Jan. 8, 1963 C. E. COX ETAL 3,072,320

ROTARY FLUID COMPRESSOR

Original Filed May 11, 1954 9 Sheets-Sheet 1

Fig. 1.

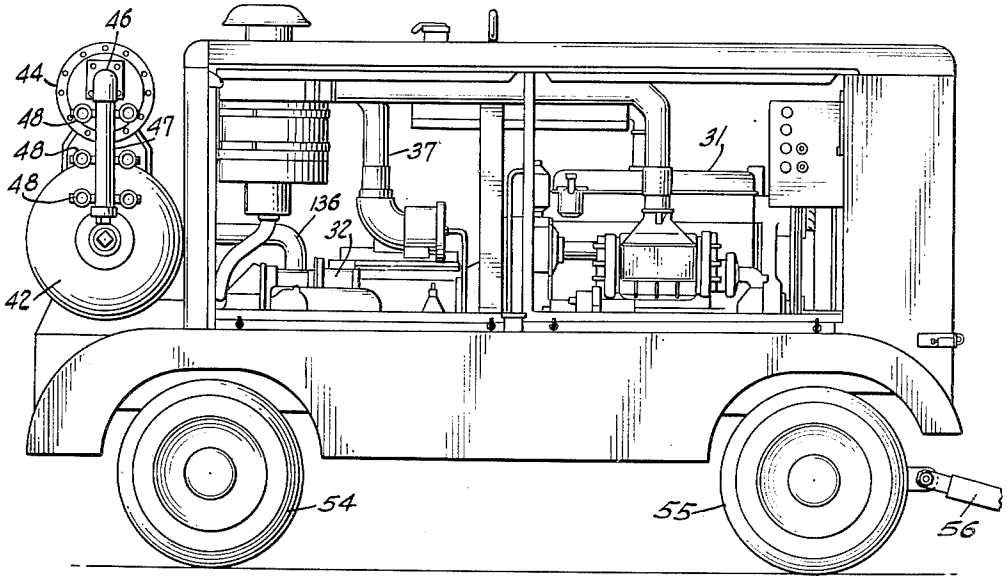
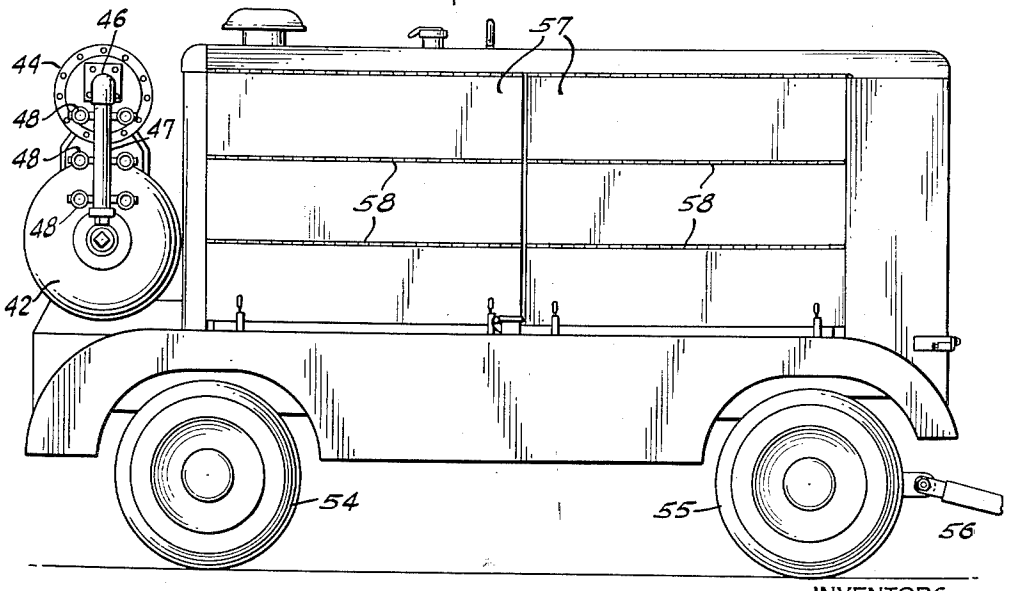


Fig. 2.



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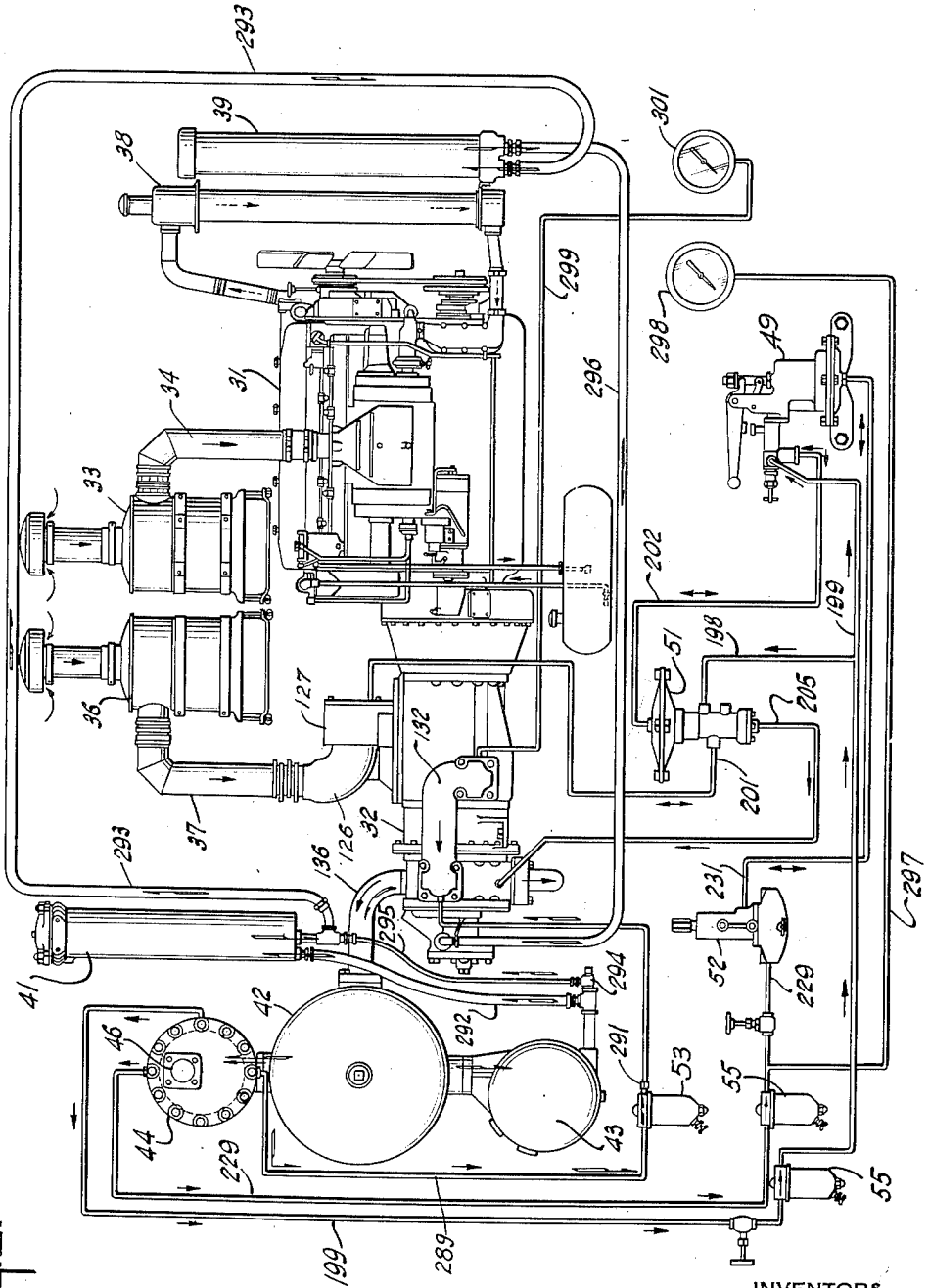


FIG. 3.

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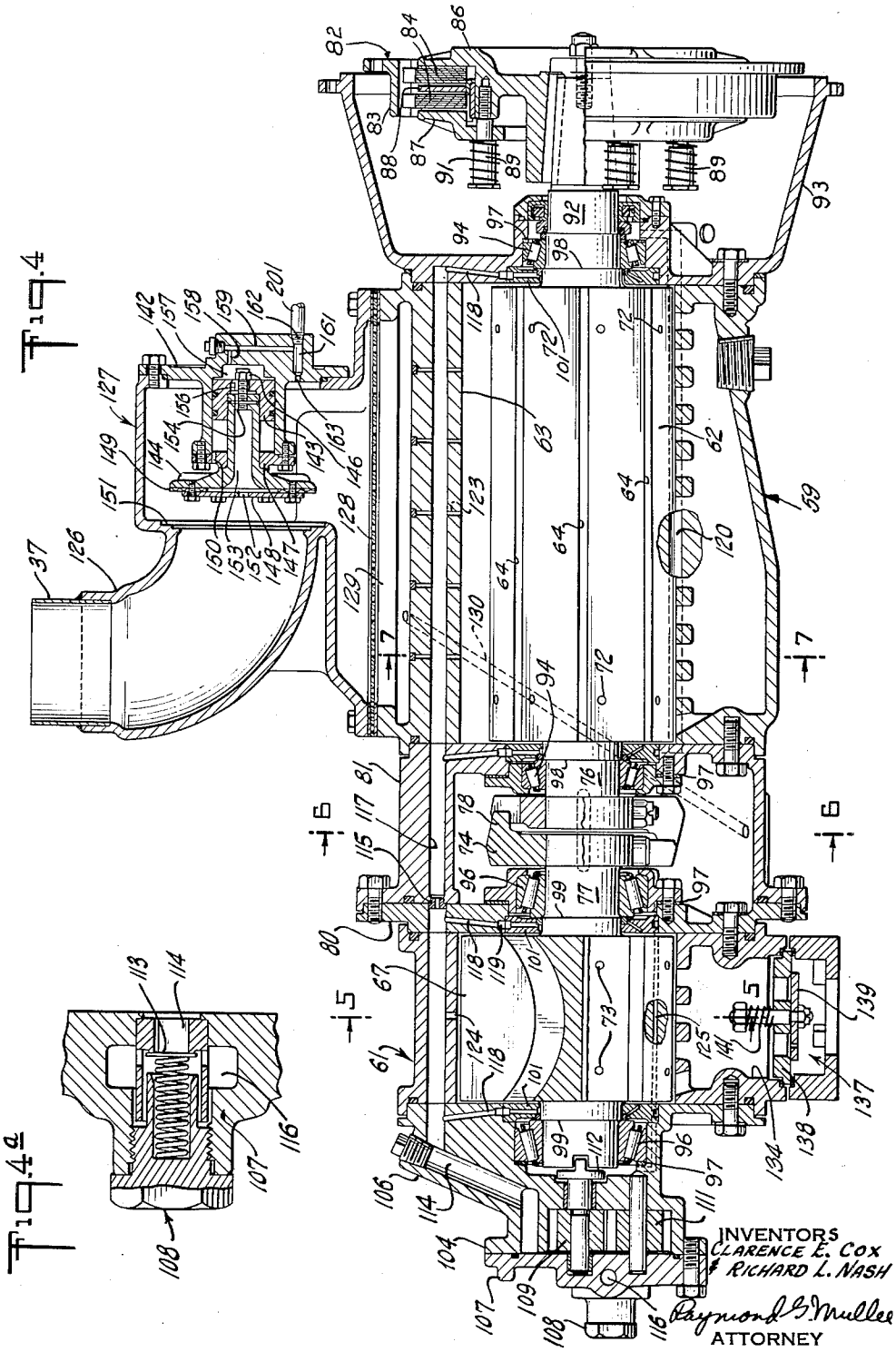


