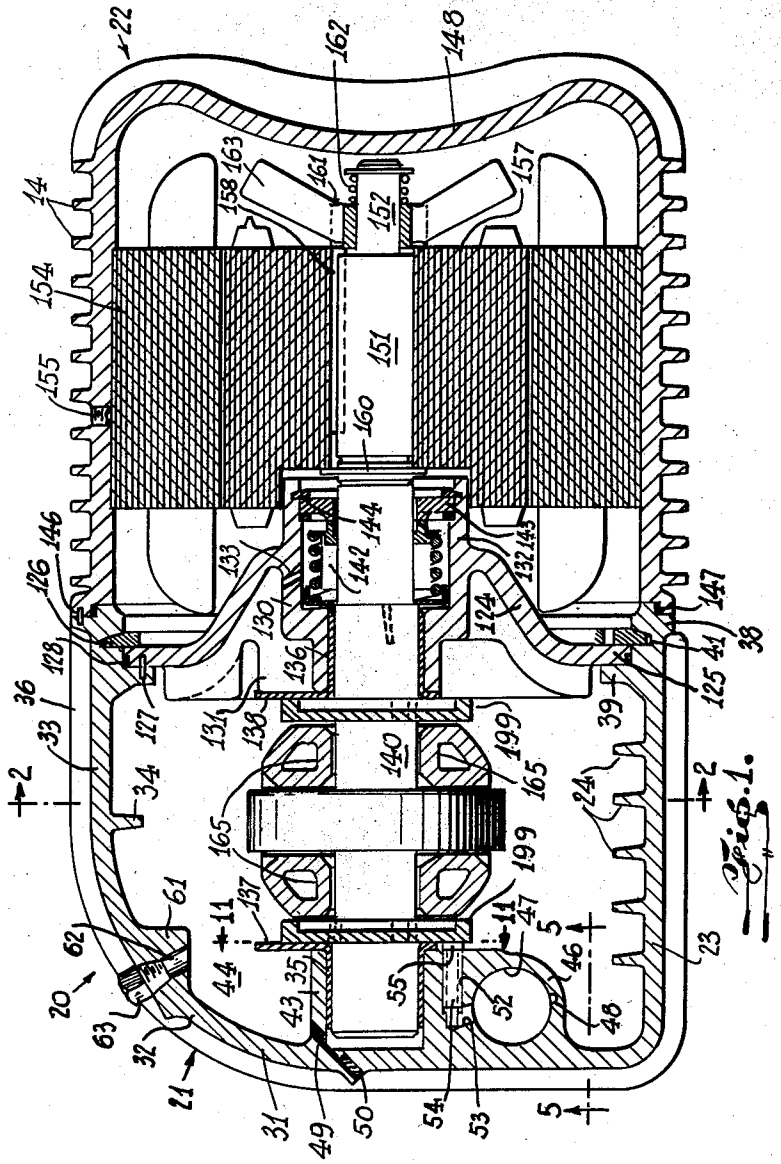
Dec. 2, 1958 M. M. KADISON 2,862,656

MULTI-STAGE COMPRESSOR

Filed April 4, 1955 5 Sheets-Sheet 1



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MULTI-STAGE COMPRESSOR

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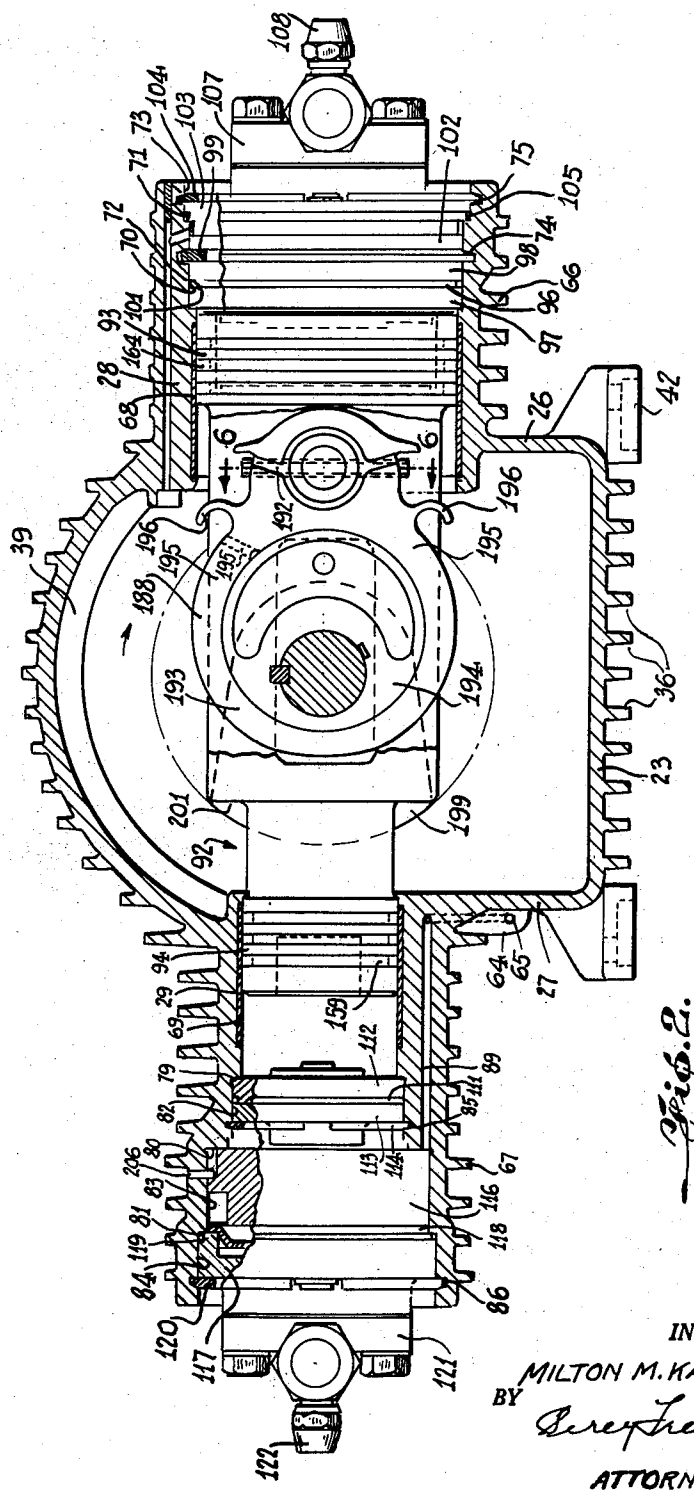


Fig. 2.

