rotor means disposed about said shaft for rotation with said shaft, eccentrically disposed within the pumping chamber of said pump-compressor body, thus providing a compression space between the rotor and interior surfaces or walls defining the pumping chamber, said rotor means having a plurality of spaced slots formed therein for slidably receiving fluid moving means, (*f*) gas inlet means and gas outlet means in communication with said pumping chamber, (*g*) liquid inlet means and liquid outlet means in communication with said pumping chamber, and (*h*) fluid moving means, such as vanes, operatively associated with the rotor means, being slidably engaged in said slots of the rotor, upon rotation of the shaft, for compressing and moving said inlet gas to said gas outlet and moving said inlet liquid to said liquid outlet, the walls of the pumping chamber acting as a cam surface for said fluid moving means whereby upon said eccentric rotation of the rotor means said fluid moving means will be caused to move into and out of said slots; (2) liquid-gas separation means in communication with said pump-compressor body, and (3) means to recycle substantially gas-free liquid back to the liquid inlet, in communication with said liquid-gas separation means and said liquid inlet, to effect self-priming of the system.

Further, in accordance with the present invention, a gas-liquid atomizing system is provided. The self-priming pump-compressor system of the invention as well as other pump-compressor combinations are particularly adapted for use with and in a gas-liquid atomizing system, such as air for atomizing fuel oil in oil furnaces. Such atomizing systems include, in addition to the pump-compressor system described hereinbefore, additional gas-liquid separation means where necessary, as well as means for atomizing substantially gas-free liquid with substantially liquid-free gas, in communication with liquid and gas outlets of the liquid-gas separation means of the pump-compressor system of the invention. In addition to the self-priming pump-compressor system of the invention, other self-priming and non-self-priming pump-compressor combinations can be employed including those units as described hereinbefore without liquid recycle means and related components for self-priming.

The liquid-gas separation means of the pump-compressor system of the invention may be an integral part of the pump-compressor in which case it will take the form of a recycle separation passageway, preferable substantially vertically disposed, in the pump-compressor body, in communication with the pumping chamber and liquid outlet means, the upper end of said passageway including a first orifice in communication with the liquid outlet means, the lower end including a second orifice in communication with said means to recycle substantially gas-free liquid. The internal recycle separator functions by allowing gas to disengage from the liquid in the recycle separation passageway and rise to the upper portion of the passageway. A split in liquid flow in the passageway is provided by the difference in the sizes of the first and second orifices. Substantially gas-free liquid is flowed through said second orifice of the passageway and into the recycle means and liquid inlet means where it combines with the fresh liquid feed. The balance of the liquid in said separation passageway containing entrained air flows out of the upper end of the passageway through the first orifice. A second liquid-gas separation means is in communication with the liquid outlet means and the gas outlet means of the pump-compressor and effects liquid-gas separation of (1) the liquid containing entrained gas leaving the upper end of the recycle separation passageway and (2) compressed gas containing oil leaving the gas outlet means. The second liquid-gas separation means includes outlet means for gas-free liquid in communication with said atomizing means and liquid-free gas outlet means in communication with said atomizing means.

In an alternative embodiment of the invention, the first liquid-gas recycle separation means may be located externally to the pump-compressor and includes (*a*) a recycle liquid-gas separation unit, (*b*) liquid inlet means in communication with the liquid outlet means of the pump-compressor, (*c*) liquid outlet means for substantially gas-free liquid in communication with said recycle means which in turn is in communication with said liquid inlet means of said pump-compressor and (*d*) second outlet means for liquid containing entrained gas. A second liquid-gas separator means is positioned in communication with the gas outlet means of the pump-compressor and said second outlet means for liquid containing entrained gas flowing from the recycle liquid-gas separation means, said second separation means including a gas outlet for substantially liquid-free gas and a liquid outlet for substantially gas-free liquid, each in communication with said atomizing means.