Fig. 4

Fig. 4a

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Fig. 5.

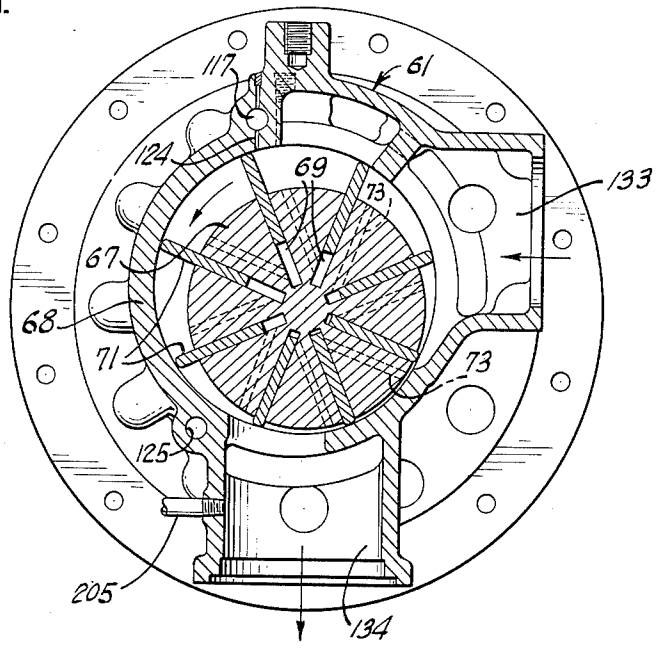


Fig. 7.

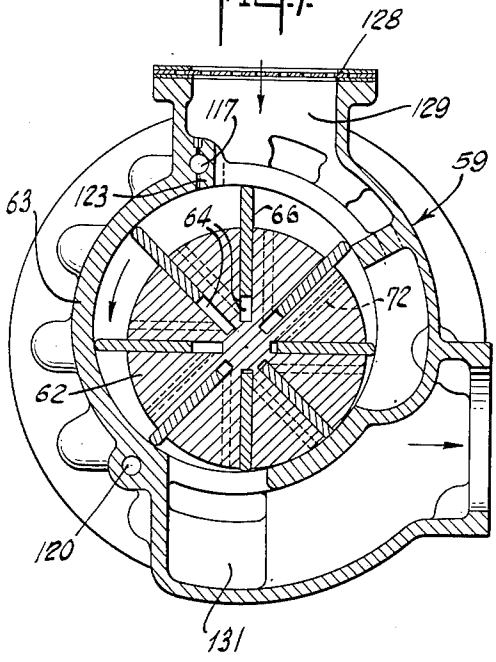
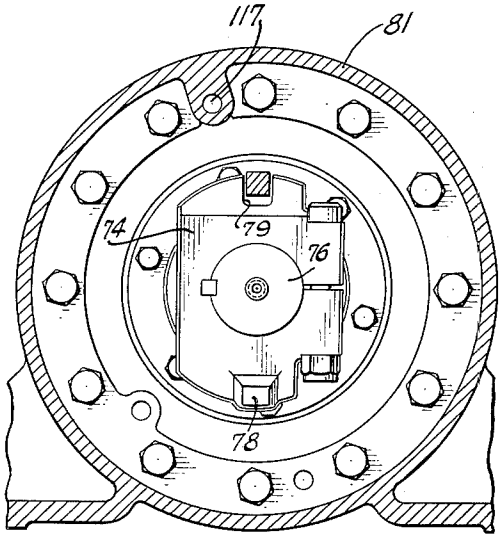


Fig. 6.



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Fig. 8.

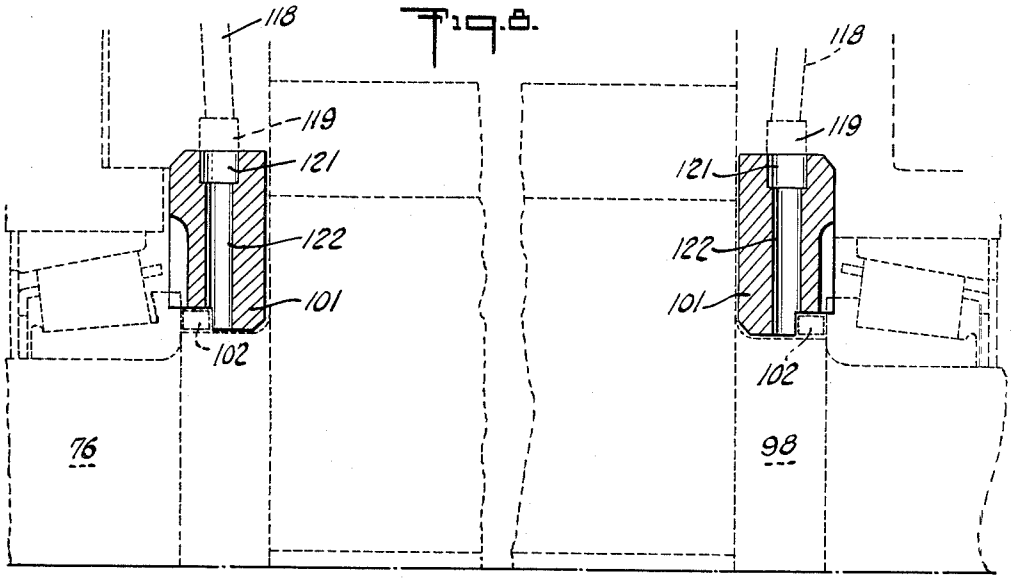


Fig. 9.

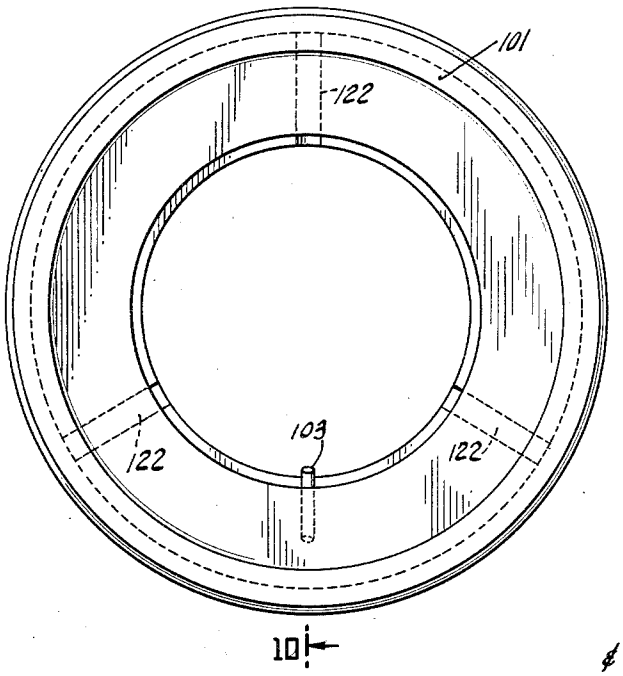
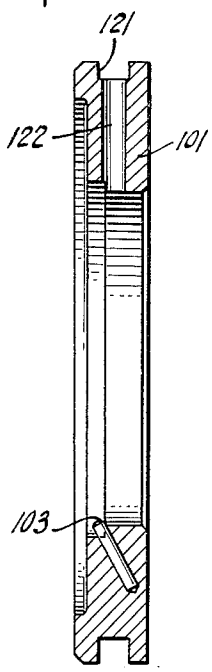


Fig. 10.



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Fig. 11.