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MULTI-STAGE COMPRESSOR

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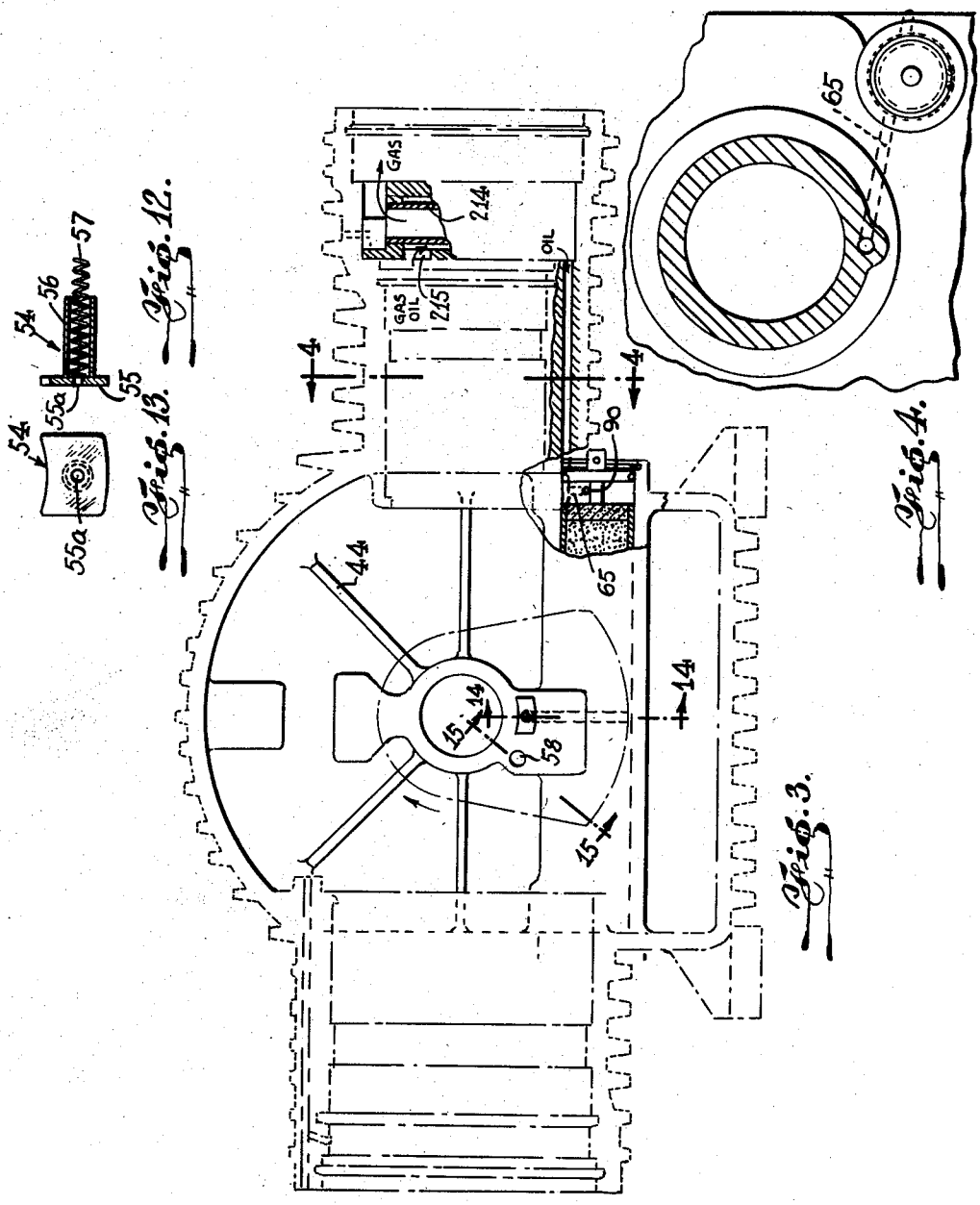


Fig. 3.

Fig. 4.

Fig. 12.

Fig. 13.

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MULTI-STAGE COMPRESSOR

Filed April 4, 1955 5 Sheets-Sheet 4

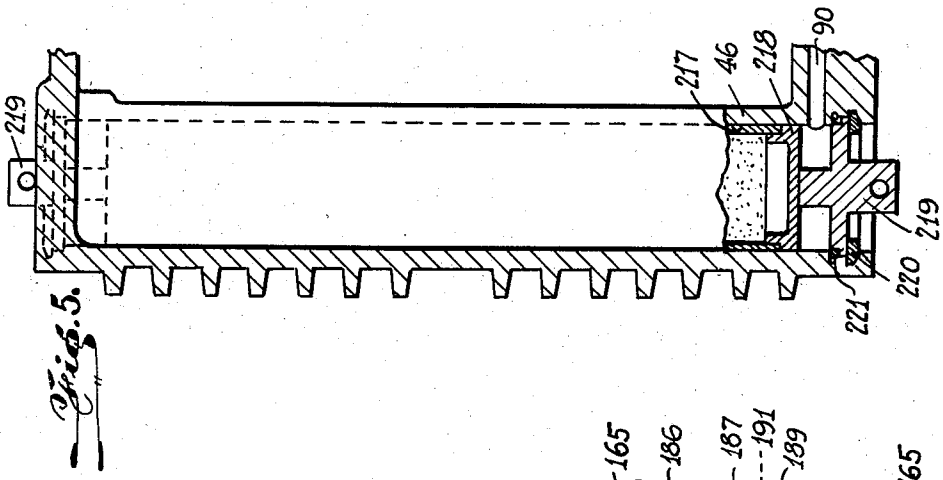


Fig. 5.

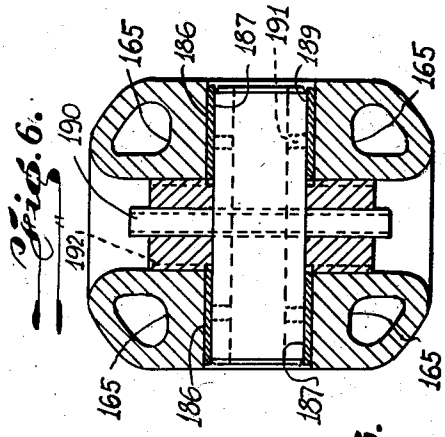


Fig. 6.