Referring now to the accompanying Figures, FIG. **1** illustrates a fluid handling system including a pump-compressor unit of the invention, particularly adapted for supplying atomizing air and oil to an oil combustion system. This system includes a pump-compressor unit generally referred to by the numeral **10** having an oil inlet conduit **12,** air inlet conduit **14,** oil outlet conduit **16,** and air outlet conduit **18.** Air inlet conduit **14** is linked to air supply source **20** by means of air conduit **22** which includes air filter **24.** Oil inlet conduit **12** is linked to oil supply and storage **26** through oil conduit **28** which includes oil filter means **30.** Oil outlet conduit **16** which includes flow control means **32,** a one way check valve **33** and air outlet conduit **18** are in communication with liquid-gas separation means generally referred to by the numeral **34.** Oil-free air conduit line **36** and air-free oil conduit line **38** lead from liquid gas-separation means **34** to air-oil atomizing means generally referred to by the numeral **40.** Oil return conduit line **42** leads from liquid-gas separation means **34** and communicates with oil supply and storage means **26.**

Referring now to FIGS. **1** through **5** a preferred embodiment of the pump-compressor unit **10** is there set out in detail, and comprises a pump-compressor body **50** having a cylindrical pumping chamber **52** formed therein, a first closure means or end plate **54** (FIG. **3**) having a bore **56** therethrough for receiving rotatable shaft **58,** and a second closure or face plate **60** (FIGS. **2** and **3**) operatively associated with the other end of said body **50.** The shaft **58** extends from a driver such as an electric motor through bore **56** in the first closure means **54** and into pumping chamber **52** formed in body 50, and a slotted rotor 64 is disposed about the shaft 58 for rotation therewith in chamber 52. As best indicated in FIG. 1, the rotor means 64 is mounted on shaft 58 which is eccentrically disposed within the pumping chamber 52.

A plurality of fasteners (not shown) extend through body 50, and plate 54 into a mounting bracket (not shown) formed as part of the driver for mounting the unit on the driver, and fasteners such as bolts 66 (FIGS. 2, 3, and 5) are provided thus allowing removal of the face plate 60 from the unit without the necessity of removing the unit from the driver.

An annular recess 68 is formed in end plate 54 to receive a lip seal 70 (FIG. 3) to prevent leakage of fluid from chamber 52 along shaft 58.

As seen in FIG. 1, rotor 64 has a plurality of spaced slots 72 formed therein dimensioned to slidably receive fluid moving means or vanes 74. With respect to the drawing, the horizontal center line of shaft 58 is off-set vertically from the horizontal center line of body 50 and chamber 52 thereby allowing the rotor 64 to rotate eccentrically with respect to the body 50 and pumping chamber 52. Thus, the interior surface or walls 76 of pumping chamber 52 act as a cam surface upon rotation of rotor 64, forcing vanes 74 into slots 72 during 180° of rotation. During the other 180° of rotation, the vanes 74 are, due to gravity and centrifugal force, partially ejected from slots 72 which at the rear portions thereof function as pumping chambers for the liquid being pumped as will be more fully described below.

Formed within second closure means of face plate 60 are two arcuate grooves 84 and 92 formed within end plate 54 are two arcuate grooves 90 and 98. As best seen FIGS. 4 and 5, gas inlet 80 communicates with gas inlet passage 82 which in turn communicates with gas inlet groove 84 (Note FIG. 5 is in reverse with respect to FIG. 4). As shown in FIGS. 1, 2 and suggested in FIG. 5, liquid inlet 86 in communication with liquid inlet passage 88 which in turn communicates with liquid inlet groove 90. Gas outlet groove 92 is in communication with gas outlet 96, as shown in FIGS. 2, 3, and 4 and suggested by the superposition drawing of FIG. 5.

Turning now to FIG. 5, it is seen that gas inlet groove 84, in addition to communication with gas inlet passage 82, also communicates with pump chamber 52 such that upon rotation of rotor 64, and as vanes 74 pass over gas inlet passage 82, gas will be drawn into groove 84 and swept into pump chamber 52 for compression therein. Trapped between successive vanes, the gas is compressed and delivered to gas outlet groove 92 (which also communicates with pump chamber 52), and is thus discharged through gas outlet passage 94 and gas outlet 96.

Liquid inlet groove 90, in addition to communicating with the liquid inlet passage 88, also communicates with cavity 104 between vanes 74 and rotor slot 72, which cavity is created by the outward movement of the vane 74 comparable to the action of a piston moving outward in a cylinder. Upon rotation of the rotor, and as vanes 74 are projected out of slots 72, the volume of cavity 104 increases and is filled with the liquid to be pumped. With further rotation, and after the vane has passed the vertical center line of the unit, the cavity 104 begins to decrease in volume and the liquid is pumped into liquid outlet groove 98 and thus liquid is discharged out through liquid outlet passge 100.