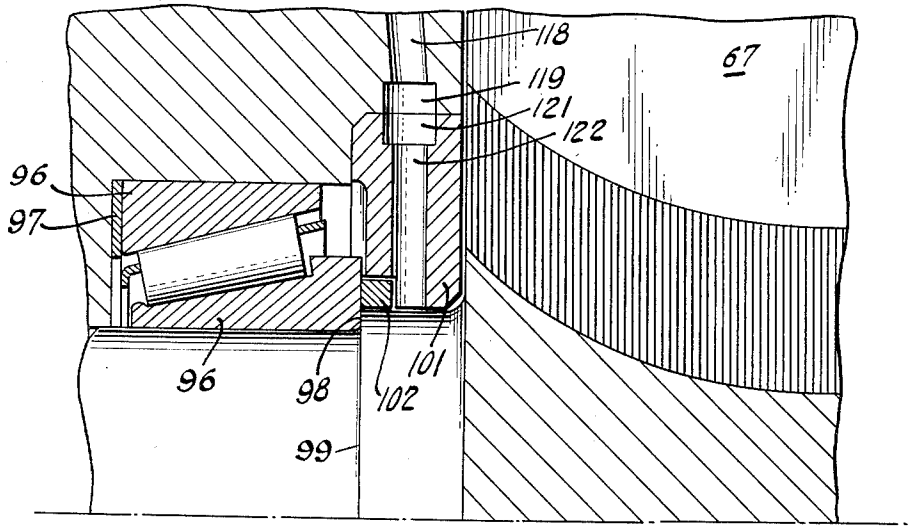
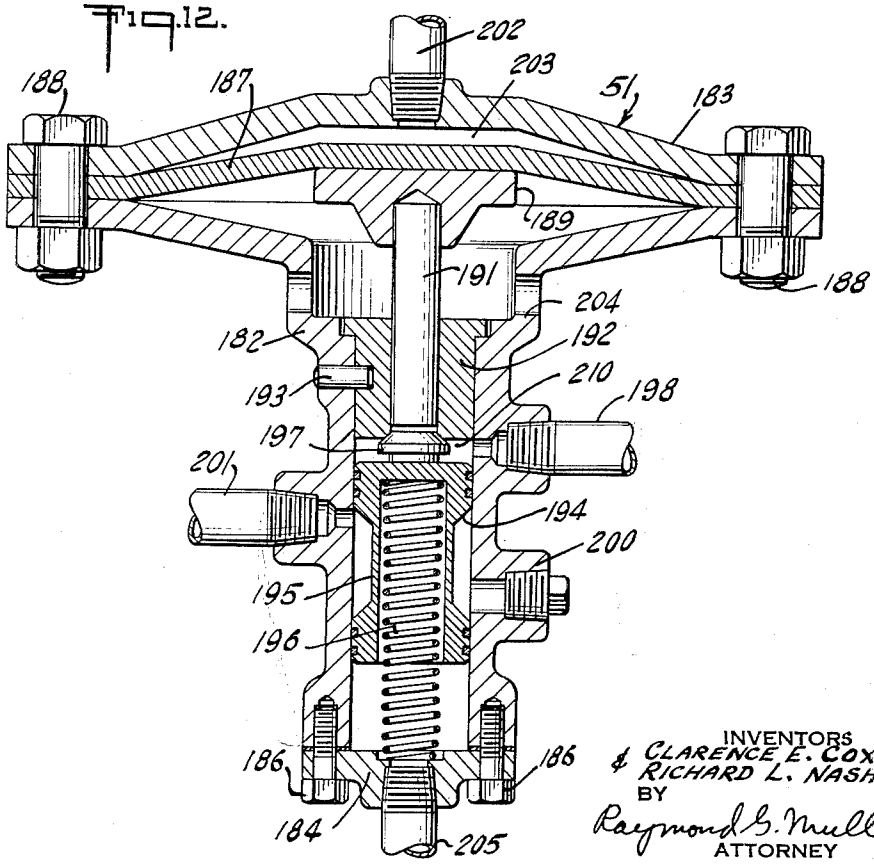


Fig. 12.



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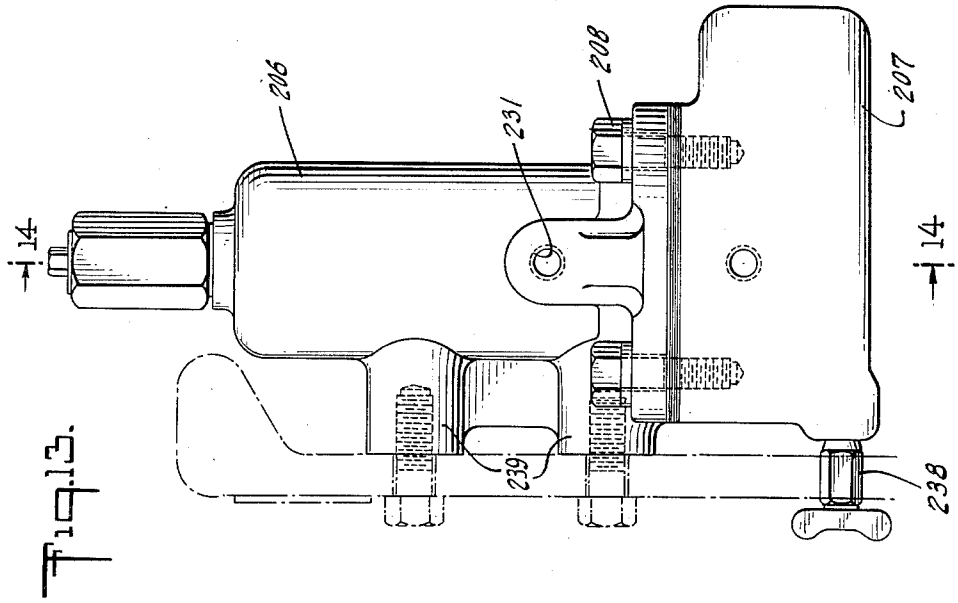


Fig. 13.

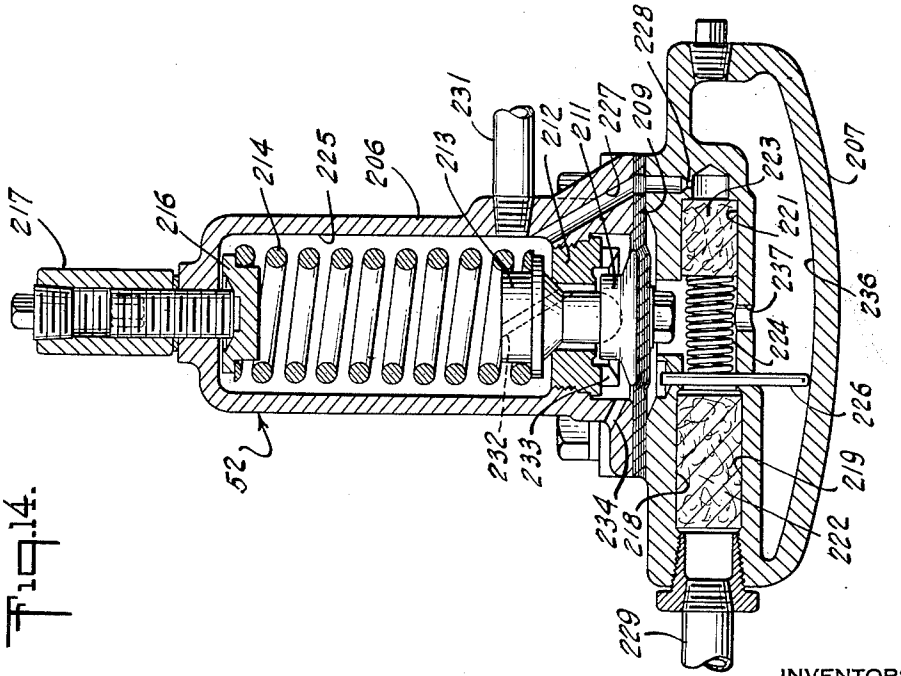


Fig. 14.

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Fig. 15.

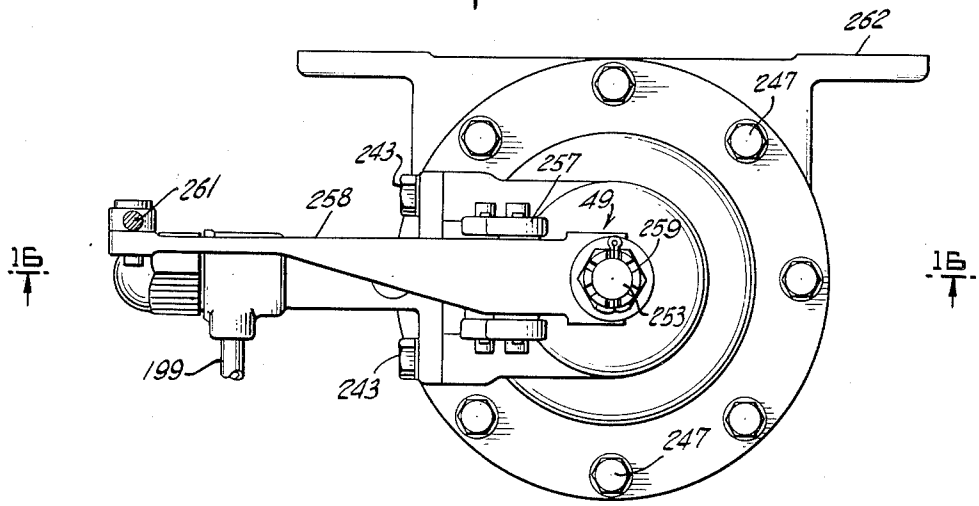


Fig. 16.

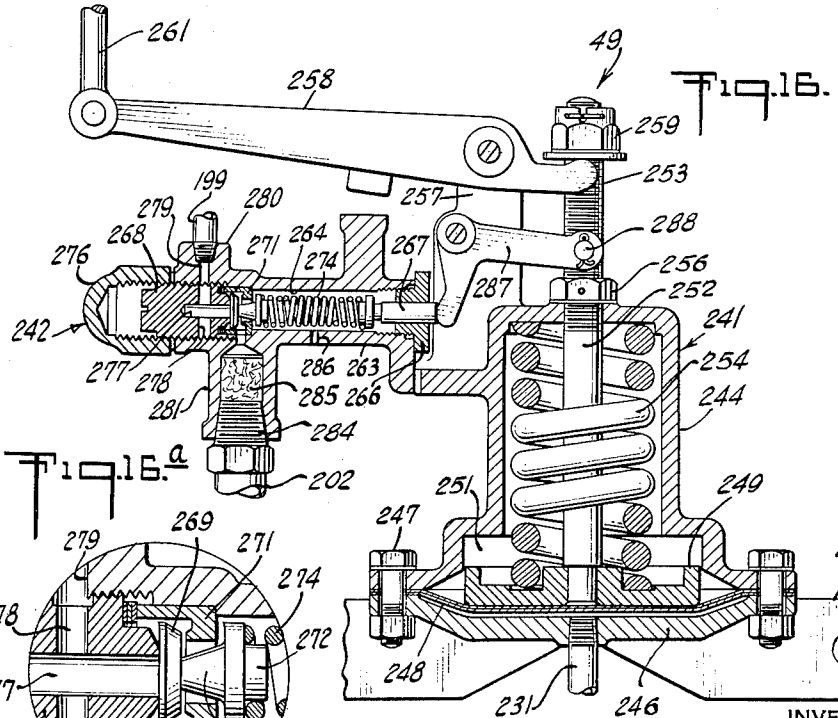


Fig. 16a

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Fig. 17.