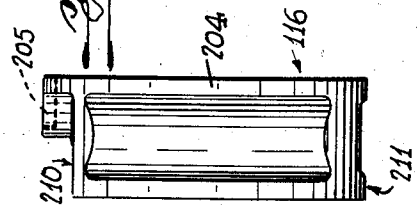


Fig. 9.

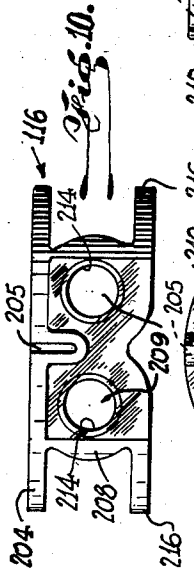


Fig. 10.

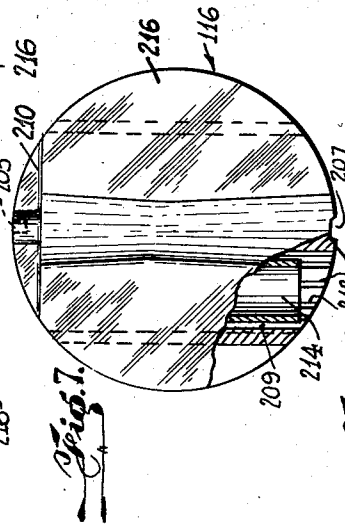


Fig. 7.

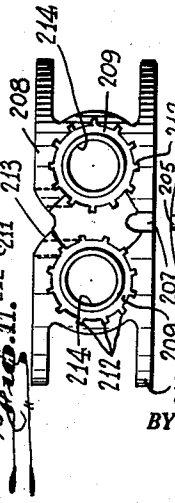


Fig. 11.

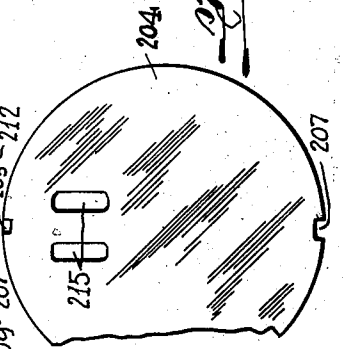


Fig. 8.

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MULTI-STAGE COMPRESSOR

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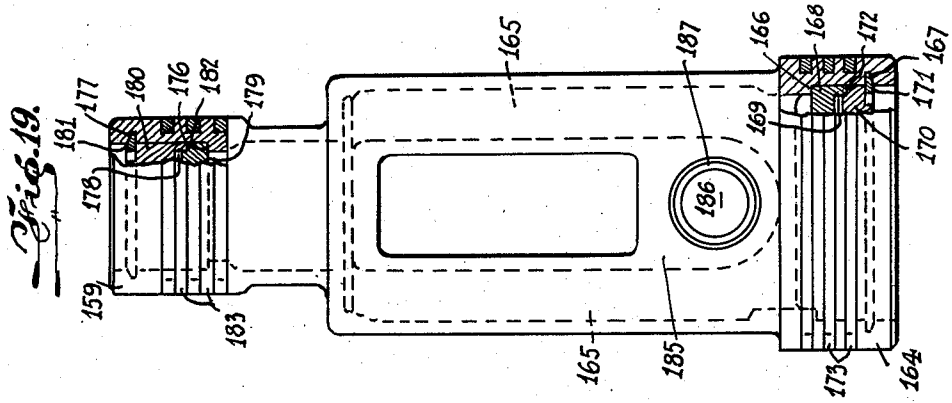


Fig. 19.

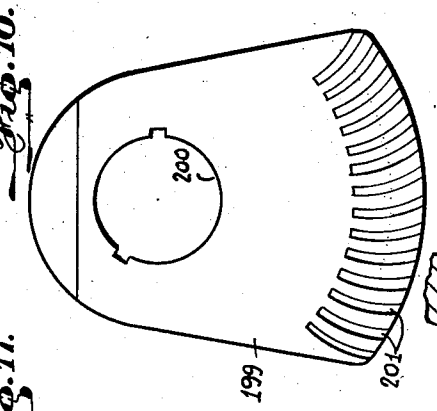


Fig. 18.

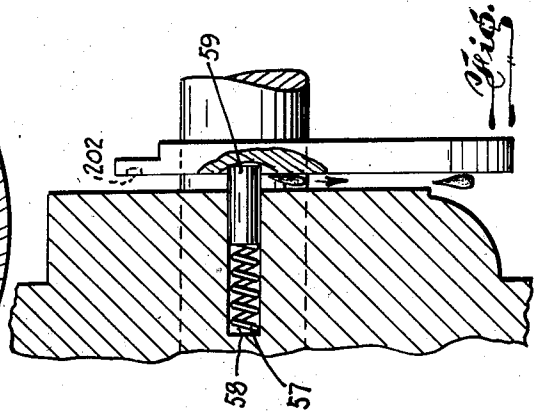


Fig. 15.

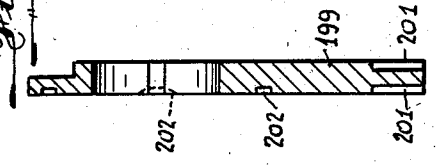
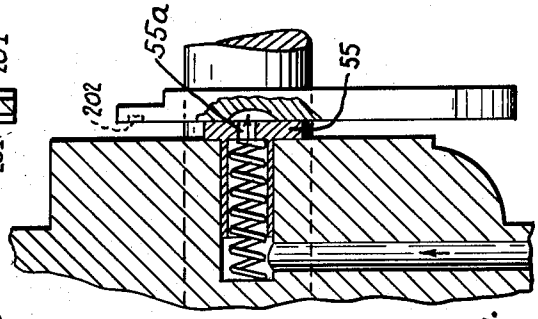


Fig. 17.



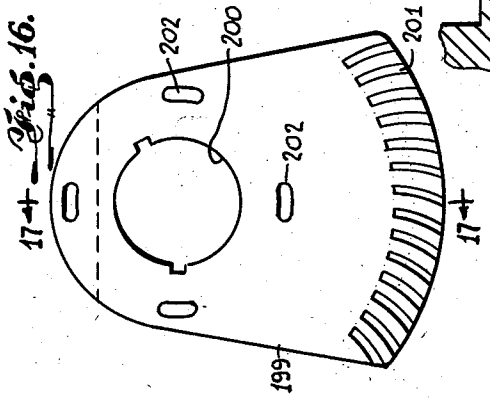


Fig. 16.

Fig. 14.