Liquid outlet groove 98 and passage 100 are in communication with recycle separation passageway 106 which may be formed in pump compressor body 50, the lower portion of which, via orifice 107, is in communication with recycle conduit 108 which in turn is in communication with recycle liquid inlet 86*a* and passageway 86*b*. The upper portion of separation passageway 106, via orifice 109, is in communication with liquid outlet 102. Recycle liquid inlet passageway 86*b* is in communication with liquid inlet passage 88.

A description of the operation of the fluid handling system illustrated in the FIGS. 1 through 5 described above, follows.

Air from air supply 20 enters conduit 22, which may be in the form of an inverted tube. Air is drawn in through air inlet 80, through air inlet passageway 82 to air inlet groove 84 formed in the face plate 60, shown in FIG. 5, and swept into pumping chamber 52. As rotor 64 continues to rotate a gradually enlarging space is formed by the action of the sliding vane 74, moving out by centrifugal force to contact the wall 76, of the pump chamber 52. As this suction volume increases gas continues to flow in through gas inlet 80 and gas inlet passageway 82, to the gas inlet groove 84. Then when the vane 74, passes its point of maximum extension, the trapped volume decreases (raising the pressure of the air) and the compressed air is delivered to gas discharge groove 92. The location and dimensions of the gas grooves 84 and 92, and the number of vanes can be varied to give the desired built-in compression ratio.

The gas flows from gas discharge groove 92 into the communicating passageway 94, in cover plate 60, FIG. 5, which opens into gas discharge outlet 96 in the body, as shown in FIG. 4. The gas, such as air, then flows through gas discharge conduit 18, to the upper portion of the gas-liquid separating means 34. The air leaving the compressor is laden with oil. The quantity of oil in the air is a function of the clearance between the rotor 64 and the forward surface 76*a* and 60*a* of the clearance between the vanes 74 and rotor slots 72. The oil quanitity is also a function of the oil pressure generated by the oil pump portion of the pump-compressor unit. However, the system performance is not effected per se by reason of the quantity of oil in the air. The volume of such entrained oil is only a small fraction of the volume of air. In any case, it is effectively separated by the actions which are made to take place in the gas-liquid separator means 34. As will be discussed in greater detail hereinafter, the performance of the air compressor, particularly at high discharge pressure, is favored by a high oil pressure in the pump portion.

Oil from oil storage 26 is drawn through conduit 28, oil filter 30, oil inlet conduit 12, oil inlet 86, oil inlet passage 88, oil inlet groove 90 and finally into the cavity 104, formed in the rotor 64 by the outward movement of the vane 74 in slot 72.

The suction action formed on the outward travel of vane 74 is followed by a discharge action which occurs on the inward travel of vane 74 when cavity 104 communicates with discharge groove 98. For the case of two vanes, each rotation results in two suction and two discharge strokes in toto. For a 1,750 rpm speed, there are then 3,500 suction and discharge pulses each minute, using two vane rotor. Slot 72 formed in the rotor 64 serves as both conduit and "cylinder" for the "piston" formed by sliding vane 74. Suction occurs during about 160° of the rotation and discharge for a succeeding 160° with closure elements of about 20° separating the two ends of the respective inlet and discharge grooves.

During the suction stroke, the force required to seal the vane **74** against the wall **76**, is largely created by centrigual force. The centrifugal force of the outward moving vane is primarily utilized to draw oil into the "cylinder," cavity **104**. On the discharge stroke, the pressure difference across the vane is slightly greater than the pressure rise created in the gas compressor, the small difference being due to friction.

Because the full pressure difference exists across the vane on the discharge stroke, it is important to establish good sealing against wall **76** by sliding vanes **74**. Centrifugal force unaided might be inadequate to overcome the lifting action created by the air at discharge pressure. Restriction of the oil flow in a manner to be described can create a pressure on the inner radius of the vane to force it outward and so form an effective seal.

