Aug. 20, 1940.

B. S. AIKMAN

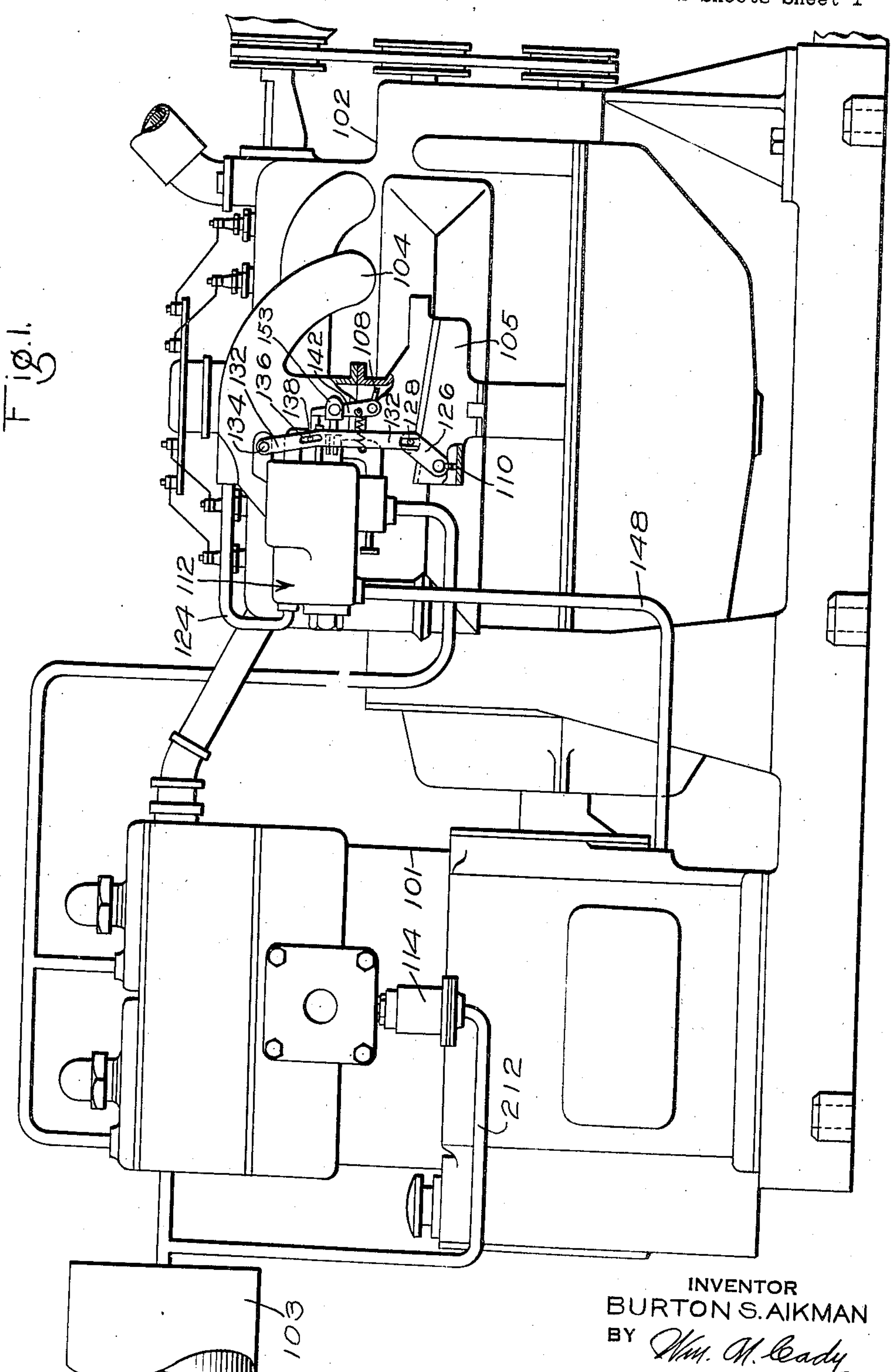
2,211,875

COMPRESSOR CONTROL SYSTEM

Original Filed Dec. 18, 1936

2 Sheets-Sheet 1

Fig. 1.