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United States Patent Office

2,862,656

Patented Dec. 2, 1958

2,862,656

MULTI-STAGE COMPRESSOR

Milton M. Kadison, Croton-on-Hudson, N. Y., assignor of twenty-five percent to Anna Colton, Bronx, N. Y., twenty-five percent to Hyman Bettigole, New York, N. Y., and fifty percent to Reba David, Bronx, N. Y.

Application April 4, 1955, Serial No. 499,099

2 Claims. (Cl. 230—202)

This invention relates generally to compressors, pumps, and the like, and is particularly directed to such devices of the multi-stage type.

While the present invention has been primarily developed and employed in the function of a fluid compressor, and will be described hereinafter with particular reference thereto, it is appreciated that the invention may also serve as a fluid pump or compressor, and with slight modification as a fluid motor; and hence, the term compressor as used hereinafter is intended to comprehend the various uses for which the invention may be employed.

The particular embodiment of the present invention which is illustrated in the drawings and which will be described hereinafter in greater detail comprises generally a housing provided with a pair of spaced cylinders, a pair of pistons slidable in the cylinders, fluid conduit means connecting the pistons together for movement as a unit and serving to transfer fluid between the cylinders.

Heretofore, the use of compressors, as in the common hermetic design of refrigerating motor-compressors, required special motor windings, and extreme care in assembly and shipment to avoid dirty contamination of the refrigerant path. That is, in order to cool the motor, it was necessary to suck the refrigerant through the motor windings, which operation served to sharply increase the work of compression. Further, in prior refrigerator motor-compressor constructions, it was impossible to repair or replace the motor without breaking into the refrigerant system, and hence no switch contacts or commutators could be placed inside the motor housing. This seriously limited the types of motors and controls capable of being employed, and prevented the use of highly desirable centrifugal switches and commutator type motors. In addition, the refrigerant was in intimate contact with the crankcase oil, presenting the constant danger of refrigerant contamination and the plugging or breakage of elements in the refrigerant system.

Accordingly, it is a general object of the present invention to provide a novel compressor construction which retains the advantageous features of the prior compressor art, and overcomes the above-mentioned difficulties. Some of the prior art advantages retained in the instant construction are those of life-time bearing lubrication, direct motor-compressor coupling, two bearing motor-compressor mounting, silent operation, and the use of a shaftless motor built into the unit.

It is another object of the present invention to provide a compressor of the type described which is extremely compact in construction and efficient in operation, so as to require a minimum of space and permit the use of less powerful, relatively small driving means or motors to achieve the same refrigerating capacity as previous compressors. Specifically, for equal refrigerating tonnage, the compressor construction of the present invention requires 25 percent less horsepower, up to 80 percent less overall size or volume, and has effected up to 30 percent reduction in weight.

It is another object of the present invention to provide a compressor having the advantageous characteristics mentioned above and which is adapted for use with conventional or stock types of motors without the need for special handling. This, of course, reduces costs and facilitates motor repairs and replacements in the field. Moreover, the motor can be readily removed and replaced in the field, without adversely affecting the life-time lubricating system or refrigerant. In addition, the construction of the present invention permits of quick and easy disassembly and reassembly by mechanics of only ordinary skill, insuring correct reassembly and efficient compressor operation independent of the mechanic's skill.

It is still another object of the present invention to provide a fluid compressor of the type described which includes novel means for separating dispersed particles or dispersoid from the compressed fluid, to prevent the entrance of water, oil or other foreign material into the refrigerating circuit. The dispersoid separator of the present invention is adapted to be located in the high pressure side of the compressor, occupying a relatively small space therein, and eliminates the need for a bulky, full-flow separator in the refrigerant circuit. While the highly improved separator of the instant invention is capable of effective operation over long periods of time, rapid replacement, as for cleaning, may be easily accomplished without loss of refrigerant.

It is a further object of the present invention to provide a compressor construction having the improvements mentioned in the foregoing paragraphs, and wherein all shaking forces and rocking couples in the vertical plane are eliminated by a novel construction employing counterweights which also effect positive feeding of lubricant to all bearing surfaces. While the motor coils and refrigerant circuit are both completely isolated from the lubricant, all working parts, including motor bearings, are automatically and positively, flood-splash lubricated at the required rate for all operating speeds.

The compressor construction of the present invention contemplates a further, highly advantageous construction, wherein the fluid passing between the compression stages is effectively cooled by the liquid of the lubricating system, so as to substantially increase overall refrigerating efficiency.

It is still a further object of the present invention to provide a compressor having the advantageous characteristics mentioned in the foregoing paragraphs, which is simple in construction, requiring a minimum of parts, which is durable in use, and which can be manufactured, sold and maintained at a reasonable cost.

Other objects of the present invention will become apparent upon reading the following specification and referring to the accompanying drawings, which form a material part of this disclosure.

The invention accordingly consists in the features of construction, combinations of elements, and arrangements of parts, which will be exemplified in the construction hereinafter described, and of which the scope will be indicated by the appended claims.

In the drawings:

Fig. 1 is a sectional elevational view of a motor-compressor assembly constructed in accordance with the present invention.

Fig. 2 is a sectional elevational view taken substantially along the line 2—2 of Fig. 1.

Fig. 3 is a sectional elevational view similar to Fig. 2, but with the piston assembly removed from the compressor housing.

Fig. 4 is a sectional view taken substantially along the line 4—4 of Fig. 3.

Fig. 5 is a sectional view, partly broken away, taken substantially on the line 5—5 of Fig. 1.

Fig. 6 is a sectional view taken substantially along the line 6—6 of Fig. 2.

Fig. 7 is a rear elevational view showing the separator of the present invention, removed from the assembly and partially broken away for clarity of understanding.

Fig. 8 is a partial front elevational view of the separator.

Fig. 9 is a side view of the separator.

Fig. 10 is a top plan view of the separator of Fig. 7.

Fig. 11 is a bottom plan view of the separator of Fig. 7.

Fig. 12 is a longitudinal sectional view showing a valve member of the device, removed therefrom.

Fig. 13 is an end view of the valve member of Fig. 12.

Fig. 14 is a partial, sectional view taken substantially along the line 14—14 of Fig. 3.

Fig. 15 is a partial sectional view taken substantially along the line 15—15 of Fig. 3.

Fig. 16 is a front view showing one rotary counterweight of the device, removed therefrom.

Fig. 17 is a sectional view taken substantially along the line 17—17 of Fig. 16.

Fig. 18 is a rear view showing the counterweight of Fig. 16.