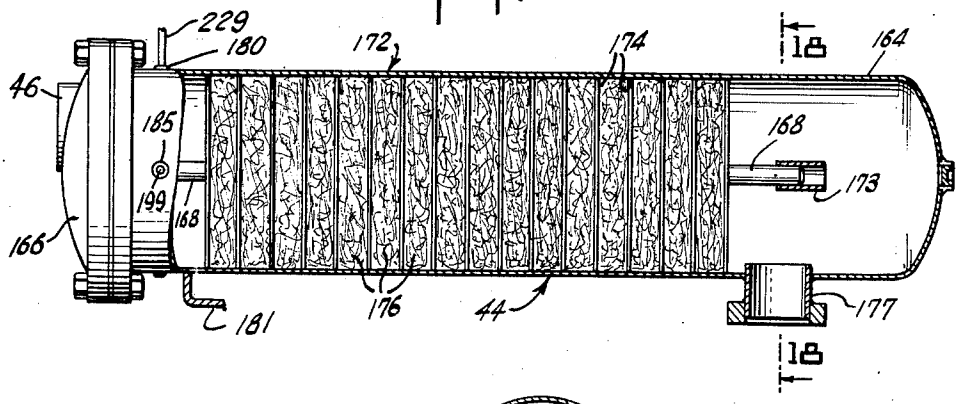


Fig. 18

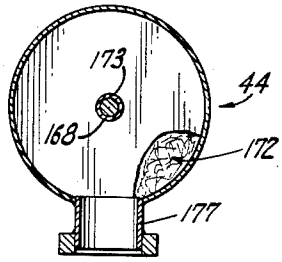
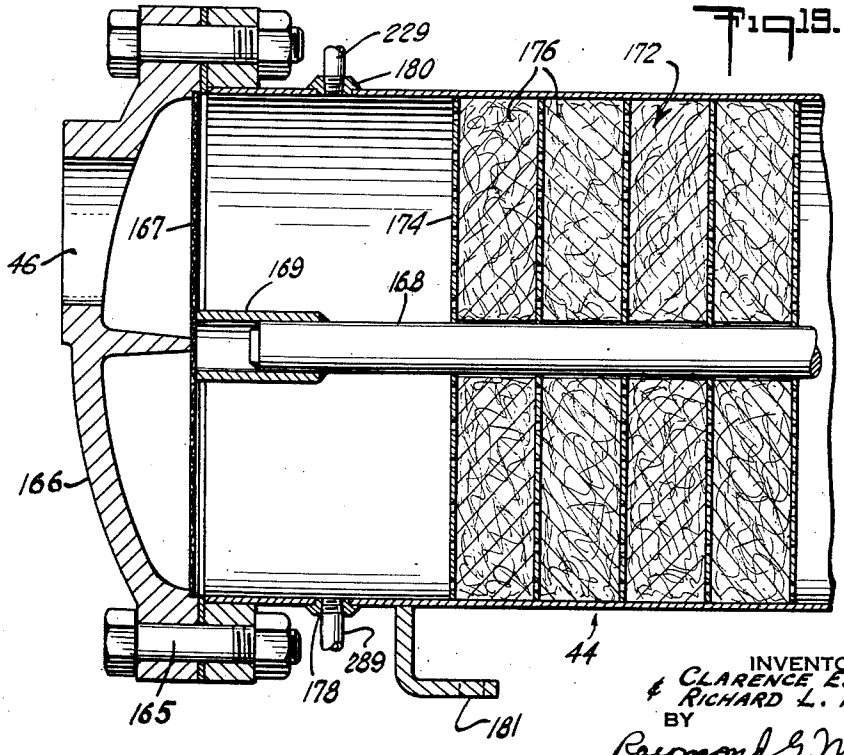


Fig. 18.



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3,072,320
ROTARY FLUID COMPRESSOR

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Continuation of application Ser. No. 428,942, May 11, 1954. This application Oct. 5, 1960, Ser. No. 60,748
9 Claims. (Cl. 230—210)

This invention relates to fluid compressors, and more particularly to rotary fluid compressors of the portable type. This application is a continuation of our application for a Rotary Fluid Compressor, Serial No. 428,942, filed May 11, 1954, and abandoned after the filing of the present application.

An object of the invention is to provide a rotary fluid compressor with an improved capacity control wherein compressed air is automatically supplied in accordance with demand.

Another object of this invention is to provide a rotary fluid compressor of the oil charged type having improved, practical and efficient means for supplying demand air free of oil.

Another object is to provide a rotary fluid compressor with means to prevent rise in receiver pressure when the compressor is running unloaded.

A further object is to provide a rotary fluid compressor with means whereby oil will be prevented from flooding the compressor when the compressor is shut off due to an emergency, or when it is being stopped after operation and before the shut-off valves are set.

Another object is to provide a rotary fluid compressor with a rotor which is restricted in its axial movement so as not to touch the enclosing end plates, but wherein sufficient axial movement of the rotor is permitted to allow for bearing clearance.

These and further objects and features of the invention will become more apparent from the following description when taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a side elevational view of a machine comprising a portable rotary fluid compressor, which embodies the features of the present invention;

FIG. 2 is a view of the machine of FIG. 1, but with side doors thereof closed;

FIG. 3 is a schematic illustration of the various elements of the machine of FIG. 1 showing operative connections;

FIG. 4 is a longitudinal sectional view of the rotary compressor unit of the machine of FIG. 1;

FIG. 4A is a sectional view taken through a pressure relief valve used on an oil pump in the rotary compressor of FIG. 4;

FIGS. 5, 6 and 7 are cross sectional views as seen from lines 5—5, 6—6 and 7—7 respectively in FIG. 4;

FIG. 8 is a fragmentary sectional view of a rotor sealing and positioning means of the compressor unit of FIG. 4;

FIG. 9 is a plan view of a floating head used in the sealing means illustrated in FIG. 8;

FIG. 10 is a sectional view as seen from line 10—10 in FIG. 9;

FIG. 11 is an enlarged fragmentary sectional view of the floating head and sealing ring of FIG. 8;

FIG. 12 is a sectional view of a relay assembly used in the machine of FIG. 1;

FIG. 13 is an elevational view of a pressure transformer assembly used in the machine of FIG. 1;

FIG. 14 is a sectional view as seen from line 14—14 in FIG. 13;

FIG. 15 is a plan view of a throttle control and unloader assembly used in the machine of FIG. 1;

FIG. 16 is a longitudinal sectional view as seen from line 16—16 in FIG. 15;

FIG. 16A is an enlarged fragmentary sectional view of the device of FIG. 15;

FIG. 17 is a longitudinal view, partly in section, of an oil separator assembly used in the machine of FIG. 1;

FIG. 18 is a sectional view as seen from line 18—18 in FIG. 17; and

FIG. 19 is a fragmentary sectional view of the oil separator assembly of FIG. 17, but in a larger scale.

Referring now to the drawings, and more particularly to FIG. 3 thereof, numeral 31 indicates an engine which is coupled for direct drive to a rotary compressor unit 32, the latter of which incorporates certain features of the invention, as will later be discussed. An engine air cleaner 33 is positioned for connection with an engine air intake pipe 34, while a similar air cleaner 36 is positioned for connection with a compressor air intake pipe 37. A radiator 38 for cooling the engine water, is connected in the usual manner at the front end of the engine 31, while adjacent the forward side of the radiator is positionally maintained a four-pass radiator type cooler 39, which cools the oil being used, during operation, in the rotary compressor unit 32. A full flow oil filter 41 is arranged for removing dust and dirt from the oil. An air receiver 42 is positioned at the rear end of the unit, and has connected to the bottom thereof an oil tank 43, while at the top is connected an oil separator 44. The latter has an air discharge opening 46, to which is connected an air outlet manifold 47 having service valves 48, as best seen in FIGS. 1 and 2. The general arrangement includes various other elements, such as a throttle controller and unloader assembly 49, a relay valve 51, a pressure transformer 52, and oil and air filters 53 and 55 all of which will be described in greater detail hereinafter. The engine 31, compressor unit 32, and associated elements, may be mounted upon a carriage supported upon pairs of wheels 54 and 55, the latter of which can be turned by a handle 56 arranged in the usual manner, for easy movement and positioning of the machine. Side doors 57, which have horizontal hinges 58, are provided for purposes of protecting the machine during transportation, or non-operation thereof.

The above is a general description of the main elements of the machine; a more detailed description of the various elements will now be given.

Rotary Compressor Unit

Referring to FIGS. 4 to 7, the rotary compressor unit comprises a low pressure portion 59, and a high pressure portion 61, providing a low pressure stage and a high pressure stage respectively. The low pressure portion 59 has a simple vane type rotor 62, which is eccentrically arranged in a low compression chamber defined by a case 63, and has eight longitudinal radially arranged slots 64, each slidably maintaining a non-metallic blade 66. The high pressure portion 61 has a simple vane type rotor 67, which is eccentrically arranged in a high compression chamber defined by a case 68, and has eight longitudinal radially arranged slots 69, each slidably maintaining a non-metallic blade 71. The rotor and blade arrangement of each stage is identical, and differ only in the length thereof. It is to be noted that a plurality of passageways 72, 73 extending between the periphery of each rotor 62, 67, and lower end of each slot 64, 69 provide a pressure means for each blade 66, 71 respectively, so that the latter will be constantly urged outwardly into contact with the inner periphery of the case 63, 68 respectively, by virtue of the air pressure acting on the lower edge of each blade.