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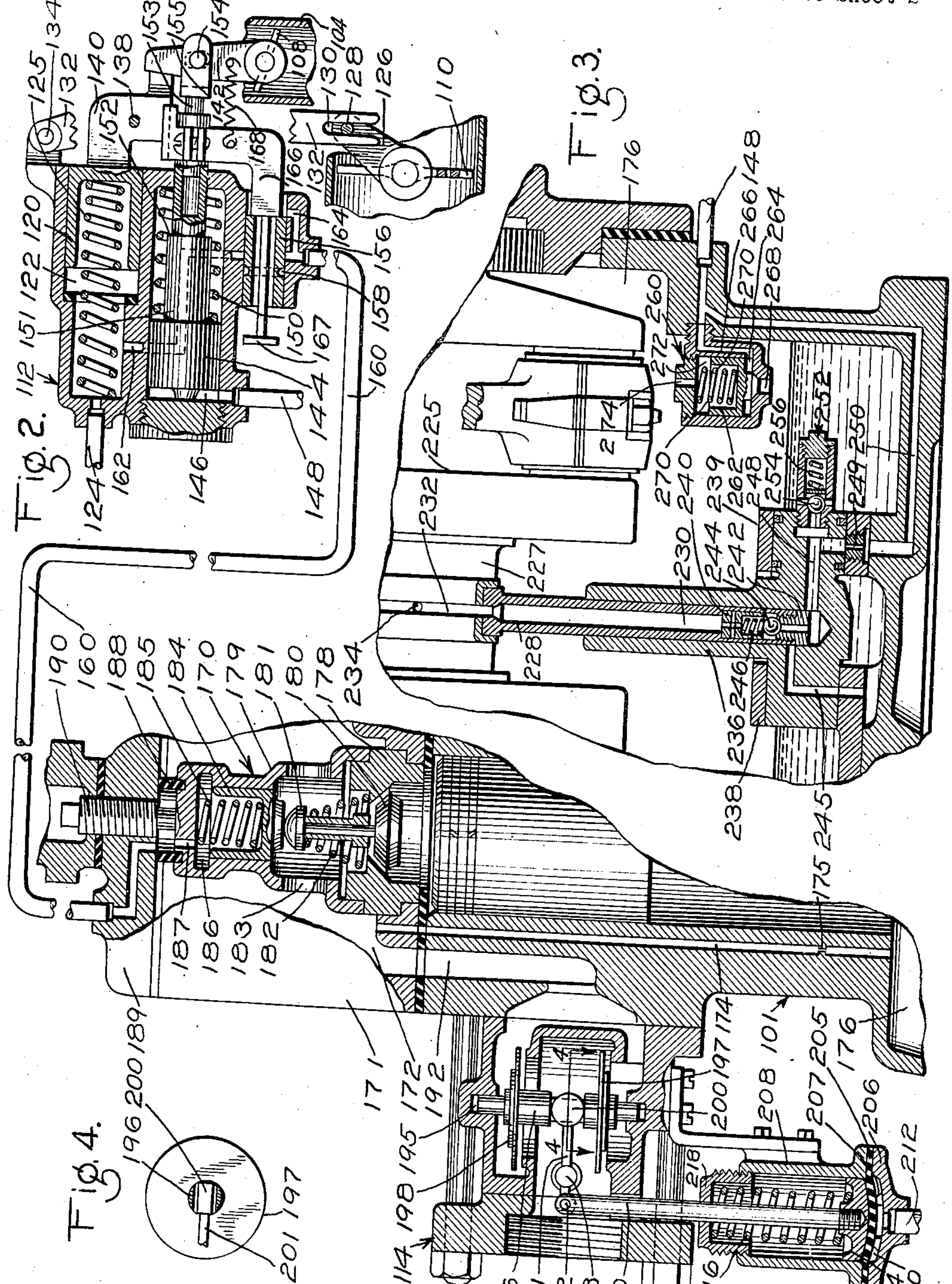