Fig. 19 is a side view, partly broken away, showing the double piston unit of the instant device, removed from the assembly.

Referring now more particularly to the drawings, the embodiment of the invention illustrated therein comprises a housing, generally designated 20, which includes a main or compressor housing section 21 and an auxiliary or motor housing section 22.

The main or compressor housing section includes a generally rectangular, normally horizontal bottom wall 23 formed with a plurality of parallel spaced, internal ribs 24. Extending upwards from opposite sides of the bottom wall 23 are a pair of facing, spaced side walls 26 and 27, which are formed, respectively, with horizontally disposed cylinders 28 and 29. A front housing wall 31 extends upwards from the front side of the bottom wall 23, and extends between the side walls 26 and 27. The upper portion of the front main housing wall 31 curves rearwards and upwards, as at 32, to merge smoothly with a generally dome-shaped top wall 33 which extends between and is fixedly secured to the upper portions of the main housing side walls 26 and 27. The inner or under surface of the top wall 33 is formed with a laterally extending, depending rib or fin 34, while a plurality of parallel spaced, external ribs or fins 36 extend forwards and rearwards on the top and bottom housing walls 33 and 23, and vertically along the front housing wall 31. The compressor housing 21 is preferably integrally cast of aluminum, or other lightweight, high conductivity material, for purposes appearing more fully hereinafter.

The rearward end of the compressor housing 21, to the right in Fig. 3, is open, generally circular in configuration and preferably formed with peripherally extending, shoulders 38 and 39, respectively disposed externally and internally of the compressor housing. The rear end of the compressor housing is further formed with a peripherally extending internal groove 41, disposed between the shoulders 38 and 39 and generally wedge-shaped in section. A plurality of supporting feet or legs 42 project from the corners of the main housing bottom wall 23 for supporting the housing on an appropriate surface, and may be shaped to receive anchoring bolts or other fastening means, as desired.

The front wall 31 of the compressor housing 21 is provided internally with a centrally located, rearwardly extending tubular journal support 43, and a plurality of fins or webs 44 extending radially from the journal support along the front housing wall 31 toward the top and side walls of the main housing section. The front housing wall 31 is further provided on its interior, just below the journal support 43 with a laterally extending, hollow cylindrical portion or pocket 46 which terminates at the opposite housing side walls 26 and 27. More specifically, the interior hollow or cavity 47 of the pocket 46 is generally cylindrical in shape, and preferably provided with an upwardly facing, longitudinally extending internal groove or trough 48.

Formed in the front wall 31 of the compressor housing 21 is a rearwardly and upwardly inclined through bore 49 which opens intermediate its ends into the interior of the tubular journal support 43. A plug 50 is threadedly, or otherwise inserted into the forward portion of the bore 49 to close the latter and permit communication through the inner bore portion between the interiors of the compressor housing section and the journal support. A generally horizontally disposed bore 52 extends forwardly into the front wall 31 of the compressor housing between the journal support 43 and the cylindrical pocket 46 and communicates with the interior of the latter through a downwardly extending passage 53. Thus, the bore 52 and passage 53 communicate between the interior of the cylindrical body or pocket 46 and the interior of the compressor housing.

A horizontal valve member 54 is disposed slidably within the bore 52, and includes an enlarged apertured head 55 (see Figs. 12 and 13) on one end of a hollow tube 56. Suitable resilient means are provided, such as a helical coil spring 57 disposed within the tube 56 to urge the valve member and head rearward. In addition, a horizontal, blind bore 58 (see Fig. 3), extends forwardly into the front housing wall 31 between the hollow body 46 and journal support 43, on one side of the bore 52; and, a spring pressed wiper finger or pin 59 is slidable in the bore 58 and resiliently urged rearwards into the compressor housing, all for purposes appearing presently.

The upper, curved portion 32 of the front housing wall 31 is formed with an internal boss 61 having a downwardly and rearwardly extending through bore 62, which is normally closed by a threaded plug 63 or other suitable means, and facilitates the introduction and removal of liquid lubricant from the compressor housing interior. An external boss or protuberance 64 is formed on the compressor housing side wall 27 extending from the cylinder 29 to the front wall 31, and is formed with a longitudinal bore 65 for a purpose appearing more fully hereinafter.

The horizontal cylinders 28 and 29 are in substantial, longitudinal alignment, and are preferably formed with circumferential, external heat dissipating fins 66 and 67, respectively. The cylinders 28 and 29 are preferably formed integrally with the compressor housing 21, having their outer ends open and the inner portion of each cylinder internally, circumferentially recessed for receiving cylinder linings or bushings 68 and 69. More specifically, the inside diameter of the cylinder 28 increases outwardly by steps so as to define outwardly facing, annular shoulders 70 and 71 in alternate relation with circumferential, internal lands 72 and 73. The land 72 is formed with an annular groove 74, and the land 73 is formed with an annular groove 75, both annular grooves being generally wedge-shaped in section.

The inside diameter of the outlet or high pressure cylinder 29, while generally less than that of the low pressure or inlet cylinder 28, also increases outwardly in steps defined by annular, outwardly facing shoulders 79, 80 and 81, and alternate circumferential lands 82, 83 and 84. The lands 82 and 84 are each formed with an annular, internal groove 85 and 86, which are also generally wedge-shaped in cross section. In addition, the relatively small, high pressure cylinder 29 is formed in its lower portion with a longitudinal bore 89 extending inwards from the shoulder 80 and communicating through the

boss 64 with the interior of the cylindrical body or pocket 46, as at 90 in Figs. 3 and 5.

A dumbbell-like piston unit, generally designated 92, extends between the inner portions of the cylinders 28 and 29 and includes pistons 93 and 94 on its opposite ends slidable, respectively, in the bushings or cylinder liners 68 and 69.

Disposed within the circumferential, internal land 72 is a suitable low pressure inlet valve 96 having on opposite sides thereof a back-up plate 97 and inlet valve seat 98, the back-up plate being adjacent to the shoulder 70 and maintained in abutting engagement with the latter by a resilient, C-shaped retaining ring 99 received in the groove 74 and resiliently engaging the valve seat 98. A seal ring 101, preferably fabricated of dead-soft aluminum or other suitable material, is wedged between the back-up plate 97, land 72 and low pressure inlet valve 96.

