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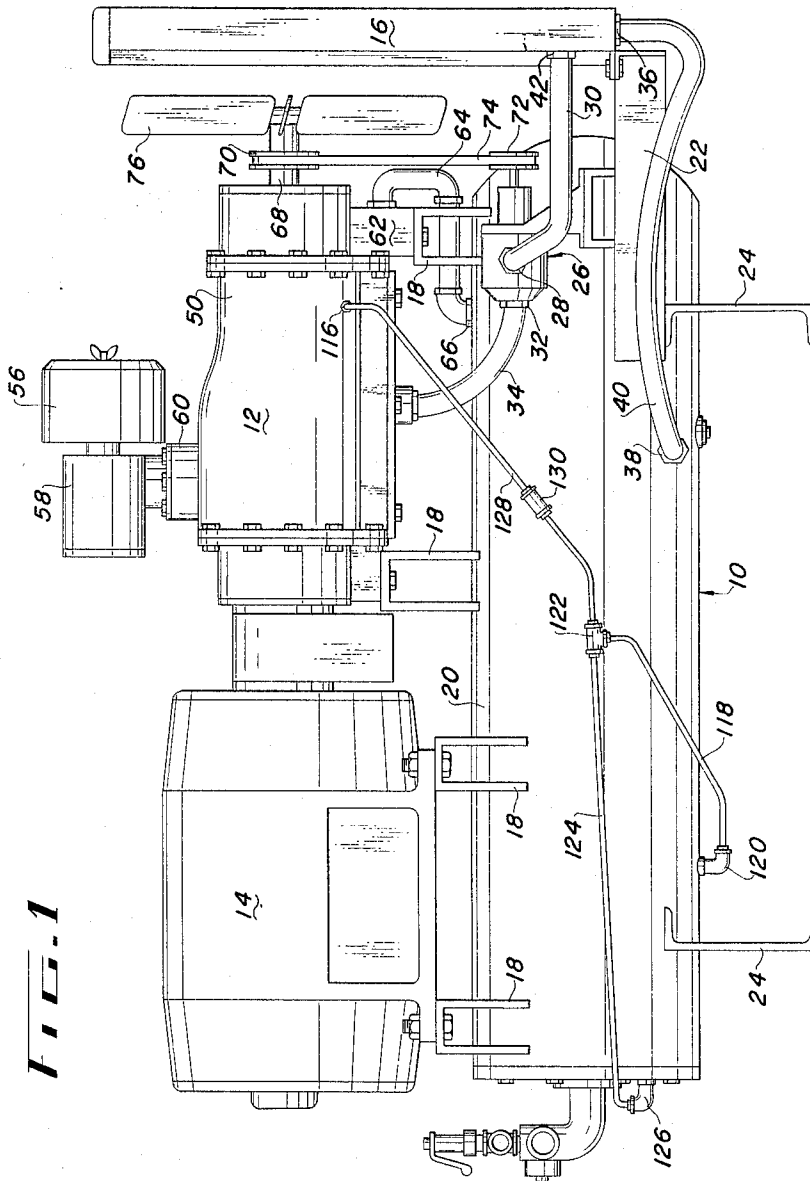
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3,291,385