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2,211,875

COMPRESSOR CONTROL SYSTEM

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12 Claims. (Cl. 230—3)

This invention relates to compressor and driving motor equipments, and more particularly to means responsive to the pressure of fluid delivered by a compressor for simultaneously controlling the unloading thereof and the operation of the driving motor, the present application pertaining to subject matter divided out of my copending application for improvements in Compressor control systems, which was filed in the United States Patent Office December 18, 1936, Serial No. 116,473, and for which Patent Number 2,148,719 was issued on February 28, 1939.

It is an object of this invention to provide an improved compressor control system adapted for use with a fluid compressor driven by an internal combustion engine, and operative to maintain the pressure of the fluid compressed by the compressor within desired values.

Another object of the invention is to provide a control system of the above type which operates to control the throttle valve and the choke valve associated with the carburetor of the driving engine to provide the best starting conditions for the engine.

A further object of the invention is to provide a compressor control system incorporating means to vary the volumetric efficiency of the compressor in accordance with the pressure of fluid compressed thereby.

Another object of my invention is to provide an improved control system for a fluid compressor driven by a variable speed motor, and including means for varying the speed of the motor in accordance with variations in the pressure of fluid compressed by the compressor.

Another object of the invention is to provide a compressor control system of the above type which operates to maintain the compressor unloaded until the driving motor has reached substantially its normal speed, and to effect unloading of the compressor in the event the motor ceases to drive the compressor.

Other objects of the invention and features of novelty will be apparent from the following description taken in connection with the accompanying drawings, in which,

Fig. 1 is an elevational view showing a compressor and driving motor therefor equipped with a preferred form of control system embodying my invention;

Fig. 2 is an enlarged sectional view showing a portion of the control mechanism and of the compressor shown in Fig. 1;

Fig. 3 is an enlarged sectional view of a portion of a compressor shown in Fig. 1; and

Fig. 4 is a sectional view taken substantially along the line 4—4 of Fig. 2.

Description

Referring to Fig. 1 of the drawings, there is illustrated therein a compressor 101, which is driven by an internal combustion engine 102 and compresses fluid into a reservoir 103.

The engine 102 may be of any well known construction and has an inlet manifold 104 through which fuel is supplied to the cylinders of the engine from a carburetor 105, which may also be of a well known construction. A throttle valve 108 is interposed in the passage through the inlet manifold 104 at a point intermediate the carburetor and the engine, while a choke valve 110 is provided to control the flow of air from the atmosphere to the carburetor.

The control system provided by this invention comprises a control device indicated generally by the reference numeral 112 and operative in response to variations in the pressure of the fluid in the inlet manifold 104, and to variations in the pressure of the lubricant in the lubricating system of the compressor 101 for controlling the throttle valve 108, the choke valve 110, and for also controlling operation of the unloading means for the cylinders of the compressor 101.

The control system provided by this invention includes, in addition, a control device indicated generally by the reference numeral 114 for controlling the supply of fluid from the atmosphere to the inlet chamber of the compressor.

The construction of the control device 112 is best shown in Fig. 2 of the drawings, and, as illustrated, comprises a body having a bore therein in which is mounted a piston 120, which is subject at one face to the atmosphere, and at the other face to the pressure of the fluid in a chamber 122, which is constantly connected by way of a pipe 124 with the inlet manifold 104 of the engine 102. A spring 125 is mounted in the chamber 122 and yieldingly urges the piston to the right, as viewed in Fig. 2 of the drawings, until further movement of the piston is prevented by a stop, not shown.

The choke valve 110 is secured on a shaft on which is secured a lever 126. The lever 126 carries a pin 128, which extends into a slot 130 in the free end of a lever 132, which is pivotally supported from the body of the control device 112 by means of a pin 134.

As is best shown in Fig. 1 of the drawings, the lever 132 has a slot 136 formed therein into which extends a pin 138 carried by an arm 140 formed on the piston 120.