The oil on the discharge stroke flows into oil discharge groove **98**, and then by means of passage **100**, enters the recycle separation passageway **106**. The oil in recycle passageway **106** is in the form of a two phase fluid, containing appreciable quantities of air. A split in flow is provided by means of suitable sized orifices, **107** and **109** inserted respectively in the bottom and top portions of passageway **106**. The flow out the bottom through orifice **107** is essentially pure liquid, free of gas. This flows through oil recycle tube **108** to the recycle oil inlet **86**a and recycle passage **86**b, where it combines with the fresh stream of oil being drawn in from the oil supply tank **26** in the manner previously described. The balance of the oil in passageway **106**, containing significant quantities of entrained air flows out at the top through orifice **109**. It flows out through oil outlet conduit **16** to the lower portion of the liquid-gas separator means **34**.

The liquid-gas separator means **34** causes a separation of the entering fluids into liquid-free gas and gas-free liquid, for example oil-free and air-free oil. The oil-free air flows through conduit **36** and the air-free oil flows through conduit **38**, each into atomizing means **40** wherein the air serves to atomize the oil atomized for use in fine droplet suspension form, for example, as a fuel in an oil combustion system.

In the fluid handling sysyem shown in FIG. **1**, the recycle air-oil separator passageway **106** within pump-compressor body **50** should be sufficiently large to ensure sufficient residence time to effect proper separation, that is so that the air in the oil can rise quickly to the surface of the oil and then be discharged into the atmosphere above the mixture.

FIG. **6** is a modified version of thee fluid handling system illustrated in FIG. **1**. In FIG. **6**, the numeral **120** generally refers to a first or recycle air-oil separator means positioned externally to the pump-compressor unit **10**. Pump-compressor unit **10** is similar to the unit shown in FIGS. **1** through **5** with the exceptions that (1) it does not include an internal separator passageway **106** or (2) a recycle line **108** and (3) liquid outlet groove **98** is in communication with liquid outlet passage **100** which is in direct communication with liquid outlet **102**. Oil outlet conduit **16***a* leading from the pump-compressor unit is in communication with oil intake means of recycle separator **120**. Air-free oil outlet conduit **122** leading from recycle conduit **124** which leads into oil inlet **86***a*, orifice **107***a* and recycle passageway **86**b of the pump-compressor unit **10**. Outlet conduit **126** communicates with orifice **109***a* and extends from recycle separator means **120** through one way check valve **190** and is used to carry air-oil mixtures from the recycle separator means **120** to liquid-gas separator means **34** which may be the same as and functions in a similar manner as does the external separator means **34** shown in FIG. **1**. Air outlet conduit **18** extends from the pump-compressor unit **10** and leads to liquid-gas separator means **34**.

The system of FIG. **6** operates in essentially the same manner as that shown in FIG. **1** with the exception that oil containing some air is discharged from pump-compressor unit **10** via outlet **102** and conduit **16**a to recycle separator **120**. Air-free oil is recycled from separator **120** via conduits **122** and **124** back to pump-compressor unit **10** via inlet **86***a*, orifice **107***a* and recycle passageway **86***b* to effect the self-priming. Air containing oil leaves separator **120** via orifice **109***a* and is fed via conduit **126** to liquid-gas separation means **34**. Discharged air of the pump-compressor unit **10** is fed via conduit **18** into separation means **34**.

The amount of air-free oil leaving recycle separator **120** and entering unit **10** via orifice **107***a* and the amount of air plus oil leaving separator **120** via orifice **109***a* is controlled by varying the size of the orifices (in the same manner as described hereinbefore with respect to the internal separator passageway **106** of FIG. **1**) or by including flow control means in the appropriate conduits.

Henceforth, operation of the FIG. **6** system is as described with respect to FIG. **1**.

FIG. **7** is yet another modification of the fluid handling system of FIGS. **1** and **6**, wherein the recycle separator **120** is combined with the external or second liquid-gas separator means **34** as shown. Oil recycle line **122**, extends from recycle separator **120** and is in communication with oil recycle inlet **86***a*, orifice **107***a* and recycle passageway **86***b* of the pump-compressing unit **10**. Oil inlet conduit **128** which includes orifice **120** extends from the recycle separator **120** and into the external liquid-gas separation means **34**.