The low and high stage rotors are connected for syn-

chronous rotation by means of coupling members 74, which are keyed to shaft extensions 76, 77 of the low and high stage rotors respectively. Each coupling member 74, has a finger 78 which projects laterally for engagement with a slotted portion 79 of the opposite coupling member. A tandem piece 81, enclosing the rotor coupling arrangement, is adapted to maintain the low and high pressure portions 59, 61 in alignment. A head piece 80 is arranged between the tandem piece 81 and high pressure case 68.

At the forward, or engine end, of the low pressure portion 59 is arranged a main shaft coupling assembly 82, for direct transmission of rotary driving power from the engine 31, to the compressor unit 32. The coupling assembly 82 includes: a driving ring 83, which is bolted to the fly wheel of the engine, and which is keyed to a pair of driving plates 84 made of conventional clutch material; a clutch hub 86, and pressure plate 87; a center plate 88, which is spaced between the driving plates 84, and affixed rotationally by sliding spline engagement to the hub 86, and a plurality of spring supporting bolts 89, which are threadably secured to the clutch hub 86, and which compressively maintain a pressure spring 91 against the pressure plate 87. The clutch hub 86 is keyed to a forward extension 92 of the low pressure rotor 62. It will be seen that by regulating the tension of each pressure spring 91, the frictional driving engagement between the engine 31 and compressor unit 32 can be controlled. In practice, the springs 91 are set so that upon realization of a torque appreciably in excess of that required for normal driving of the compressor unit 32, slippage will occur in the coupling assembly, whereupon the engine 31 will be automatically stopped by engine control means, not shown or herein described. By such means, breakage or damage to the operative parts of the compressor unit 32 upon accidental overload, is avoided. A tandem piece 93 enclosing the main shaft coupling assembly 82, is adapted to maintain the compressor unit 32 in fixed alignment with the engine 31.

The low and high pressure rotors 62, 67 are mounted for rotary movement upon sets of tapered roller bearings 94, 96 respectively. From the arrangement of the bearings it will be seen that the axial movement of each rotor 62, 67 is limited to the lateral play inherent in each bearing, which may be in the order of a few thousandths of an inch. In the assembly of the compressor 32, the final setting, or positioning of the bearings 94, 96 may be established by the use of shims 97. In any case, the inner race of each roller bearing is press fitted to a rotor shaft extension, while the end of each inner race of bearings 94, 96 seat against shaft shoulders 98, 99 respectively. The shims 97 are adjustable in thickness by adding or removing laminations thereof. They have a large central opening disposed opposite the inner races of the roller bearings 94, 96. The solid area of the shims abut the outer end wall of the outer races of the bearings, and they act through the outer races and the inner races to position or center the rotors 62, 67 axially so that the latter will rotate clear of the adjacent end plates or walls of the compression chambers.

Adjacent each end of the low and high pressure rotors 62, 67 is a floating head 101 (FIGS. 8, 9 and 10) which serves as an aid for use with anti-friction bearings, particularly wherein it is desired to press fit the inner races to the shaft, as in the case of the present arrangement. By means of the floating head, the inner surfaces of the rotor end closures are extended nearly to the shaft, and the inner ends of rotor slots 64, 69 are covered to prevent, or reduce, air leakage. In disassembling the compressor, the floating heads will allow for removal of the rotor from its casing, without the necessity of removing the inner bearing race from its press-fitted engagement with the rotor shaft extension.

The inner edge of each floating head 101 is counterbored to receive a shaft sealing ring 102 (FIG. 11) which has a gap (not shown) providing an opening required for ring flexibility, and to also permit a small amount of oil and air under pressure to leak through for lubrication of the adjacent bearing. A small pin 103 secured in the floating head 101, projects into the gap of a sealing ring to prevent the ring from turning with the rotor shaft. Each sealing ring 102 is held against the side of the inner bearing race, by virtue of the pressure developed within the compressor chamber, thus reducing leakage of compressed air via the roller bearings.

An oil pump assembly 104 is mounted at the rear end of the high pressure portion 61, and includes: a body assembly 106, which is secured to the end of the case 68; a cover 107 secured to the end of the body assembly; a relief valve assembly 108 positioned in the cover 107; a set of oil pump gears 109, 111 (spur gear type), gear 109 being a drive gear, and gear 111 being a driven gear; and a driving gear shaft 112 which is flexibly coupled, as shown, to the end of the high pressure shaft extension. The oil pump 104 is used to pressurize oil and circulate it through the compressor 32, for air cooling purposes and for sealing and lubricating purposes, as will be presently explained. The oil pump also serves the purpose of automatically metering the oil for flow in accordance with demand requirements. The relief valve assembly 108 includes a valve 113 (FIG. 4A) which is spring loaded to seat against an opening connected with an oil pump discharge passageway 114; when the valve is unseated due to a rise in oil pressure beyond a predetermined maximum, oil flow occurs around the valve and into a passageway 116, which leads back into an oil pump inlet chamber (not shown). In this manner damage to the oil pump is avoided whenever a restriction develops which would hinder free oil flow, such as may occur under extreme cold weather conditions wherein the oil may become sluggish or congealed.

The oil discharge passageway 114 connects with a longitudinal passageway 117 which extends through the high pressure case 68, head piece 80, tandem piece 81, low pressure case 63, and terminates in the coupling assembly tandem piece 93. A series of passageways 118 extend downwardly from the passageway 117 and terminate in a recess 119, which are in alignment with circumferential grooves 121 formed on the outer periphery of each floating head 101. Radially extending from grooves 121 are passageways 122 formed in each floating head 101, the lower ends of which are in open engagement with the counterbores containing sealing rings 102. In such manner, oil under pressure from the oil pump 104 flows through each floating head 101, and about the inner periphery thereof, and around the shaft, into the end of the compression chambers 63, 68, to prevent the escape of air being pressurized therein. Also, as previously mentioned, the oil forces the sealing rings into contact with the edge of the inner bearing races of roller bearings 94, 96 for sealing purposes.

Oil from passageway 117 is also directed downwardly via passageways 123, 124 into compression chambers 63, 68 respectively, wherein it is dispersed in an atomized condition for purposes of reducing the temperature of the air during compression. As best seen in FIGS. 5 and 7, the oil is injected into the air during and at the beginning of compression thereof, and eliminates the need for interstage air cooling.

A choke 115 arranged in the passageway 117 serves to maintain sufficient pressure in the upstream end of passageway 117, so that an ample supply of oil is fed into the high pressure portion 61 during compressor operation.

A scavenger passageway 120 is located in the low pressure case 63, while a similar scavenger passageway 125 is located in the high pressure case 68; the scavenger passageways 120, 125 are arranged to conduct the oil, which leaks past roller bearings 94, 96, back into the tandem piece 81. Such oil is conducted from the tandem piece 81, back to the air inlet chamber 129, via a passageway 130; in such manner the leakage oil is returned to the com-

pressor air flow circuit from whence it is circulated with the air and ultimately is separated and returned to the inlet side of oil pump 104, as will be described hereinafter.

Air under atmospheric pressure is admitted to the low pressure portion 59 by way of an intake valve housing 126, which is connected to air intake pipe 37 and which includes an unloading valve assembly 127 which will be described in greater detail hereinafter. The incoming air passes through an intake screen 128, which is of the form of a flat perforated sheet and which acts as a guard to prevent any debris or loose parts from accidentally falling into the compressor. The incoming air passes onward into an air inlet chamber 129, which extends approximately one-third of the way about the compression chamber 63. The air is compressed between the sliding blades 66 as the rotor turns counter-clockwise (FIG. 7) and is discharged at the lower side of the compression chamber 63 into an air discharge chamber 131. An interstage connecting pipe 132 (FIG. 3) connects the chamber 131, with an air intake chamber 133, formed in the high pressure portion 61, the air intake chamber 133 extending approximately one-third of the way about the compression chamber 68. The air is thus further compressed between the sliding blades 71 as the rotor turns counter-clockwise (FIG. 5) and is discharged at the lower side of the compression chamber 68 into an air discharge chamber 134. A discharge pipe 136 connects with discharge chamber 134 and conducts the pressurized air to the receiver 42 (FIG. 3).

In the lower portion of discharge chamber 134 is positioned a discharge valve assembly 137 (FIG. 4) which includes a valve seat 138, a valve 139, and a spring loaded bolt 141 which is arranged to urge the valve 139 to seated position. During normal operation of the compressor, the air pressure in the discharge chamber 134 is sufficient to unseat the valve to allow for the continuous flow of compressed air therethrough; however, upon stopping of the engine 31, the air pressure in discharge chamber 134 quickly falls and the valve 139 immediately seats, thereby preventing flow of air from the receiver 42 backwards into the compressor 32. In such manner, the compressor is prevented from running as an air motor and exhausting the air in the receiver.

The unloading valve assembly 127 includes a closing cylinder 142 which is affixed to and within the intake valve housing 126, a piston 143 slidably positioned in the cylinder 142, a plunger 144 having the rear end thereof affixed to the piston by bolt means 146, a cylinder head 147 secured to the end of closing cylinder 142, and an orifice plate 148 fastened to the end of the plunger 144, all as best seen in FIG. 4. The piston 143 is arranged to slide forwardly in the cylinder 142 and move the plunger 144 so that the forward end thereof, which has a leather disc 149, will engage a valve seat 151 formed within the valve housing 126. Such action takes place during compressor unloading, as will later be described, and results in the interruption of air flow into the low pressure compressing chamber 63. A passageway 150 is formed in the cylinder head 147 to vent the underside of piston 143. An orifice 152 is provided in orifice plate 148, while a bore is formed in the plunger 144. Extending from the bore 153 is a passageway 154 which is in alignment with a passageway 156 formed in the piston 143. A chamber 157 is provided between the piston 143 and cylinder 142, the chamber 157 being connected by a passageway 158 to a vertically extending passageway 159 formed in the cylinder 142. Passageway 159 connects with a horizontal passageway 161 formed in the cylinder 142, the passageway 161 having a threaded opening 162 at one end for receipt of a pipe 201 leading from the relay 51 (FIG. 12), the other end containing an orifice 163 which opens into the intake housing 126 in the region above intake screen 128.