RECEIVER-SEPARATOR UNIT FOR LIQUID-INJECTED COMPRESSOR

Filed June 1, 1965

2 Sheets-Sheet 1



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FIG. 2

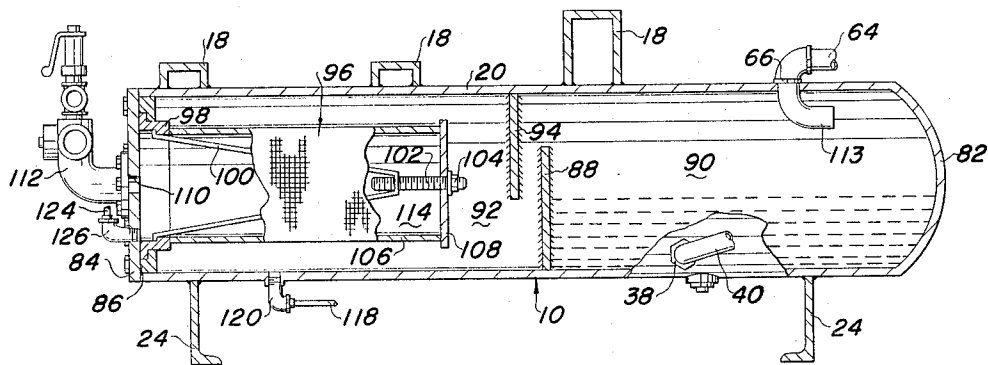


FIG. 3

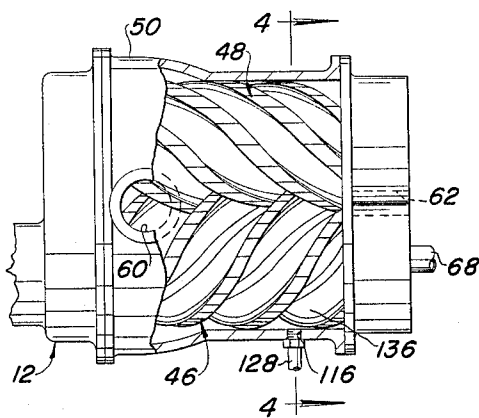
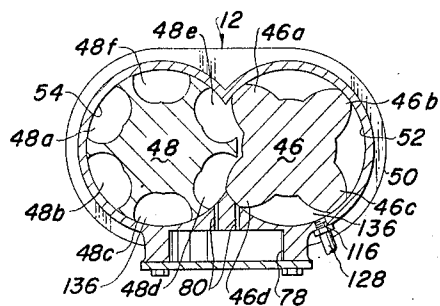


FIG. 4



AVERAGE WORKING CHAMBER PRESSURE P.S.I.G.

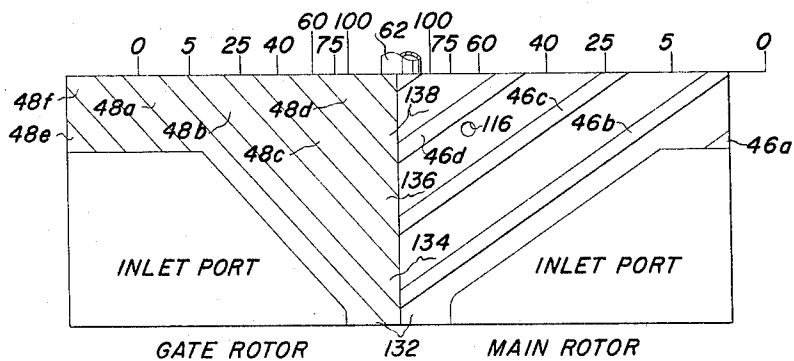


FIG. 5

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RECEIVER-SEPARATOR UNIT FOR LIQUID-INJECTED COMPRESSOR

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4 Claims. (Cl. 230-207)

This invention relates to an improved receiver-separator unit for a gas compressor of the type which is injected with a liquid, such as oil or water, for lubricating and sealing operation parts and for removing the heat of compression from the compressor. In this type of compressor, liquid is entrained in the discharge gas in substantial quantities; and, it is generally desirable to separate the liquid from the gas to the greatest possible extent in order to conserve the liquid for reuse and to provide liquid-free discharge gas.

One object of the present invention is to effect highly efficient liquid separation by means of a receiver-separator unit which is constructed to remove entrained liquid from gas in three progressive steps or stages.

Another object is to provide a receiver-separator tank wherein gas-entrained liquid separated in three stages together with improved means for removing liquid from each of three compartments associated with a stage of liquid separation. Still another object is the provision of a receiver-separator tank having plural liquid separating compartments wherein each of said compartments is in fluid communication with a working chamber of an associated gas compressor.

A further object is to provide a receiver-separator tank which includes a liquid reservoir at the gas inlet end and an internally mounted liquid agglomerator at the gas discharge end; the inlet and discharge ends being separated by an internal partition which serves as a baffle for gas flowing through the tank.

A specific object is the provision of a tank which not only functions as a gas receiver and a liquid separator, but also serves as a liquid reservoir and as a mounting base for a motor-compressor unit and for a heat exchanger.

Another specific object is to provide a tank of the aforedescribed type which is characterized by simple and compact construction.