FIG. **8** illustrates essentially the same fluid handling system shown in FIG. **7** with the following additions. The fluid handling system shown in FIG. **8** includes oil outlet **102***a* and oil outlet passageway **106***a* in communication with oil outlet groove **98** (in the unit **10**). Pressure actuated flow control means **196** is positioned in oil inlet conduit **28**. Flow control means **196** regulates inlet oil and flow control means **197** regulates outlet oil, both in response to oil pressure from conduits **198** and **198***a* leading from oil outlet passageway **106***a* and outlet **102***a* of pump-compressor unit **10**. Such control prevents oil flooding of the system on shutdown, for those installations where the storage tank is elevated with respect to the pump-compressor system. Further, flow control means **192** is positioned in air inlet conduit **22**, as an aid to priming for those installations where the storage tank is lower than the elevation of the pump-compressor system. As shown, flow control means **192** controls air inlet in accordance with the oil pressure from outlet passage **106***a* and outlet **102***a* via conduit **194** shown as broken lines. These controls may be combined into one or two units. A preferred arrangement is to have controls in a single assembly, and to change the selection of controls depending on whether the storage tank is elevated or sunken. For the elevated tank, control means **192** would be omitted, and for sunken tank, control means **197** would be omitted. Furthermore, conduit **198** may lead into conduit **200, 202** which includes safety relief control means **204** and leads to oil conduit **28***a* as shown.

The system of FIGS. **7** and **8** operate essentially in the manner as does the system of FIG. **6.** The ratio of flow rates of air-free oil recycled via conduit **122,** from recycle separator **120** to pump-compressor **10** to flow rate of air plus oil leaving recycle separator **120** via conduit **128** may be controlled by varying the size of orifices **107***a* and **130,** respectively and/or by including flow control means in the conduits **122, 124** and/or conduit **128.**

In the operation of the valve or flow control arrangement of FIG. **8,** the pressure actuated inlet valve **196** will close when the safety relief valve opens. The shut-off would be momentary, until the safety valve closes. This short-time closing would not affect operation of an oil burner since there is a reservoir of oil in the air-oil separator means **34.** Any extended shut-off of oil supply would, of course, lead to flame failure and conventional safety control shut-down of the unit.

The recycle separator whether located internally in the pump-compressor as shown in FIGS. **1** through **5** or externally thereto (as shown in FIGS. **6** to **8**) should supply sufficient oil to supply the necessary pressure to ensure that the pump-compressor unit will be self-priming.

The external liquid-gas (oil-air) separation means **34** employed in fluid handling systems of the invention as shown in FIGS. **1, 6, 7,** and **8** may take the form of any conventional liquid-gas separators as known in the art. The oil-air separator **34** shown in the Figures is particularly preferred and comprises an upper portion **150** and a lower portion **152.** The upper portion **150** of the separator **34** preferably comprises a section containing a high surface area packing material. The lower section **152** includes oil reservoir **166.** Positioned within the lower section **152** is a float valve mechanism comprising float **160** in communication with actuating linkage **162** and flow control means **164,** the latter being in communication with oil supply and storage **26** via conduit **42.** The float is responsive to the level of oil in the reservoir **166,** and actuates flow control means **164** allowing excess oil to flow via conduit **42** to storage **26.** A filter **168** may be included in the lower portion of the separator means **34** for quieting oil flow and for filtering oil removing solid contaminants before it is transported to the atomizing nozzle means **40.** Transformation of the two contaminated fluid streams entering separator **34** into respectively pure streams of air and oil is effected as follows. Oil is removed from the air as it (air) flows upward through packed section **150** of the air-oil separator **34.** The packing material contacts the oil mist or droplets dispersed with and/or entrained in the air causing the mist or droplets to coalesce into relatively large droplets which fall into the lower section **152.** Air escapes from the oil as the oil is allowed to settle quietly and reside for sufficient time in the lower section **152.** Filter screen **168** aids this process of separation by quieting the oil flow.

Examples of packing materials which can be employed in the air-oil separation means includes porcelain, stoneware, carbon or metal Raschig rings, ceramic Berl. saddles, tiles, ceramic grids, spiral rings, partition rings, aluminum rings or spirals, Pyrm rings, steel rings or spirals, Stedman packing, McMahon packing, wire helixes or any other high surface area packing material known in the art.

Other gas-liquid separation apparatus which may be employed herein includes impact or impingement separators where staggered plated, wires, cables, rods, and other shapes are inserted in gas ducts, as well as electrostatic separators and batt filters.