A porous filter disc 102 is disposed within the land 72 just outwards of the retaining ring 99, and a peripherally stepped cylinder closure or head 103 is positioned just outwards of the filter disc, partially within the land 92 and partially within the land 93. That is, the peripherally stepped cylinder closure or head 103 is maintained in abutting engagement with the outwardly facing shoulder 71 by a resilient, C-shaped retaining ring 104 and extends within the land 72 to hold the filter disc in position. The dead-soft seal ring 105 is wedged between inlet cylinder head 103, the shoulder 71 and land 73, to prevent the passage of fluid therebetween. A suitable inlet shut-off valve 107 is provided on the cylinder end closure 103, which permits selective communication through the cylinder end closure, filter disc 102, and inlet valve 96 with the interior of the low pressure cylinder. The inlet shut-off valve 107 includes appropriate means, as at 108, for connection to a source of fluid supply.

Disposed within the circumferential, internal land 82 of the high pressure cylinder 29 is a suitable high pressure outlet or discharge valve 111 having a discharge valve seat 112 on its inner side and a discharge valve back-up plate 113 on its outer side, the discharge valve seat being held in abutting engagement with the annular shoulder 79 by a resilient, C-shaped retaining ring 114 received in the groove 85 and bearing against the discharge valve back-up plate.

A particle or dispersoid separator 116 is seated within the circumferential land 83 in engagement with the outwardly facing shoulder 80, and a cylinder closure or head 117 is disposed within the outer land 84 in engagement with the outwardly facing shoulder 81. Interposed between the separator 116 and cylinder closure or head 117 is a filter disc 118; and, a dead soft seal ring 119 is wedged between the land 84, shoulder 81 and cylinder head 117, the latter being positively retained in position within the cylinder by a resilient C-shaped retaining ring 120. Provided on the cylinder head 117 is a discharge shut-off valve 121 which communicates through the cylinder head 117, filter disc 118, separator 116 and high pressure discharge valve 111 with the working interior of the cylinder 29. Outlet connection means 122 are provided on the discharge shut-off valve 121, as for connection to a refrigerating coil, pneumatically operated device, etc. While the inlet and discharge shut-off valves 108 and 122, respectively, may be manually operated, if desired, the low pressure inlet valve 96 and high pressure discharge valve 111 are necessarily completely automatic, opening and closing in response to predetermined pressure differentials, and may be of the well-known, spring-pressed flutter type valves.

Disposed within the open rear of the compressor housing 21 is a generally circular, rearwardly cupped wall 124 having its peripheral marginal portion 125 seated against the rearwardly facing, annular shoulder 39 and maintained thereagainst by a resilient, C-shaped retaining ring 126 received in the annular groove 41. One or more locating pins 127 are used to properly position the wall 124 on the shoulder 39, and a seal ring 128, preferably of dead soft aluminum or other suitable material is wedged between the wall 124 and the shoulder 39 to seal the juncture thereof. The wall 124 is formed centrally with an open-ended, tubular journal support 130, and on its forward face with a plurality of fins, blades or webs 131 extending radially from the journal support. The journal support 130 is arranged coaxially with the journal support 43, and has an enlarged rearward portion 132 formed with a diagonal through bore 133, communicating between the upper cupped or hollow part of the wall 124 and the interior of the enlarged rearward journal support portion 132.

A pair of similar, tubular bearings 135 and 136 are seated in the journal bearing supports 43 and 130, respectively, each of the bearings being formed with an upstanding, segmental flange or wall, as at 137 and 138. The flange 137 combines with the upper ribs, fins or webs 44 of the front housing wall 31 and the upper portion of the journal support 43 to define a well for containing liquid lubricant, while the flange or wall 138 combines with the upper fins, ribs or webs 131 and the upper portion of the journal support 130 to form another well for holding liquid lubricant.

A drive shaft 140 extends transversely through the piston unit 92, being operatively connected to the latter for effecting reciprocation thereof as will be seen in greater detail hereinafter, and is rotatably supported in the bearings 135 and 136. Further, the shaft 140 extends rearwards through and beyond the journal support 130 for connection to a suitable driving means. An appropriate shaft seal 142 is circumposed about the shaft 140 in the rearward, enlarged portion 132 of the journal support 130; and, a shaft seal seat 143 is retained in the enlarged tubular portion 132 by a C-shaped retaining ring 144. It will now be appreciated that the wall 124 combines with the compressor housing section 21 to completely enclose the space within the latter and define a hermetically sealed casing or chamber.

The auxiliary housing section or motor shell 22 is generally cylindrical in configuration and disposed just rearwards of the compressor housing section. More specifically, the motor shell 22 has its front end open and detachably secured to the rear end of the compressor housing section by bolts or other suitable securing means. Locating pins 146 are employed to properly position the motor shell with respect to the compressor housing, and a seal ring 147 serves to hermetically seal the motor shell. The rear end of the motor shell 22 is closed by an end wall 148, and a suitable opening (not shown) is provided for electric wires entering the shell. External ribs or fins 149 are advantageously provided on the auxiliary housing 22 including the rear end wall 148, for dissipating heat generated within the auxiliary housing or shell.

The rearwardly extending portion of the shaft 140, as at 151, is disposed longitudinally within the auxiliary shell 22, and terminates in a reduced end portion 152 adjacent to the rear auxiliary shell end wall 148. A shaftless motor is the preferred form of drive means, and is illustrated as including an outer stator 154 seated within the auxiliary shell 22 and fixedly positioned therein by one or more set screws 155. Keyed to the rearwardly extending shaft portion 151, as at 158, is an inner rotor 157 which effects rotary movement of the shaft. A retaining ring 160 is circumposed about the shaft portion 151 just forwardly of the rotor 157, and a hub 161 is longitudinally slidable on the reduced shaft end portion 152 and resiliently biased forwardly by a coil spring 162 against the motor rotor to maintain the latter in engagement with the retaining ring 160. If desired, fan blades 163 may be provided on the hub 161 for cooling the motor, however, this has been found to be unnecessary under most operating conditions.

The double piston unit

As best seen in Fig. 19, the double or dumbbell-like piston unit **92** includes a hollow, relatively large, low pressure piston **164**, a hollow, relatively small high pressure piston **159**, in longitudinal alignment with the low pressure piston and connected to the latter by a plurality of parallel spaced, rectangularly arranged hollow struts **165** (four being illustrated in the drawings see Fig. 6). That is, the struts **165** are generally tubular in construction preferably with walls of minimum thickness, and each opens at its opposite ends into the interiors of the low pressure and high pressure pistons **164** and **159**, respectively.