These and other objects and advantages will appear upon reading the following description and appended claims and upon considering in conjunction therewith the accompanying drawings, in which:

FIG. 1 is an elevation showing a preferred embodiment of the invention;

FIG. 2 is a partial longitudinal section of the tank;

FIG. 3 is a plan view of a gas compressor with a portion of the housing thereof broken away to show a pair of helical rotors;

FIG. 4 is a sectional view taken along lines 4-4 of FIG. 3; and

FIG. 5 is a diagrammatic development of the compressor housing and helical rotors shown in FIG. 3 and 4.

In the drawings, a preferred form of the inventive receiver-separator tank is generally designated by numeral 10 and is shown in FIG. 1 in assembled relation with a gas compressor 12, a compressor driving motor 14, and a radiator type heat exchanger 16. Both the compressor 12 and the motor 14 are mounted directly upon the tank 10 by means of upstanding brackets 18 which are rigidly secured, as by welding, to the cylindrical wall 20 of the tank. The radiator 16 is vertically mounted near one end of the tank 10 on a pair of horizontal beams 22 which are rigidly secured to one of the transversely arranged foot channels 24 upon which the tank is rigidly

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mounted and supported. A belt-driven liquid pump 26 is mounted on the beam 22 and includes an inlet port 28 connected to radiator 16 by a conduit 30 and an outlet port 32 connected to the bottom of compressor 12 by a conduit 34. The inlet 36 of radiator 16 is connected to a fitting 38 opening near the bottom of the tank wall 20 by a conduit 40; and, in the outlet 42 of the radiator is connected to the pump inlet port 28 by the aforementioned conduit 30.

The compressor 12 is of the rotary type and is particularly adapted to compress air; however, it is not intended that the invention be limited thereto. As shown in FIGS. 3 and 4, compressor 12 employs meshing helical rotors 46 and 48 which rotate in approximate contact with the inner periphery of a plural part housing 50 having parallel intersecting bores 52 and 54. As will be more fully described, the rotors 46 and 48 and the housing 50 coact, upon rotation of rotor 46 by the motor 14, to draw air through a suitable filter 56, a compressor inlet control valve 58, and a compressor inlet port 60 into the housing 50 and to discharge air, after compression thereof, through a discharge port 62. The discharge air is communicated to the inlet end of the tank 10 by means of a conduit 64 connecting the compressor discharge port 62 to a fitting 66 at the top of the tank wall 20. From the above description, it will be understood that the exemplary compressor 12 is of the rotary screw type; however, the invention is not limited thereto as it may be advantageously employed with other compressors such as the sliding vane type, for example.

A liquid, such as oil, for example, is supplied under pressure to the interior of the compressor 12 by the aforementioned pump 26 which is coupled to a shaft extension 68 of rotor 46 by a driving connection comprising the sheaves 70 and 72 and a flexible belt 74. A fan 76 is connected to the shaft extension 68 and is rotatable therewith for creating a flow of cooling air through the radiator 16. Preferably, the oil delivery of pump 26 is connected to an oil gallery 78 defined in the base of the compressor housing 50; and, oil is then injected from the gallery directly into the intersecting bores 52 and 54 through a plurality of spaced apertures 80. The injected oil is intended to cool the compressor and to seal the clearances between the rotors 46 and 48 and between the rotors and the housing 50. The injected oil becomes entrained in the air being compressed and is discharged with the compressed air from the discharge port 62, through the conduit 64 and into the inlet end of the tank 10.

Referring to the illustrative embodiment of the improved receiver-separator tank shown in FIG. 2, the tank 10 comprises an elongated cylinder closed at the inlet end by a curved wall 82 and closed at the discharge end by a removable head 84; the latter being bolted to an annular plate 86 which is rigidly secured to the interior surface of the tank wall 20. Preferably, the length of the tank is several times greater than its diameter; and, the longitudinal axis of the tank is parallel to the supporting surface upon which the foot channels 24 rest. Intermediate the ends of the tank, a transverse partition 88 extends normally from the bottom of the tank to close a major portion of the bore of the tank and to divide the tank longitudinally into two compartments or end portions 90 and 92. A baffle plate 94 extends from the top of the tank in longitudinally spaced and parallel relation to the partition 88 for a purpose to be described.