Combustion of liquid fuels is carried out efficiently in a furnace because of the fine degree of atomization produced by the use of compressed air in specially designed air atomizing nozzles. Such nozzles have been known to give superior performance but have not been widely applied in small systems because of the complexity introduced by the need for both an air compressor and an oil pump, and for means to regulate the flow and pressure of the two fluids. However, in the present invention, the pump and the compressor are formed by one integral unit. Accordingly, such atomizing nozzle calls for the removal of the contaminants in each of the air and oil streams so that air free of oil and oil free of air are supplied to the passages of the atomizing nozzle.

Contamination of either fluid with the other does not spoil atomization per se, but does affect steadiness of operation, and tends to cause dribbling of liquid from the nozzle after shutdown. Further, the presence of gas in the liquid interferes with effective and accurate metering of the liquid flow.

The atomizing means shown in the Figures includes an air or gas inlet **210,** an oil or liquid inlet **212,** the oil inlet including filter means **214** and flow control orifice **216.** Other atomizing means which may be employed herein may take the form of pressure nozzles, centrifugal disks, other conventional two-fluid nozzles or other atomizing apparatus known in the art.

The atomizing means employed herein should deliver atomizing air and oil in any desired proportions. Effective control of the desired proportions is maintained by judiciously supplying oil-free air and air-free oil to the atomizing means at required flow rates. The flow rates can be controlled by adjusting operation of the separator means as well as the flow rates of air and oil entering and leaving the pump-compressor unit.

It is to be understood that the fluid handling system shown in the Figures represent preferred embodiments. Other embodiments encompassed by the present invention include the following: Those employing air-oil separation means and atomizing means other than that illustrated; those where the external recycle separator **120,** such as in FIGS. **6, 7** and **8** is deleted, oil outlet means **102** is in communication with oil-air separator means **34** and a portion of air-free oil leaving the oil-air separation means **34** via line **42** is recycled back to oil inlet **86** to effect self-priming. Furthermore, the driver or motor employed in the pump-compressor unit of the invention may be made double-ended to drive a combustion air blower.

The number of fluid moving means or vanes employed in the pump-compressor unit of the invention may be varied from two to three to four or more depending upon the working pressures employed. Thus, for example, where a discharge pressure of about 14 psig or more is employed, three or four vanes can be used.

With respect to the system of FIG. **6** which employs a recycle oil-air separator means **120,** externally to the pump-compressor unit, oil drops to the bottom of the separator as air rises in the oil. Upon disengaging at the surface, the air joins the liquid passing through orifice **109***a* at the top of the separator to pass to the float/-separator **34.** In the latter unit there is a definite level maintained by the float.

As previously described, the air entering the upper portion of the separating means **34** contains appreciable quantities of oil. By virtue of the low velocity in separator **34** and subsequently by the impingement action of the media contained in the coalescing section **150** located in the uppermost portion of separator **34,** the oil drops downward to join the pool of oil created by the discharge from the pump.

Because of this effective separating capability, the pump-compressor can be made to operate with the optimum pressure for the oil discharge. The highest tolerable pressure of the oil would be advantageous in the sense that this effects the best sealing of the vane **74** against the wall **76.** However, inasmuch as the compressor may be called upon to meet widely varying conditions of flow and discharge pressure, it is desirable to have one size of compressor cover a range of operating conditions. Accordingly, it is possible to vary the performance by adjustment of the pressure of oil discharged into oil discharge groove **98.** This is done by suitable sizing of orifices **107, 107***a* and **109, 109***a* or **130,** respectively.

Further, the proportion of oil recycled within the pump to that drawn in from the storage tank is established by the relative proportioning of the openings in orifices **107, 107***a* and **109, 109***a* or **130,** respectively. For example, if orifice **107** and **107***a* is made relatively large compared to orifice **109** or **109***a* respectively, then a major portion of the oil will be recycled within the pump, and only a small portion will be drawn in from storage. The choice of mode of operation is dependent in part on the oil properties. The limit at one extreme is to have virtually no recycling within the pump. At the other extreme, the limit is to have only a small excess of oil above that required for combustion being drawn in from the external storage tank.