The throttle valve 108 is secured by means of a shaft to a lever 142, one face of which is engageable with the arm 140 of the piston 120 at certain times, as will hereinafter more fully appear.

The body of the control device 112 is further provided with a bore having mounted therein a piston 144, which is subject on one face to the pressure of fluid in a chamber 146 constantly communicating by way of a pipe 148 with the lubricating system of the compressor 101, and at the other face to the opposing force exerted by a spring 150. The piston 144 has formed integral therewith a stem 151 which extends through and is guided by a bore in the end wall of the body of the control device. The stem 151 has a shoulder 152 formed thereon and adapted to engage the body of the control device to limit movement of the piston 144 against the spring 150.

The stem 151 has a bore in the end thereof in which is inserted a member 153 which is secured to the arm 142 by means of a pin 154. The member 153 has a shoulder 155 formed thereon and adapted to engage the end of the stem 151 to limit leftward movement of the member 153 relative to the stem 151, as viewed in Fig. 2 of the drawings.

The body of the control device 112 has, in addition, a bore therein in which is mounted a valve 156 in the form of a tube having an annular groove 158 cut therein, which in one position of the valve is adapted to establish communication between a pipe 160 leading to the unloading means for the compressor 101, and a passage 162 leading from the chamber 122. The valve 156 is adapted also to control communication between the atmosphere and a branch passage 164 leading from the pipe 160.

A member 166 is secured to the stem 151 of the piston 144 and has a reduced portion extending through a longitudinal bore of the valve 156 and carrying a head 167 engageable with the valve. The member 166 has movement relative to the valve 156 and is operable to shift the valve along its bore in either direction. A spring 168 extends between the member 166 and the arm 142 associated with the throttle valve 108, and yieldingly urges the arm 142 against the arm 140 on the piston 120. The spring 168 is proportioned, however, so that it will not exert sufficient force on the piston 120 to move it against the spring 125, nor cause movement of the piston 144 against the spring 150.

As shown in Fig. 4 of the drawings, each of the cylinders of the compressor 101 has associated therewith unloading means indicated generally by the reference numeral 170. The compressor 101 has secured thereto a cylinder head 171 having formed therein an inlet chamber 172, which is common to both of the cylinders of the compressor, and which is constantly connected with the crankcase chamber 176 of the compressor by way of a passage 174 having a restricted portion or choke 175.

The portion of the cylinder head 171 above each of the cylinders has a suitable passage formed therein for receiving a seat member 178, which is held in position against a shoulder on the cylinder head 171 by means of a hollow member 179. Each of the seat members for the respective compressor cylinders has associated therewith an inlet valve 180 adapted to engage a seat on the seat member, each of which inlet valves has a stem which carries a spring seat 181. A spring 182 is interposed between the seat member 178 and the spring seat 181 and yieldingly presses the inlet valve toward its seat.

Each member 179 has openings 183 extending through the wall thereof to permit fluid to flow from the inlet chamber 172 to the chamber within the member, and thence past the inlet valve 180 to the compression chamber in the cylinder with which the inlet valve is associated. Mounted in a suitable bore formed in the member 179 is a piston 184, which is adapted to engage the spring seat 181 on the stem of the valve 180 and is yieldingly pressed into engagement therewith by means of a spring 185 mounted in a chamber 186. The spring 185 is proportioned so that the force exerted thereby on the piston 184 is great enough to move the piston 184 and the valve 180 against the opposing force of the spring 182.

The piston 184 is subject on one face to the pressure of fluid in the inlet chamber 172, and is subject on the other face to the pressure of fluid in the chamber 186, which is constantly connected by way of a passage 187 with the area within an annular gasket 188 which is clamped between the member 179 and a cover section 189. The cover section 189 has a passage therein forming communication from the area within the annular gasket 188 to the pipe 160 leading from the control device 112. A set screw 190 secured in the cover section 189 engages the upper wall of the member 179 and operates through this member to press the seating member 178 into engagement with a shoulder on the head 170.