An oil agglomerator unit, generally indicated at numeral 96, is mounted with respect to the head 84 and the flange 86 by means of a flanged base plate 98 which matingly fits into the center bore of the annular plate 86. The agglomerator includes a legged frame 100 which coacts with a threaded member 102 and a nut 104 for

releasably clamping a cylindrical agglomerating screen 106 between the base plate 98 and a clamping plate 108. In this manner, the agglomerator 96 is mounted internally of compartment 92 and in coaxial relation with the tank 10 and an air outlet aperture 110 in the head 84. A conventional service connection 112 is attached to the head 84 in fluid communication with the outlet aperture 110. Preferably, the agglomerator screen 106 is of the replaceable type and periodic replacement thereof is accomplished in a simple manner by detaching the head 84 together with the agglomerator unit 96 from the tank 10.

One of the objects of this invention is the provision of an air receiver, oil separator tank wherein oil entrained in the compressor discharge air is removed in three stages prior to delivery of the air to the service connection 112. This object is accomplished in the following manner: The initial stage of oil separation is effected in compartment 90 as the discharge air is directed by a bent conduit 113 against the end wall 82 of the tank. Due to the change of direction of travel and the loss of velocity of the oil laden air, a major portion of the oil particles will separate from the air stream and will fall to the bottom of compartment 90. Other particles will separate from the air due to impingement thereof against the tank end wall 82. As the air reverses its flow to escape from compartment 90, additional oil particles will collect upon the cylindrical tank wall 20 and run down the wall to the bottom of compartment 90. It is contemplated that a substantial quantity of separated oil will be collected and contained in a reservoir defined at the bottom of compartment 90 by the walls 20 and 82 and the partition 88. Thus it will be appreciated that compartment 90 not only effects the initial stage of oil separation but also provides an oil reservoir.

The compartment 92 not only provides air receiver volume, but also serves as a second or intermediate stage of oil separation. Thus, the air which enters compartment 92 will be reduced in velocity and changed in direction of flow by the baffling coaction of the partition 88 and the plate 94 whereby more entrained oil particles will separate and drop to the bottom of compartment 92. Other particles will impinge against and adhere to the tank wall 20 and will thereafter run to the bottom of compartment 92.

The third and final stage of oil separation is effected by the agglomerator unit 96 in the usual manner, i.e. as air flows through the screen 106 to the interior of the agglomerator, the last residuum of fine oil particles will adhere to the screen 106 and will coalesce to form droplets which fall to the bottom of compartment 92. Unavoidably, some of the oil coalesced upon the screen 106 may be forced by the air acting thereon into the interior compartment 114 of the screen 106; however, this invention contemplates improved means to be described for purging any oil from the agglomerator compartment 114 to prevent the same from contaminating the air discharged from the service connection 112.

Preferably, the separated oil in the reservoir defined in the bottom of compartment 90 is drawn therefrom and through the radiator 16 by the pump 26 which delivers the oil under a predetermined pressure and in metered quantities to the gallery 78 for injection into the compressor interior in the hereinabove described manner. As noted above, oil separated out during the second stage of separation will collect at the bottom of compartment 92 due to gravity. It is highly desirable to purge compartment 92 continuously of such oil so that the oil level therein does not approach the underside of the agglomerator to interfere with the proper operation of the latter. Moreover, it is desirable to prevent any substantial accumulation of oil in compartment 92 so that, upon sudden dumping of receiver pressure, the usual oil foaming is eliminated and the exterior of the agglomerator screen 106 is not subjected to a coating of oily foam. Also, as explained

above, some separated oil will enter the interior compartment 114 of the agglomerator 96; and, unless compartment 114 is continuously purged, it will not satisfactorily perform its intended purpose. As air passes through the agglomerator compartment 114 the oil therein combines with air to form an air-oil foam which tends to collect at the bottom of the screen 106 and to be blown toward and through the opening of the base plate 98.

Since the separated oil which collects in compartments 92 and 114 is subjected to compressor discharge pressure, oil may be evacuated conveniently from both compartments to an area of lower pressure by means of differential air pressure. The present invention contemplates the utilization of such a pressure differential condition to purge separated oil from the bottom of the second stage separating compartment 92 and to evacuate air-oil foam from the interior compartment 114 of the agglomerator unit 96 in a more efficient manner than has heretofore been proposed. To this end, the oil which collects in compartment 92 is communicated directly to an oil-return aperture 116 which opens into a selected working chamber defined within the compressor housing 50; and the agglomerator compartment 114 is also in communication with the aforementioned oil-return aperture 116. As shown in FIG. 1, a conduit 118 connects a fitting 120 opening through the bottom of compartment 92 to a T connector 122; and, a conduit 124 connects a fitting 126 in the tank closure head 84 to the T connector 122. The T connector 122 is communicated to a fitting in aperture 116 by a conduit 128 which has a choke 130 inserted therein.