A further feature of the invention is that a startup delay time is readily built into the system. On shutdown, oil drains from the nozzle **40** into the air-oil separator **34,** which also serves as a reservoir. Then on startup this oil is forced by the combination of the atomizing air pressure and the inducing action of the nozzle to flow into the oil passages of the nozzle. By varying the volume of the connecting tubing from the reservoir to the nozzle, it is possible to vary the time between startup of the motor-compressor-pump and the beginning of fuel flow out of the nozzle.

On startup for the case of the feed line being empty, the time to initiate combustion is unaffected because of the delay associated with pumping oil into the line from storage tank to pump. There is ample capacity in the air-oil separator **34** to take care of the period in which the pump is acting as a self-priming unit.

The present system is designed for rapid startups due to the self-priming capacity aand can shut down without dribbling of oil from the nozzle (inasmuch as the oil delivered is air-free) and without delay from the moment the oil burner or other controlling device calls for shut-down.

Startup of the present system requires only that the power be supplied to the electric motor driving the pump-compressor unit. Shutdown calls only for stopping the supply of current to the electric motor. However, for the case where the main oil storage reservoir is at an elevation above that of the oil burner system, shut-off valves are required to prevent oil flowing by gravity into the system. For most installations, with buried oil tanks such shut-off valves are not needed.

In view of the fact that the pump-compressor unit of the invention simultaneously compresses gas and pumps liquid, the fluid moving means or sliding vanes slidably engaged in the slots in the rotor means are lubricated by the liquid being pumped, thereby obviating the need for a make-up supply of lubricant, as required in many prior art compressors. Accordingly, vane life is greatly increased and the use of carbon blades is no longer necessary.

The fluid handling system of the invention including those illustrated in the accompanying Figures are particularly suited for supplying atomizing air and fuel oil to oil furnaces, such as used in single and multiple dwelling heating plants. These normally operate on a start-stop basis, for which the system here disclosed is particularly suited. However, these systems may be adapted for other applications requiring a gas-free liquid and a liquid-free gas, also the required pump-compressor combination may be employed in a system wherein a pumped lubricant is not required beyond the pump-compressor itself.

Although this invention has been described with respect to its preferred embodiments, it should be understood that many variations and modifications will now be obvious to those skilled in the art, and it is preferred, therefore, that the scope of the invention be limited, not by the specific disclosure herein, but only by the appended claims.

What is claimed is:

1. A self-priming pump-compressor system for simultaneously compressing gas and pumping liquid comprising (*a*) a pump-compressor body, having a pumping chamber formed therein, (*b*) a shaft rotatably mounted in the pump-compressor body and extending into the pumping chamber, (*c*) rotor means disposed about said shaft, for rotation with said shaft, eccentrically disposed within the pumping chamber of said pump-compressor body, thus providing a compression space between the rotor and interior surfaces of walls defining the pumping chamber, said rotor means having a plurality of spaced slots formed therein for slidably receiving fluid moving means, (*d*) gas inlet means and gas outlet means in communication with said pumping chamber, (*e*) liquid inlet means and liquid outlet means in communication with said pumping chamber, and (*f*) fluid moving means, operatively associated with the rotor means, upon rotation of the shaft, for compressing and moving said inlet gas to said gas outlet means and moving said inlet liquid to said liquid outlet means, the walls of the pumping chamber acting as a cam surface for said fluid moving means whereby upon said eccentric rotation of the rotor means said fluid moving means will be caused to move into and out of said slots;

(*g*) first liquid-gas separation means in communication with said pump-compressor liquid outlet means, and (*j*) means to recycle substantially gas-free liquid back to said pump-compressor liquid inlet means in communication with said first liquid-gas separation means and said pump-compressor liquid inlet means, to ensure self-priming of the system, said first liquid-gas separation means comprising a recycle separation means substantially vertically disposed within said pump-compressor body and having an upper portion and a lower portion, the upper portion of said recycle separation means including a first orifice of predetermined size in communication with said pump-compressor liquid outlet means, the lower portion of said recycle separation means including a second orifice of predetermined size in communication with said means to recycle substantially gas-free liquid.

2. A self-priming pump-compressor system in accordance with claim **2,** including second liquid-gas separation means in communication with said pump-compressor liquid outlet means and said pump-compressor gas outlet means to effect liquid-gas separation of the liquid containing entrained gas flowing from the upper portion of the recycle separation means and effect liquid-gas separation of the gas containing liquid flowing from said pump-compressor gas outlet means.

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