The control device 114 shown in Fig. 4, which in effect constitutes an unloader common to all the compressor cylinders, comprises a body which is secured to the face of the body of the compressor 101 surrounding a passage 192 leading from the inlet chamber 172 through a central passage in the body of the control device 114 to the atmosphere, the central passage being controlled by a balanced valve device indicated generally by the reference numeral 195.

The valve device 195 comprises a stem 196 having reduced end portions which are slidable in aligned bores in the body of the control device 114, to which stem is secured a valve disc 197 that is disposed in the central atmospheric passage in the body and is adapted to engage a seat on the body of the control device 114. The stem 196 also has secured thereto a valve disc 198 which is mounted in the passage 192 and is adapted to engage a seat on the body of the control device 114. Both valves 197 and 198 are thus adapted for simultaneous operation to control the flow of fluid from the atmosphere to the passage 192.

The stem 196 has a slot extending therethrough adjacent the middle thereof and into which extends the rounded end portion 200 of a lever 201, which is pivotally supported from the body of the control device 114 by means of a pin 203.

The control device 114 has associated therewith a movable abutment in the form of a flexible diaphragm 205, which is clamped between confronting flanges formed on a cover section 206 and on a body portion 208 carried by the casing of the control device. The diaphragm 205 has at one face thereof a chamber 210, which is constantly connected by way of a pipe 212 with the reservoir 103.

The body 208 has a bore therein in which is mounted a plunger 214 which engages a face of the diaphragm 205. The plunger 214 is yieldingly pressed into engagement with the diaphragm 205 by means of a coil spring 216, which is interposed between the plunger and an adjustable spring seat 218. The plunger 214 has secured thereto a rod 220, which extends through a bore in the spring seat 218 and is pivotally connected to the end of the lever 201 by means of a pin 222.

The compressor 101 is provided with a pressure lubricating system, the construction of which is shown in Fig. 3 of the drawings. The compressor has a crankshaft 225, which is mounted in the crankcase chamber 176, and is supported by suitable bearings on the body of the compressor. The crankshaft 225 has cranks on which are journaled connecting rods to which are secured the pistons of the compressor cylinders.

The crankshaft 225 has, in addition, an eccentric 227 formed thereon on which is journaled a piston 228 having a passage 230 therein, which communicates with an annular groove 232 in the face of the eccentric 227. A passage indicated at 234 communicates with the groove 232 and extends through the crankshaft 225 to the faces of the bearings of the connecting rods which are secured on the crankshaft.

The piston 228 extends into a piston bore in a body 236, which is pivotally supported on the lower wall of the crankcase chamber 176 by means of brackets 238 and 239. Positioned in the lower portion of the piston 228 is a member 240 having a restricted passage communicating with the bore 230. The end of the piston 228 has a seat member 242 secured therein, which seat member has a passage extending therethrough and surrounded by a seat adapted to be engaged by a ball valve element 244, which is urged to the seated position by means of a spring 246.

The piston 228 is reciprocable in the bore in the body 236, and at one point in its range of movement the member 242 is positioned above a passage 245, which communicates with the lower portion of the crankcase chamber 176 and with the bore in the body 236. At another point in the range of movement of the piston 228, the member 242 is located adjacent the end of the piston bore in the body 236 so as to cut off communication thereto from the passage 245. A passage 248 is formed in the body 236 and communicates with the piston bore therein at a point adjacent the end thereof, and this passage also communicates through a choke 249 with a passage 250 to which is connected the pipe 148 leading to the control device 112.

A pressure release valve device indicated generally by the reference numeral 252 is provided for controlling the pressure of the fluid in the lubricating system of the compressor. The valve device 252 comprises a seat member having a passage therein which communicates with the passage 248 in the member 236. The passage in the seat member is surrounded by a seat adapted to be engaged by a ball valve element 254, which is yieldingly pressed to the seated position by a coil spring 256.