As indicated above, the illustrative compressor 12 is provided with intermeshing rotors 46 and 48 which have complementary helical lobes and grooves. The rotors are commonly referred to as the main rotor 46 and the gate rotor 48, the former having convex lobes 46a-d and the latter having concave grooves 48a-f. The main rotor 46 is directly driven by the motor 14 and the gate rotor 48 is rotated in a direction opposite to the rotation of the main rotor by either direct engagement of the rotors or by suitable timing gears, not shown. The compressor working chambers are defined by intermeshing lobes and grooves of the rotors as the latter rotate in approximate contact with the walls of the intersecting bores 52 and 54; and, as the rotors rotate, the working chambers sequentially open to their full volume and draw in air while in communication with the inlet port 60. Thereafter, due to entrance of the main rotor lobes into the cooperating gate rotor grooves and before the working chambers open to the compressor discharge port 62, the volumes of the closed working chambers are progressively decreased by the shortening of the working chambers from their inlet ends toward their discharge ends. In effect, the working chambers are axially displaced toward the compressor discharge port 62 during compression and discharge of the air in the working chambers.

The progressive increase in working chamber pressure from inlet pressure to discharge pressure, due to progressively greater entrance of the lobes 46a-d into grooves 48a-f, may be better understood by referring to FIG. 5 which shows a diagrammatic development of the casing 50 and the main and gate rotors of an exemplary compressor designed to compress air from atmospheric pressure to approximately 100 p.s.i.g. With the rotors intermeshed substantially in accordance with FIG. 4, a working chamber 132 is in axial and radial communication with the inlet port 60 and is receiving a full charge of air at zero p.s.i.g. The closed working chambers 134, 136 and 138 have rotated past the inlet port and the volumes of these chambers will be progressively reduced. It will be noted that chamber 138 is in position to open to the discharge port and that further rotor rotation will produce complete evacuation of that chamber at a final discharge pressure of approximately 100 p.s.i.g. It will also be noted that the pressure in a given closed work-

ing chamber increases as that chamber is displaced axially from the inlet port toward the discharge port 62.

An important feature of the present invention is the provision of a separated oil return system wherein the oil collected with in the agglomerator 96 and the compartment 92 is communicated by means of differential pressure directly into a compressor working chamber. This aspect of the invention is accomplished by connecting the oil return conduit 128 with the aperture 116 which opens through the wall of the compressor casing 50. Aperture 116 is shown in communication with closed working chamber 136; however, it will be appreciated that aperture 116 will sequentially communicate with each of the working chambers formed by the rotors as these chambers are displaced axially from the inlet end of the compressor housing 50 to the discharge end. As FIG. 5 indicates, the oil return aperture 116 communicates with working chamber 136 after the trailing edge of lobe 46d overrides the aperture 116 and before the leading edge of lobe 46c covers the aperture 116. During the period of communication established by these events, the average pressure within working chamber 136 is approximately 40 p.s.i.g. as indicated by FIG. 5. It may be conveniently said that the oil return conduit 128 is connected to the 40 p.s.i.g. developed pressure point of the compressor unit 12. The illustrated selection of a connection pressure point for the oil return conduit 128 establishes the air pressure differential available to evacuate separated oil from the agglomerator 96 and the compartment 92. It will be appreciated that the operating pressure differential need not be fixed, but may be selectively varied by locating the aperture 116 at infinitely variable pressure points ranging from substantially inlet pressure to substantially discharge pressure. Thus, if a greater pressure differential is required, the aperture 116 could be located nearer the inlet port end of the compressor housing 50. Provision of a lower pressure differential would, of course, entail locating the aperture 116 nearer the discharge end of the compressor housing.