Oil and Air Storage Arrangement

The oil and air storage arrangement includes the air receiver 42, the oil tank 43 and the oil separator 44, all of which were heretofore mentioned. The air receiver and oil tank are of the type familiar to those skilled in the art and need not be further described except to point out that the relative sizes thereof remain a matter of choice consistent with design requirements.

The oil separator 44, as best seen in FIGS. 17 to 19, includes an elongated tank 164, one end of which is permanently closed, the other end of which is open and arranged to receive a tank head 166 affixed thereto by bolt means 165. A metallic screen 167 is affixed within the tank head 166 to prevent passage of any filter material into the exhaust manifold 47. A filter supporting rod 168, having a sleeve 169 welded at the end thereof for abutment with the screen 167, extends through a filter assembly 172, the far end of the rod 168 having affixed thereto a sleeve 173 which may be used for abutting the end of the filter during filter removal operation. The filter assembly 172 is formed of a plurality of perforated discs 174 which are affixed to the rod 168 by means such as welding and are spaced apart to provide chambers each of which contain a mass of filtering material 176 such as lambs wool. Toward the permanently closed end of the tank 164 and beyond the filter assembly 172 and at the bottom of the tank is an inlet sleeve 177 which connects with the top of the air receiver 42, while at the other end of the tank, beyond the filter 172 and at the bottom of the tank, is an oil outlet 178. The tank head 166 has an opening 146 to fixedly receive the air outlet manifold 47 (FIGS. 1 and 2). An opening 180 is provided at the top of the tank for a pipe connection 229 while an opening 185 is provided at the side of the tank for connection with a pipe 199 (FIGS. 3 and 17). A bracket 181 is affixed to the outside bottom of the tank for securing that end of the tank to the top of the air receiver 42.

Air entering the tank from the inlet sleeve connection 177 passes through the filter element 172 and in so doing the oil contained therein is removed and returned to the oil supply via oil outlet 178 as will more clearly be described hereinafter. The arrangement of the oil separator provides a means for removing oil from the air with a high degree of efficiency making the loss of oil negligible.

Relay Valve

FIG. 12 illustrates in section the relay valve 51 which includes: a valve body 182; a top cover 183; a bottom cover 184 secured to the valve body by bolt means 186; a composite leather-rubber diaphragm 187 positioned beneath the top cover, and being held in position by bolt means 188 extending through flanged portions of the top cover and valve body; a piston 189 arranged in abutment with the underside of the diaphragm; a piston rod 191, the upper end of which engages the piston 189, the lower end of which is slidably supported in a bushing 192 which is held in fixed position within the valve body 182 by a dowel pin means 193; a valve 194 which is supported for reciprocal motion in the valve body and having a reduced diameter mid-portion 195; and a valve spring 196, the upper part of which is enclosed by the valve 194, and the lower part being arranged in abutment with the bottom cover 184.

The top of valve 194 is constantly urged into contact with the end of piston rod 191 by means of the valve spring 196; the upward extent of the piston rod movement is fixed by virtue of the fact the lower end of the piston rod 191 contains a tapered seat 197 which may be brought into abutment with the bushing 192 as shown. A pipe 198 is threadably affixed to the valve body 182 for communication with a chamber 210, defined by the underside of bushing 192 and the top of the valve 194. The other end of pipe 198 connects with a pipe 199 (FIG.

3), the purpose of which will be later described. Another pipe 201 is threadably affixed to the valve body 182 for communication with chamber 210 only when the valve 194 has moved downwardly sufficiently in the valve body 182 as can be seen. The other end of pipe 201 is affixed to the threaded opening 162 provided in the closing cylinder 142 of the unloading valve assembly 127. Thus the pipe 198 is always in communication with chamber 210, whereas the pipe 201 is in communication only when the valve has moved downwardly, such movement taking place during unloading of the compressor. Means are provided in the form of a threaded boss 200 for connecting a pipe (not shown) with the low pressure compression chamber 63 for operation of the machine under certain conditions not described. Threadably affixed within the top cover 183 is a pipe 202 which is in constant communication with a chamber 203 defined by the underside of the top cover and the top side of the diaphragm 187. The other end of pipe 202 is connected to the throttle controller and unloader assembly 49 in the manner and for purposes of which will later be described. The region underneath the diaphragm 187 is vented by holes 204 formed in the valve body 182. Within the bottom cover 184 is threadably affixed a pipe 205 which is in communication with the region on the underside of valve 194. The other end of pipe 205 connects with the high pressure compression chamber 66.

Pressure Transformer

Referring more particularly to FIGS. 13 and 14, the pressure transformer 52 includes: a body element 206; a base portion 207 affixed to the body element by screw means 208; a diaphragm 209 fixedly positioned between the body element 206 and base portion 207, said diaphragm being of a material, such as linen, which is impregnated with a plastic composition; a valve 211 which is affixed to the center of the diaphragm 209; a valve seat 212 which is threadably secured within the body element 206; a valve lifter 213 which is arranged in lowermost position to engage the valve seat 212; a spring 214 compressively arranged between the valve lifter 213 and a spring seat 216; and an adjusting screw arrangement 217, positioned at the top of the body element 206 and adapted for regulating the compression of spring 214.

A horizontal passageway 218 is arranged in the base portion 207 and has a first filter chamber 219 and a second filter chamber 221, the first filter chamber containing a loose wool filter unit 222 while the second filter chamber contains a dense wool filter plug 223, a spring 224 is compressively arranged between a pin 226 and the wool filter plug 223 to maintain the latter in position within the chamber 221. A passageway 227 connects the inner end of passageway 218 with a chamber 225 formed in the body element and enclosing the spring 214 It is to be noted that the end of the passageway 227 at the point of connection with passageway 218 is of reduced diameter to provide an orifice 228. Threadably connected to the outer end of passageway 218 is a pipe 229 which is connected to the opening 180 formed in the oil separator 44. A pipe 231 is arranged in communication with the chamber 225, the other end of said pipe being connected to the throttle controller and unloader assembly 49.

Within the valve lifter 213 is arranged a passageway 232 which affords communication between the chamber 225 and a chamber 233 formed at the upper side of diaphragm 209. A hole 234 formed in the body element 206 vents the chamber 233 to atmosphere. The lower part of the base portion 207 is arranged to form a condensate chamber 236; a hole 237 is provided in the wall of passageway 218 in the region of spring 224 which allows condensate to flow into the chamber 236 while a drain cock 238 is arranged for draining said condensate from the chamber 236. Threaded bosses 239 are provided on the side of the body element 206, for securing the pressure transformer 52 in position on the machine.

Throttle Controller & Unloader Assembly

In FIGS. 15 and 16 is illustrated the throttle controller and unloader assembly 49 which comprises a throttle controller portion 241 and an unloader portion 242 affixed to the controller portion 241, means such as bolts 243.

The throttle controller portion includes: a regulator body 244; a body cover 246 affixed at the bottom of the body 244 by bolt means 247; a diaphragm 248 made of a rubberized cloth which is positioned between the body 244 and cover 246 and is positionally maintained by the bolt means 247; a plunger head 249 which is arranged for reciprocal movement in a chamber 251 formed in the regulator body 244, said plunger head 249 being in contact with the upper surface of the diaphragm 248; a plunger pin 252 which seats at the lower end against the plunger head 249 and which extends upwardly through the body element 244 and projects exteriorly therefrom, said projecting portion having thread means 253 as shown; and a spring 254 surrounding the plunger pin 252 and being compressively arranged between the plunger head 249 and the top portion of the body 244. A nut 256 is arranged on the threaded portion 253 of the pin 252, and is adapted to abut the top of the regulator body 244, and provide downward limiting movement of the plunger head 249.

A lug 257 formed integral with the regulator body 244 projects upwardly and serves as a pivotal support for a control lever 258. The short end of lever 258 is arranged in engagement with the underside of an adjusting nut 259, which is mounted near the outer end of the pin 252 while the long end of the lever 258 is arranged for attachment with a governor rod 261 which is connected to a governor (not shown) forming part of the speed control system used on the engine 31. Lugs 262 cast integral with the cover 246 are provided for affixing the throttle controller assembly in position on the machine.

The unloader portion 242 of the assembly 49 includes: an unloader body 263 having a bore 264 which is threaded at each end; a plunger nut 266 threadably secured at the inner end of bore 264; a plunger 267 slidably arranged in the nut 266 and projecting at the outer side thereof, an unloader valve seat 268 threadably secured at the other end of the bore 264; and unloader valve disc 269 movable into engagement with the valve seat 268; an unloader valve seat bushing 271 which positionally guides the valve disc 269 in its movement; a valve holder 272 which has a tapered end 273 engaging the side of the valve disc 269; a spring 274 which is compressively arranged within the bore 264 between the valve holder 272 and the plunger 267; and an acorn nut 276 which is threadably affixed to the valve seat 268.

The valve seat 268 has a centrally positioned horizontal bore 277 from which radiate a plurality of passageways 278 arranged in alignment with a threaded opening 279 in a boss 280 which receives the end of pipe 199. A boss 281 extends from the side of the unloader body 263 and has a passageway 282 opening in alignment with a hole 283 formed in the valve seat bushing 271; the boss 281 contains a filter assembly 285 which is maintained in position by a bushing 284 to which the pipe 202 is threadably secured. It will be seen that when the valve disc 269 is unseated from the side of valve seat 268, air can flow from pipe 199 through opening 279 into passageways 278 and bore 277, past unseated valve disc 269 through passageway 282, and past the filter 285 into pipe 202. A passageway 286, formed in the unloader body 263, vents the bore 264 to atmosphere in the region of the spring 274.

Pivotally secured to the lug 257 is an unloader lever 287 which is in the form of a bell crank, one arm of the lever 287 being in engagement with the projecting end

of the plunger 267, the other arm being secured to the threaded projecting portion 253 of the plunger pin 252 by means of a pin 288. It will be seen that as the plunger pin 252 moves upwardly, the lever 287 is rotated counter-clockwise (FIG. 16) so that the pressure of spring 274 acting to maintain the valve disc 269 seated, is reduced, thus allowing for the unseating of the disc 269 under certain conditions as will be more fully described hereinafter.