The interior of the low pressure piston **164** is formed with an annular, longitudinally outwardly facing shoulder **166** and an annular internal groove **167**, the latter being spaced between the shoulder and the outer end of the low pressure piston. A valve back-up member **168** is disposed within the low pressure piston **164** in engagement with the annular shoulder **166**. A low pressure discharge valve **169** and a low pressure discharge valve seat **170** are also disposed within the low pressure cylinder, the discharge valve being located between the back-up member and valve seat, and all being held in the low pressure piston by a C-shaped retaining ring **171** received in the groove **167**. A dead soft seal ring **172** is wedged between the valve seat **170** and the interior surface of the piston **164** to prevent the passage of fluid therebetween; and, a plurality of piston rings **173** are circumposed about the exterior of the low pressure piston.

The hollow interior of the high pressure piston **159** is also formed with an annular, outwardly facing shoulder **176** substantially spaced from the outer piston end, and an annular, internal groove **177** adjacent to the outer piston end. A high pressure inlet valve **178** is positioned interiorly of the high pressure piston **159**, interposed between a high pressure inlet valve seat **179** and a high pressure inlet valve back-up member **180**. The high pressure inlet valve seat **179** is disposed in engagement with the internal shoulder **176**, and the valve seat, valve and back-up member are held in position by a C-shaped retaining ring **181** located in the groove **177** and engaging the back-up member. A dead soft seal ring **182** is wedged between the high pressure inlet valve seat **179** and the interior surface of the high pressure piston to prevent the passage of fluid therebetween, and a plurality of piston rings **183** are circumposed about the high pressure piston in the conventional manner.

The rectangularly arranged tubular struts **165** are substantially spaced apart to define intersecting vertical and horizontal passageways therebetween. The horizontal passageway is partially closed by a web **185** extending between each adjacent pair of vertically spaced struts. The webs **185** are apertured in alignment with each other, as at **186** and each provided with a journal bearing or bushing **187**. A connecting rod **188** (see Fig. 2) is disposed in the vertical passageway defined between horizontally spaced pairs of struts **165** and has a wrist pin **189** extending transversely through one end and journaled in the bearings **187**. Stated otherwise, the connecting rod **188** is pivotally connected to the double piston unit **92** by the wrist pin **189**. The wrist pin **189** is non-rotatably secured to the connecting rod **188** by the pin **190** extending through the connecting rod and wrist pin at right angles to the latter, so that all relative rotation takes place between the wrist pin and bearings **187**. Lubricating passageways, as at **191**, are advantageously formed in the wrist pin **189** communicating between the interior of the latter and the bearing surfaces thereof. Additional lubricating passageways are provided by grooves **192** formed on opposite sides of the connecting rod for lubricating relative movement between the latter and the struts.

The crank end **193** of the connecting rod **188** is disposed in the vertical, inter strut passageway adjacent to the high pressure piston **159** and provided internally with a rotary eccentric **194**. The drive shaft **140** extends through the horizontal inter strut passageway and through the eccentric **194**, eccentrically thereof, and is keyed to the eccentric for effecting positive rotation of the latter about the axis of the shaft. Thus, rotation of the shaft **140** will oscillate the connecting rod **188** and reciprocate the pistons **164** and **159**, in the cylinders **28** and **29**, respectively. A pair of lubricating passageways **195** extend into the connecting rod **188** and communicate with the sliding surfaces of the connecting rod and eccentric to lubricate the latter. Toward this end, curved lips or tongues **196** project from the connecting rod adjacent to the passageways **195**, to collect liquid lubricant and guide the latter toward the passageways.

The lubricating system

Keyed to the shaft **140** on opposite sides of the struts **165** are a pair of counterweights **199**, (Figs. 14–18), which are preferably identical in construction for simplicity of assembly (see Fig. 16), and are proportioned to completely balance all vertical vibrational forces. Each counterweight comprises an oblong plate of generally segmental configuration, having a through bore **200** adjacent to one end formed with one or more keyways, and a plurality of arcuate grooves or recesses **201** extending inwards from the other plate end. That is, each face of the counterweight plate is formed with a plurality of arcuate, substantially parallel grooves or recesses extending inwards from the plate end remote from the bore **200**. In addition, one face of each counterweight plate is formed with a plurality of arcuate pockets or recesses **202** arranged in equally spaced relation circumferentially about the bore **200**. Upon rotation of the shaft **140**, and hence of the counterweights **199**, the grooved ends of the counterweights will engage in a pool of oil or other liquid lubricant contained in the lower region of the compressor housing, so as to receive and hold lubricant in the grooves **201** for centrifugal discharge upwards against the top housing wall **33** upon continued rotation of the counter weights. The counterweights are arranged to rotate in the direction of the arrow (Fig. 2), so that liquid is forced onto the grooves **201** through the open ends thereof. The liquid thrown centrifugally against the top housing wall will drip down, primarily from the rib **34** to effectively lubricate the connecting rod, wrist pin and eccentric. In addition, the counterweights effect substantial splashing of liquid from the pool or reservoir into the wells defined on the journal supports **43** and **130**, and to the piston bearing surfaces. As a continuous supply of lubricant is afforded the wells formed on the journal supports, there will be constant flow of lubricant downwards through the bores **49** and **133** and thence into the journal bearings **135** and **136**.

The dispersoid separator **116** is best seen in Figs. 7–11, and includes a generally vertically disposed cylindrical or circular partition wall barrier or body **204** interposed in the high pressure cylinder **29** and extending thereacross between the piston **94** and the cylinder head or outer closure **117**, and more specifically between the high pressure discharge valve **111** and the discharge filter **118**. The body or wall **204** is formed in its upper portion with a groove **205** for receiving a vertically disposed locating pin **206**, and is formed in its lower region with a notch **207** opening into the bore or passageway **89**. On the outer side of the cylindrical body or wall **204**, adjacent to the cylinder head **117**, is provided a projection **208** having a pair of vertically disposed cylindrical cavities **209** formed therein. The outwardly projecting separator body portion **208** has its upper end **210** spaced from the upper region of the cylinder **29**, or more specifically, from the adjacent portion of the internal land **83**, and has its lower end **211** disposed in conforming engage-

ment with the adjacent surface of the land **83**. The cylindrical cavities **209** open through the lower end of the projecting body portion **208** and are preferably longitudinally grooved or internally fluted, as at **212** throughout substantially their entire length. In addition, the body portion **208** intermediate the open lower ends of the cavities **209** is recessed upwards, as at **213**, which recess communicates through the groove or notch **207** with the passageway **89**.