The preferred mode of operation of the invention is as follows: Oil laden air is discharged at approximately 100 p.s.i.g. from the compressor discharge port 62 into compartment 90 of tank 10 where a substantial portion of the entrained oil separates due to the combined effects of loss of velocity, change of direction and physical impingement upon the tank walls 82 and 20. The oil separated in compartment 90 gravitates to the bottom reservoir portion thereof and is removed therefrom by the pump 26 for cooling in the radiator 16 and for reuse in the compressor 12. The pumped oil is injected into the intersecting bores 52 and 54 through the apertures 80 which open from the oil gallery 78. The partially cleaned air then flows from compartment 90 between the partition 88 and the baffle plate 94 into the compartment 92. In so passing into the last mentioned compartment, the air must again change direction and loss of velocity will occur which will allow oil particles to separate and to gravitate to the bottom of compartment 92. Impingement of the air on the wall portions of compartment 92 will also effect some further separation at this stage. As air is drawn off from the receiver tank 10 through the service outlet 112, the air in compartment 92 will pass into and through the agglomerator unit 96 thereby causing the last residuum of oil particles to coalesce upon the screen or filter 106. Most of the coalesced droplets of oil will fall from the screen 106 to the bottom of compartment 92; however, a small quantity of oil will be carried by the flow of air through the screen 106 into the interior compartment 114 of the agglomerator. The oil at the bottom of compartment 92 and inside the agglomerator compartment 114 is continuously purged therefrom by the effect of air pressure operating thereupon. In the illustrative embodiment of the invention, this purged oil will flow from compartments 92 and 114 by way of conduits 118 and 124, respectively, which are joined by the T connector 122 for connection

with the conduit 128. The choke 130 allows all of the purged oil to flow through conduit 128 together with only a relatively small volume of air from the tank 10. Conduit 128 is connected to an aperture 116 opening into the interior of the compressor housing 50 at a preselectable developed pressure point. In the illustrative example described above, aperture 116 opens into the working chambers of the compressor when the pressure developed therein reaches approximately 40 p.s.i.g. Since the pressure within tank 10 is approximately 100 p.s.i.g., a differential pressure of approximately 60 p.s.i. acts upon the separated oil in compartments 92 and 114 to effect a flow of oil therefrom to the aperture 116.

In certain cases where there is a substantial pressure differential between the compartments 92 and 114 it may be advantageous to employ separate conduits to connect these compartments individually to different developed pressure points in the compressor.

The advantages afforded by this invention are many. Foremost thereamong is the provision of a highly efficient means for separating oil from compressor discharge air in three stages by the use of a single tank-type receiver-separator unit. Contrary to general practice, this invention provides for separation of oil to occur in both the oil reservoir portion 90 and the air receiver portion 92 of the tank. This is made practical by provision of independent means for removing separated oil from the receiver portion 92 as well as the reservoir compartment 90. Moreover, advantage is taken of available air pressure differential between the compartment 92 and a selectable compressor working chamber to purge compartment 92 independently of the operation of the oil pump 26 or of an auxiliary purging pump. Due to the isolation of the oil in compartment 90 from compartment 92, and due to the continuous purging of oil from compartment 92, the agglomerator 96 may be structurally located entirely within the tank 10 without fear of contamination thereof with separated oil. Moreover, the provision of a stage of oil separation in compartment 92 has the highly beneficial effect of cleaning the air appreciably before it contacts the agglomerator unit 96 thereby reducing the oil-separating load imposed on the agglomerator screen 106 and increasing the time intervals between required replacements of the screen.

Another important advantage of the present invention is that the described oil purging system is closed and the air component of the purged air-oil mixture is not lost to the atmosphere thereby adversely effecting the volumetric capacity of the compressor. This is in contradistinction to known systems whereby separated oil is returned either to the compressor inlet or to certain points in the compressor lubrication system.