Simultaneous with such upward movement of the plunger pin 252 the governor control lever 258 is enabled to rotate counter-clockwise to activate the engine governor (not shown), whereby the speed of the engine is reduced.

Before entering into the description of the operating phases of the machine, it will be necessary to explain certain other piping connections which have not been touched upon heretofore. A pipe 289 (FIGS. 3 and 19) connects the oil outlet 178 of the oil separator 44 with the interstage connecting pipe 132 whereby residual oil in the oil separator is put back into the system. An oil filter 53 of the type familiar to those skilled in the art is placed in the pipe line 289 as well as a choke 291 which serves to restrict flow of oil in pipe line 289 to prevent loss of an appreciable amount of air from the oil separator 44. In other words, the quantity of residual oil flowing back to the compressor via pipe 289 is relatively small; if the choke 291 was not in the pipe line a proportionately greater amount of air would flow therethrough. The choke 291 allows all the residual oil to flow through the pipe 289 accompanied by only a relatively small amount of air. The connection of pipe 289 with the interstage pipe 132 has various advantages. The air in the interstage pipe is that which has been discharged from the low pressure stage and is flowing by air velocity and compressor suction into the high pressure stage. Air pressure in the interstage pipe is relatively less than that in the separator so that the residual oil returns without difficulty over pipe 289 under pressure of air in the separator to the interstage pipe for recirculation through the high compressor stage.

The oil being returned directly from the receiver 42 to the oil tank 43 flows under receiver pressure through pipe 292 into the oil filter 41 and out of the oil filter through a pipe 293 to the oil cooler 39. A relief valve 294 is arranged to bypass oil around the oil filter 41 by way of a pipe 295, and directly into pipe 293; this bypass arrangement is provided to assure flow of oil in the oil circulatory system in event the oil filter should fail or become so clogged with dirt that oil could not flow therethrough at the desired rate. A pipe 296 conducts the oil from the oil cooler 39 into the oil inlet chamber (not shown) of the oil pump 104.

Air filters 55 of a type well known to those skilled in the art, are arranged in the pipe line 199 and 229 while a pipe 297 connects at one end with pipe 229 and to an air receiver gauge 298 at the other end. A pipe 299 is connected at one end with the interstage connecting pipe 132 and to an interstage gauge 301 at the other end. Oil flow in pipes is shown by feathered arrows while air flow is indicated by plain arrows.

While no mention has been made of various mechanical expedients such as gaskets, washers, running tolerances, etc., it is to be understood that all of such well known devices and methods are to be applied in the assembly of the machine in accordance with well known design principles.

Operation

While quite obviously the various parts of the machine as above described could be made in many different sizes or proportions for obtaining as many different compressor capacities for the purpose of illustration it will be assumed that the machine under discussion is designed to deliver 600 cu. ft. of air per min. at a normal operating pressure of 100 lbs./sq. in. gauge. The engine 31 has been identified as a General Motors model G.M. 6–71 which is of

ample size to deliver the necessary power required to run the compressor 32 at stated capacity. The full load speed of the engine 31 is 1750 r.p.m., and the no load speed is 800 r.p.m. The air receiver 42 capacity is 17 cu. ft. and the compressor oil capacity is 32 gallons. The maximum out of level operation of the machine, having a standard deep oil pan, is 30° lengthwise and 25° sidewise.

Assuming that the engine 31 is running and the rotary compressor 32 is being rotated, air is being drawn in from the atmosphere through the air cleaner 36 (FIG. 3), into air intake pipe 37 and the air intake valve housing 126 (FIG. 4) past the unloading valve assembly 127 and through intake screen 128 into air chamber 129 of the low pressure case 63. It is then compressed in the chambers or pockets formed between the sliding blades 66 (FIG. 7) and is discharged into the discharge chamber 131 at a pressure of approximately 28 lbs./sq. in. gauge. Prior to and during such compression, oil in atomized form is sprayed into the air being compressed, as heretofore pointed out, for purposes of reducing the final temperature of the air after compression. The air then passes from first stage compression via interstage connecting pipe 132 to the second, or high stage case 68, where it enters the air intake chamber 133 (FIG. 5). It is then further compressed in the chambers formed between the sliding blades 71 and is discharged into discharge chamber 134 at a final pressure of approximately 100 lbs./sq. in. gauge. Prior to and during such compression, oil in atomized form is sprayed into the air being compressed in the manner and for reasons as pointed out above.

The compressed air then passes through the discharge valve assembly 137 (FIG. 4) and into discharge pipe 136 (FIG. 3) which conducts the air flow into receiver 42. It will be realized that the air at this point is ladened with oil particles and would not be generally suitable for use in such condition. Having entered the receiver 42 the oil rapidly settles out of the air and flows downwardly into the oil tank 43. The completeness of such separating action depends upon the time the air remains in the receiver; if it is being immediately drawn out for use a relatively large amount of oil separation is accomplished in the oil separator 44, while if it is being slowly used the oil removal job of the oil separator becomes less since a considerable portion of the oil will settle out of the air while it is in the receiver.

In any event as the air is being drawn upon for use it passes upwards into the oil separator wherein the residual or remainder of the oil therein is removed as the air is passed through the filter assembly 172 (FIG. 19); such residual oil is returned to the interstage pipe 132 via pipe 289 as heretofore explained. The air is thus delivered to the outlet manifold 47 in a clean and substantially oil free condition at specified normal operating pressure (100 p.s.i.). As an example of the efficiency of the oil separator 44, it has been found in actual practice that under normal operating conditions and for a continuous operating period of eight hours they may be oil loss of not more than one quart.

Since the oil pump 104 (FIG. 4) is directly connected to one end of the high stage compressor shaft the oil pupm will act during compressor operation to circulate oil through passageway 117 from whence it is directed to simultaneously seal the ends of the rotors in the region of the rotor shaft, lubricate the rollers bearings and cool the air during compression, all as has been discussed in greater detail heretofore.

Compressor regulation is provided whereby the speed of the engine 31 is varied to drive the compressor 32 generally in accordance with the demand, or use, of the compressed air. For example, the engine is arranged to operate at full speed (1750 r.p.m.) when the demand is 100% of capacity, 70% speed when demand is 70% of capacity, and half speed (875 r.p.m.) when the demand is 50% of capacity; when the demand for air is less than

50% of full capacity the compressor is arranged for loading and unloading at reduced engine speed.

The method whereby such compressor regulation is accomplished, will now be described.

Air under pressure from the oil separator 44 which is substantially equal to received pressure, any difference due to slight drop due to friction losses as the air flows through the filter assembly 172, is directed via pipe 229 (FIG. 3) into the pressure transformer 52 (FIG. 14) wherein it passes through the filters 222, 223 arranged in passageway 218, and upwardly through orifice 228, and passageway 227 into chamber 225. The air in chamber 225 is exhausted to atmosphere via passageway 232 formed in the valve lifter 213 through chamber 233 and hole 234 formed in the body element 206. Such exhaust of air from the transformer 52 will take place unobstructed until the air entering the transformer reaches a value of 85 p.s.i., by virtue of the fact that the spring 214 is set to prevent the valve 211 from rising until the 85 p.s.i. pressure is realized. In other words, the transformer 52 will not begin to operate until the pressure in the oil separator 44 reaches a value of 85 p.s.i.

As the pressure in the oil separator 44 rises above 85 p.s.i., the air pressure acting on the underside of diaphragm 209 overcomes the holding effect of spring 214 and the valve 211 is moved upwardly until finally it seats against valve seat 212 thereby cutting off escape of air in chamber 225 to atmosphere. As pressure in the oil separator 44 increases from 85 to a predetermined value, say 100 p.s.i., the pressure in chamber 225 increase from zero to approximately 55 p.s.i. maximum. Air in chamber 225 is directed via pipe 231 to the underside of the diaphragm 248 (FIG. 16) positioned in the throttle controller portion 241 so that any rise in pressure in chamber 225 is transmitted immediately to the throttle controller portion 241. When the air pressure in chamber 225 reaches 10 p.s.i., which corresponds to an air pressure in oil separator 44 of approximately 86 p.s.i, the holding effect of spring 254 is overcome by the air acting on the underside of diaphragm 248 and the plunger head 249 is forced upwardly resulting in the upward movement of plunger pin 252. Such movement causes the control lever 258 to rotate counterclockwise (FIG. 16) whereupon the governor (not shown) which regulates the speed of engine 31 is caused to act to reduce engine speed. In other words, by means of the arrangement above described the engine speed is regulated to correspond with any oil separator pressure between 85 to 100 p.s.i.

The throttle controller portion 241 is arranged to provide engine speed slow-down as the pressure in the oil separator rises until the demand for air diminishes to fifty percent of full load capacity. With an air pressure in the oil separator of 100 p.s.i. and a demand for air of less than 50% full load capacity the compressor unloading valve assembly 127 is caused to operate whereby the compressor is unloaded. Such action is accomplished as follows.

Air under pressure from the oil separator 44 is conducted to the unloader assembly via pipe 199 (FIGS. 3 and 17) wherein it is caused to act against the side of valve disc 269 (FIGS. 16 and 17). The disc is held in seated engagement against the valve seat 268 by virtue of the holding force of spring 274 acting through valve holder 272. As the plunger pin 252 rises during air pressure build-up under diaphragm 248, the unloader lever 287 is rotated counter-clockwise (FIG. 16) permitting the plunger 267 to move outwardly from the bore 264 thus reducing the holding force of spring 274. The latter is so adjusted that as soon as the engine speed reduces to less than 50% of full load speed and the oil separator pressure is 100 p.s.i. the valve disc 269 will be unseated. When this action occurs, the air from pipe 199 flows past the unseated valve disc 269 and into pipe 202 as heretofore described in greater detail.

Air in pipe 202 flows to the relay 51 (FIG. 12) and into the chamber 203 where it acts against the top of diaphragm 187 causing the piston 189 and piston rod 191 to move downwardly. Such downward movement causes the valve 194 to be moved whereby the air in chamber 210 [which incidentally is at oil separator pressure (in this instance 100 p.s.i.) by virtue of pipe connection 198], will be allowed to flow into pipe 201.