The upper end of each cylindrical cavity **209** is closed except for a vertically disposed tube **214** which depends spacedly within each cavity terminating at its lower end above the adjacent portion of the land **83** and opening through the upper end of the body projection **208** into the cylinder **29**. A pair of ports **215** are formed in the wall or barrier **204** and each opens into one of the cylindrical cavities **209** adjacent to the upper end thereof and substantially tangential thereto. The projecting body portion **208** may be provided with laterally extending chordal segments **216** to insure accurate positioning of the partition wall or barrier **204** in the cylinder **29** and prevent wobbling or other displacement of the separator under high fluid pressures.

During compressor operation, the finally compressed fluid from the high pressure discharge valve **111** will pass through the ports **215** and thus tangentially enter the annular spaces defined between the surfaces of the cavities **209** and the tubes **214**. Relatively heavy particles or dispersoid contained in the compressed fluid will be centrifugally forced into the grooves **212**, so as to impinge the surfaces thereof and be captured therein. The thus captured dispersoid will flow downwards along the grooves to the bottom of the cavities **209**, and thence through the recess **213** and notch **207** into the passageway **89**. In addition to a swirling movement in the cavities **209**, the fluid passes downwards exteriorly of the tubes **214** and thence upwards through the tubes into the space outwardly of the wall **204**. Along this vertically reversed path of fluid movement, the relatively heavy particles or dispersoid not captured in the grooves **212** will fall to the lower ends of the cavities **209** and also pass through the recess **213** and notch **207** into the passageway **89**.

As mentioned hereinbefore, the passageway **89** communicates through the external boss **64** and the passageway or port **90** with the cylindrical interior **47** of the pocket or body **46**.

Disposed within the pocket **46** is a generally cylindrical, previous tube **217** containing a suitable agent for cleaning the separated dispersoid, such as silica gel or other purifying and dehydrating substance. The tube **217** is closed at its ends by porous plugs **218** permitting the passage therethrough of the separated dispersoid, the plugs being maintained in position by closure heads **219**, which are in turn maintained in position by C-shaped retaining rings **220**. Seal rings **221** are preferably wedged between the closure heads **219** and the adjacent internal surfaces of the pockets **46** to prevent escape of separated dispersoid around the closure heads. As the separated dispersoid is under substantial pressure from the finally compressed fluid, it will pass readily through the filtering plugs **218**, any heavy residue being collected in the trough **48**, and after purification and dehydration by the silica gel, will be forced through the porous tube **217** into the passage **53** and bore **52**. Hence, a constant supply of clean lubricant will be readily available at the valve **55** of the bore **52**.

Upon rotation of the shaft **140** and the counterweights or splashers **199**, the counterweight adjacent to the valve **55** will effect opening and closing of the latter in predetermined timed relation with respect to the compressor operation. More specifically, the valve **54** will periodically communicate through its apertured head with the recesses or grooves **202** (see Fig. 14) to open the bore **52** and permit the passage of clean lubricant into the latter grooves. Each of the grooves **202** moves successively from the

region of the valve **54** to the region of the pin **59**, the latter entering into each groove, as seen in Fig. 15, to wipe the latter clean and discharge all lubricating liquid therefrom into the interior of the compressor housing. In this manner, there is fed a predetermined quantity of filtered lubricant back into the liquid pool, dependent upon the speed of compressor operation.

Compressor operation

Upon energization of the motor, the rotor **157** will effect rotation of the shaft **140** to rotate the counterweights **199** and reciprocate the double piston unit **92**. As the piston unit reciprocates from right to left (see Fig. 2), the low pressure inlet valve will be opened, while the low pressure discharge valve is closed, to draw fluid into the low pressure cylinder. Reciprocation to the right will effect closing of the low pressure inlet valve and compression of the fluid contained in the low pressure cylinder until a predetermined value of pressure is reached, when the low pressure discharge valve will open to permit the escape of partially compressed fluid into the tubular struts **165**. Similarly, upon reciprocation of the double piston unit **92** toward the right, as seen in Fig. 2, the high pressure inlet valve will be opened by the fluid under pressure in the tubular struts to permit the ingress of partially compressed fluid into the high pressure cylinder **29**; and, upon reciprocation of the piston unit to the left, the high pressure inlet valve will be closed and the fluid compressed in the high pressure cylinder until a predetermined value of pressure is reached. At this time the high pressure discharge valve opens to permit the discharge of finally compressed fluid for passage through the dispersoid separator **116** and thence out through the high pressure shut-off valve **12**. Of course, the finally compressed fluid is thoroughly cleaned, all particles and dispersoid having been removed during passage through the separator **116**.

In order to effect considerable increase in efficiency, the splasher-counterweights **199** discharge liquid lubricant centrifugally from the grooves **201** against the top wall **33** of the compressor housing, as described hereinbefore. The upwardly discharged liquid lubricant is cooled by contact with the finned high conductivity wall **33** and cascades downwards therefrom over the relatively thin walled, tubular struts **165** to remove heat therefrom. Thus, in addition to eliminating cumbersome and inefficient interstage conduits, the tubular struts provide a direct interstage conduit means which permits of effectively cooling the partially compressed fluid to obtain greater work from the high pressure cylinder and increased total compressor efficiency.

From the foregoing, it is seen that the present invention provides a compressor which fully accomplishes its intended objects, which is well adapted to meet practical conditions of manufacture, maintenance and use.

Although the present invention has been described in some detail by way of illustration and example for purposes of clarity of understanding, it is understood that certain changes and modifications may be made within the spirit of the invention and scope of the appended claims.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. In a compressor including a generally horizontal cylinder having one end closed, and a piston slidable in said cylinder toward and away from said closed end, the improvement comprising a body interposed in said cylinder between said closed end and said piston to subdivide said cylinder into inner and outer chambers adjacent to said piston and closed end, respectively, there being a generally vertically disposed cylindrical cavity formed in said body and opening adjacent its upper end into said inner chamber for receiving compressed fluid from the latter, and a tube disposed in spaced relation within said cavity having its lower end opening into said cavity adjacent to the lower end of the latter and having its upper

end opening through said body into said outer chamber, whereby relatively heavy dispersoid in said fluid will fall by gravity to the lower end of said cavity and relatively clean fluid will pass outwards through said tube.

2. A device according to claim 1, wherein the opening between said inner chamber and cavity is disposed generally tangential with respect to the latter for effecting a swirling fluid movement in said cavity, whereby additional dispersoid will be centrifugally separated from said fluid and captured by said grooves.

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