It will also be appreciated that the aforescribed oil-separating system affords maximum flexibility in the choice of operating pressures within the system thereby giving the designer greater flexibility in selecting the most efficient mode of operation and design and size of system components without regard to certain pressure conditions which are usually fixed in conventionally constructed oil return systems. One widely used prior art oil-separating system having fixed pressure conditions entails the return of separated oil to an interstage chamber of a plural stage compressor. If a two-stage compressor were employed to compress air from atmospheric pressure to approximately 100 p.s.i.g., efficient compressor design would require that the interstage chamber exhibit an operating pressure of approximately 27 p.s.i.g. Therefore, the pressure differential available to evacuate chambers 92 and 114 would be fixed at approximately 73 p.s.i.g.; and, the minimum pressure required within chambers 92 and 114 for effective oil evacuation would be fixed at approximately 27 p.s.i.g. However, in certain cases, it might be highly desirable to change the system differential pressure in order to maintain a proper cross-sectional area of the oil return conduits or an associated choke while maintaining a predetermined

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filter evacuation rate. Furthermore, where receiver pressure is maintained at values near compressor discharge pressure, it might be desirable to reduce the oil evacuating differential pressure in order to reduce proportionately the work required to recompress the air component of the separated oil up to compressor discharge pressure. Such flexibility in the selection of oil evacuating differential pressure is impossible in the case of the plural stage compressor example given above wherein these pressure values are fixed, for practical purposes, by the compressor exhaust pressure and the interstage pressure. On the other hand, it will be appreciated that the oil evacuating differential pressure employed with the present invention may be selected over a wide range of values by communicating compartments 92 and 114, by a common conduit, or by separate conduits, to one or more selectable pressure points within the working chambers of the compressor 12.

Not only does the tank 10 promote the aforementioned functional advantages in an oil separating system, but the structure of the tank is unusually compact and utilitarian. Thus tank 10 provides in a single cylindrical housing a reservoir, an air receiver and a final air filter which, in accordance with conventional practice, usually comprise separate and distinct tanks mounted in vertically stacked relationship. Moreover, since the tank 10 may have its longest dimension disposed horizontally, the tank wall 20 may be adapted by suitable brackets to provide a convenient mounting base for all of the necessary operating components of a motor-compressor apparatus.

It will be understood that the above description and accompanying drawings comprehend only a general and preferred embodiment of the invention and that various changes in construction, proportion and arrangement may be made without sacrificing any of the enumerated advantages of the invention and without departing from the scope of the appended claims.

Having described the invention fully, we claim:

1. A receiver-separator unit for a liquid-injected gas compressor, comprising:
 - a. an elongated tank having a cylindrical wall which defines a bore;
 - b. partition means dividing said tank longitudinally into first and second compartments;
 - c. said partition transversely closing a major portion of said cylinder bore and coacting with a portion of said tank to define a liquid reservoir in said first compartment;
 - d. gas inlet means opening to said first compartment;
 - e. gas outlet means opening from said second compartment;
 - f. said first and second compartments being in gas communicating relationship;
 - g. a cylindrical liquid separator unit disposed entirely in said second compartment in coaxially spaced relation with said tank wall; and
 - h. said separator defining a third compartment which is

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in gas communicating relation with said second compartment and with said gas outlet means.

2. A receiver-separator unit for liquid-injected gas compressor, comprising:

- a. an elongated tank;
- b. partition means dividing said tank longitudinally into first and second compartments;
- c. gas inlet means opening to said first compartment;
- d. gas outlet means opening from said second compartment;
- e. said first and second compartments being in gas communicating relationship;
- f. a liquid separator unit disposed in said second compartment defining a third compartment which is in gas communicating relationship with said second compartment and with said gas outlet means;
- g. plural conduit means opening respectively from said first, second and third compartments whereby gas-entrained liquid that is progressively separated from the gas received from the compressor by said first and second compartments and by said separator unit is removed to the exterior of said tank;
- h. the discharge of a gas compressor means having plural working chambers is communicated to said gas inlet means; and
- i. said conduit means communicates said second compartment and a selectable one of said working chambers whereby said second compartment is maintained substantially free of separated liquid due to a gas pressure differential obtaining between said second compartment and said selectable one of said working chambers.

3. The invention defined in claim 2, wherein:

- a. said conduit means communicates said third compartment and a selectable one of said working chambers whereby said third compartment is maintained substantially free of separated liquid, due to a gas pressure differential obtaining between said second compartment and said selectable one of said working chambers.

4. The invention defined in claim 3, together with:

- a. liquid pump means;
- b. said conduit means opening from said first compartment being connected to said pump means;
- c. the discharge of said pump means being connected to said gas compressor for injecting liquid into said working chamber.

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ROBERT M. WALKER, *Primary Examiner.*