Air flow from pipe 201 enters chamber 157 (FIG. 4) in the unloading valve cylinder 142 and acts against the piston 143 to move the latter so that it forces the plunger 144 toward valve seat 151 whereupon the leather disc 149 is brought into seating engagement with valve seat 151 and air intake via intake pipe 37 is cut off. The compressor thus is conditioned for running unloaded with the result that no further compressed air is delivered to the receiver 42. Any air that may leak into the compressor intake past leather disc 149 or by way of any other leakage passage is compensated for by blowing a small amount of air under pressure back into the intake pipe by way of pipe 201, passages 161, 159, 158, chamber 157, passages 156, 154, 153 and orifice 152. This feature prevents rise in the pressure in the oil separator when no air is being drawn from the manifold 47. Air under pressure in pipe 201 also passes at a restricted rate through passage 161 and orifice 163 into the compressor intake from whence it is compressed by passing through the compressor 32 into the air receiver 42 and into the oil separator 44. It will be observed that the amount of air passing through the orifice 163 is merely recirculated around inside the system and serves the purpose of scrubbing the oil through the compressor passages. The machine runs unloaded and at reduced speed until a predetermined drop in oil separator air pressure causes it to reload. Such reloading action takes place in the following manner.

When the air pressure under the throttle controller diaphragm 248 (FIG. 16) has dropped to about 30 p.s.i., the plunger head 249 is moved downward so that the plunger pin 252 causes the unloader lever 287 to rotate clockwise whereby the spring 274 is compressed sufficiently to cause the valve disc 269 to again seat against valve seat 268. When this occurs the air in pipe 202 is vented to atmosphere via passageway 286 located in the unloader body 263 in the manner of which has been described in greater detail heretofore. As a result of such venting the air pressure in chamber 203 (FIG. 12) of the relay 51 is dispersed whereupon the piston 189 and piston rod 191 move upwardly and the valve 194 acting under influence of spring 196 is moved to cut off chamber 210 from pipe 201. The air in unloading valve chamber 157 (FIG. 4) as well as the air in pipe 201 is caused to enter the chamber just above the intake screen 128 via passageway 161 and orifice 163 whereupon the plunger disc 149 is unseated and the plunger 144 and piston 143 is forced back into original position due to the pressure of air flowing into the compressor from the air intake pipe 37. A partial vacuum is created in the region above intake screen 128 during unloading and such vacuum is responsible for a pressure differential which causes a rapid opening or unseating of the unloader valve. The machine then runs loaded until the air pressure in the oil separator again rise to meet the demand.

The control system above described also includes means to prevent flooding of the compressor with oil in event the machine should shut down due to an emergency or because of lack of fuel. It will be seen that such possibility of flooding could arise by virtue of the fact that the oil under receiver pressure could leak past the oil pump and into the compressing chambers, the latter of which would be under no pressure due to stopping of the compressor rotors. The manner of providing for such a contingency is as follows.

Pipe 205, which is connected at one end to the lower cover 184 (FIG. 12) of the relay 51 and at the other end to the high pressure case 68 in the region above discharge valve assembly 137 (FIG. 4), will transmit at it were,

the drop of pressure in the high pressure case associated with rotor stopping to the underside of the valve **194**. The latter would immediately drop due to air pressure in chamber **210**, which is at oil separator pressure thereby allowing flow of air from chamber **210** into pipe **201**. Air from pipe **201** would enter the unloading valve chamber **157** and cause the plunger **144** to seat the disc **149** against valve seat **151** in the manner as heretofore explained. At the same time air in pipe **201** would flow into the compressor chambers via passageway **161** and orifice **163** to the extent of building up pressure in the compressor equal to that of the receiver pressure which is acting upon the oil. Under such balanced conditions the oil would be prevented from flooding the compressor.

Upon restarting the machine after stoppage resulting in the closing of the unloader valve sufficient pressure will immediately build up in the high pressure case **68**, such pressure being transmitted via pipe **205** to the relay **51** whereby the valve **194** is moved upwardly to close chamber **210** to pipe **201** whereupon the unloading valve disc **149** will be unseated from valve seat **151** in the manner as heretofore described and air intake to the compressor will again be effected.

Subject matter disclosed in this specification and drawings but not claimed herein is described and claimed in our co-pending applications as follows: Serial No. 55,959 filed September 14, 1960, for Unloader Control for a Rotary Compressor; Serial No. 60,730 filed October 5, 1960, for Bearing and Sealing Structure for a Rotary Compressor; and Serial No. 141,559, filed September 13, 1951, for Machine for Compressing Fluids.

What is claimed is:

1. A machine for compressing fluids, comprising in combination a rotary air compressor including a compression chamber having a discharge pipe, a rotor for compressing air in the compression chamber, and a drive shaft carrying the rotor, a receiver tank connected to the discharge pipe, an oil separator tank disposed above and in connection with the receiver tank having a demand outlet and having a filter assembly for filtering oil from air passing from the receiver tank into the oil separator tank, an oil sump tank disposed below and in communication with the receiver tank for catching oil settling out of air admitted to the receiver tank, restricted conduit means connecting the oil separator tank with the compression chamber for conducting oil filtered out by the filter assembly back to the compression chamber for recirculation through the latter, and an oil pump system operatively connected with the drive shaft for pumping oil from the sump tank and delivering it to the compression chamber to reduce the temperature of the latter.

2. A machine for compressing fluids, comprising in combination a rotary air compressor including a compression chamber having a discharge port, a rotor for compressing air in the compression chamber, a drive shaft carrying the rotor, a receiver tank connected to the discharge port, an oil separator tank disposed above and in communication with the receiver tank, said separator tank having a demand outlet and having a filter assembly for filtering oil from air passing from the receiver tank into the oil separator tank, an oil sump tank disposed below and in communication with the receiver tank for catching oil settling out of air admitted to the receiver tank, restricted conduit means connecting the oil separator tank with the compressing chamber, said conduit means being positioned to receive oil filtered out by the filter assembly and being arranged to return such oil to the inlet of the compression chamber, and an oil pump system operatively connected with the drive shaft for pumping oil from the sump tank and delivering it to the compression chamber.

3. A rotary air compressor comprising a low pressure compression stage and a high pressure compression stage, an interstage pipe connecting the discharge end of the low pressure stage with the inlet of the high pressure stage, rotor means for compressing the air in both stages, an oil storage tank, an oil pump system drivingly coupled to the rotor means for pumping oil from the oil storage tank into the high and low compressor stages, an air receiver tank disposed above the oil storage tank having an opening in its bottom area in communication with an opening in the upper area of the oil storage tank and having a connection with the discharge end of the high pressure stage for receiving compressed air charged with oil from the latter, the communication of the receiver tank with the oil storage tank permitting oil settling out of the air admitted to the receiver to drop into the oil storage tank an oil separator tank disposed above the receiver tank and having an opening in its bottom area in communication with an opening in the upper area of the receiver tank, filtering means in the separator for filtering residual oil out of air admitted to the latter, and a conduit connecting the separator tank with the interstage pipe for returning residual oil from the separator under pressure of air in the latter to the interstage pipe, the pressure of air in the latter being less than that in the separator.

4. A rotary compressor as in claim 3, wherein the conduit has a choke restriction therein so that filtered oil admitted to the conduit is returned into the interstage pipe substantially free of compressed air.

5. In a machine for compressing air including a rotary air compressor having an air compression chamber, a driven rotor for compressing air in the chamber, an oil storage tank, an oil pump system operatively coupled to the rotor for charging the air in the chamber with oil from the oil storage tank, and an air receiver tank disposed above the oil storage tank and connected to the discharge end of the chamber; means for removing the oil from compressed air discharged into the receiver, comprising a short vertical pipe communicating a bottom area of the receiver with an upper area of the oil storage tank enabling oil settling out of the receiver air to drop into the oil storage tank below, an oil separator tank arranged above the receiver, a short vertical pipe communicating a bottom area of the separator with an upper area of the receiver, filtering means in the separator for separating residual oil from the receiver air admitted to the separator, and conduit means for returning under pressure of air in the separator the separated residual oil to the inlet end of the compression chamber for recirculation through the compressor, the pressure of air at the inlet end of the compression chamber being less than that in the separator.

6. In a machine as in claim 5, wherein the conduit means is restricted.

7. In a machine as in claim 5, wherein a choke is disposed in the conduit means and is adapted to restrict escape of compressed air from the separator tank along with the residual oil being returned to the inlet end of the compression chamber.

8. A machine for compressing fluids comprising in combination a rotary air compressor including a compressor chamber having a discharge port, a rotor for compressing air in the compression chamber, and a drive shaft carrying the rotor, a receiver tank connected to the discharge port, an oil separator tank having an opening in its bottom area, a short vertical pipe connecting the latter opening with an opening in the top area of the receiver tank, the separator tank having a filter assembly for filtering oil from air passing from the receiver tank through the short vertical pipe into the separator tank, an oil sump tank having an opening in its upper area, a short vertical pipe having its lower end of greater cross dimension than its upper end connecting the said opening of the sump tank with an opening in the bottom of the receiver tank for catching oil settling out of air admitted to the receiver tank, and an oil pump

system operatively connected with said drive shaft for pumping oil from the sump tank and delivering it to the compression chamber to reduce the temperature of the latter.

9. A machine for compressing fluids comprising in combination a rotary air compressor including a compressor chamber having a discharge port, a rotor for compressing air in the compression chamber and a drive shaft carrying the rotor, a receiver connected to the discharge port, an oil separator tank having an opening in its bottom area in communication with an opening in the top area of the receiver and having a filter assembly for filtering oil from air passing from the receiver through the tank, an oil sump tank having an opening in its upper area in communication with the bottom of the receiver for catching oil settling out of air admitted to the receiver, and an oil pump system operatively connected with said drive shaft for pumping oil from the sump tank and delivering it to the compression chamber to reduce the temperature of the latter; wherein conduit means is provided for conducting oil removed by the filter assembly back to the compression chamber; and wherein a choke is disposed in said conduit means and is adapted to restrict escape of compressed air from the separator along with the filtered oil being conducted back to the compression chamber.

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