The compressor 101 has associated therewith, in addition, a pressure regulating valve device indicated generally by the reference numeral 260, and comprising a body having a bore in which is mounted a piston 262, which is subject on one face to the pressure of the lubricant in a chamber 264, which is constantly connected by way of a passage 266 with the passage 250. The piston 262 has a valve formed integral therewith and engageable with a seat on the body of the valve device surrounding a passage 268 through which lubricant may be discharged from the chamber 264 to the compressor crankcase chamber 176.

The piston 262 is subject on the other face to the force exerted by a coil spring 270, and to the pressure of the fluid in a chamber 272, which is constantly connected to the crankcase chamber 176 by way of a passage 274.

The equipment is shown in Fig. 2 of the drawings in the position which it assumes when the compressor 101 and the driving engine 102 are idle, and the pressure of the fluid compressed by the compressor is less than that which the control system is adapted to maintain.

At this time the spring 216 maintains the diaphragm 205 in engagement with projections 207 on the cover 206, and also maintains the balanced valve device 195 in its full open position.

As the compressor is idle, no pressure is exerted on the lubricant in the compressor lubricating system, while the piston 144 of the control device 112 is held at one end of its range of movement by the spring 150 so as to hold the throttle valve 108 substantially in its closed position, and to hold the valve 156 in a position to establish communication between the passage 164 and the atmosphere.

As the passage 164 is connected to the atmosphere, the unloading means for the cylinders of the compressor 101 are connected to the atmosphere, and the springs 185 operate through the respective pistons 184 to hold the inlet valves 180 away from their seats and thereby unload the compressor cylinders.

At this time, as the engine 102 is not being operated, the pressure of the fluid in the inlet manifold 104 thereof will be substantially at atmosphere, and fluid at this pressure will also be present in the chamber 122 of the control device 112 with the result that the spring 125 holds the piston 120 in the position determined by the stop, not shown, associated therewith.

In this position of the piston 120 the arm 140 thereon engages the lever 142 and holds it in a position to hold the throttle valve 108 slightly open, as shown in Fig. 2 of the drawings. With the lever 142 so positioned the shoulder 155 on the member 153 is spaced from the end of the stem 151, and the spring 168 is expanded somewhat, but the force exerted through the spring 168 is insufficient to move the piston 144 against the spring 150. The position of the piston 120 is at the same time such as to cause the lever 132 to maintain the choke valve 110 in the closed position.

Initial starting operation

If it is desired to start the engine 102, it may be started readily at this time as the carburetor is choked and the throttle valve is open slightly, while the compressor is unloaded with the result that the load on the engine is at the minimum.

As soon as the engine is started there is a reduction in the pressure of the fluid in the inlet manifold 104 of the engine and a corresponding reduction in the pressure of the fluid in the chamber 122 on the valve device 112. On a reduction in the pressure of the fluid in the chamber 122, the piston 120 is moved by the higher pressure of the atmosphere against the spring 125, and on this movement of the piston 120 force is exerted through the pin 138 to move the lever 132, and the slotted end portion of the lever 132 moves the pin 128 and the arm 126 so that the choke valve 110 is moved from the closed position to the open position.

When the engine 102 is operated the crankshaft 225 of the compressor 101 is rotated and the piston 228 of the compressor lubricant pump is reciprocated in the member 236. On upward movement of the piston 228, as viewed in Fig. 3 of the drawings, as the member 242 uncovers the end of the passage 245, lubricant from the lower portion of the crankcase chamber 176 is drawn into the bore in the member 236, and on subsequent downward movement of the piston 228 the member 242 cuts off communication between the bore in the member 236 and the passage 245, while the lubricant contained in the bore in the member 236 is subjected to pressure, with the result that the ball check valve 244 is moved against the spring 246 to permit fluid to flow through the passage in the member 242, and thence through the choked passage in the member 240 to the passage 230 leading to the annular groove 232 and the passage 234 in the crankshaft 235, through which lubricant flows to the portions of the compressor to be lubricated.

The pump is proportioned so that its capacity exceeds by a substantial amount the volume of lubricant required to lubricate the compressor, and lubricant placed under pressure by the piston 228 flows through the restricted passage 249 to the passage 250, and thence by way of the pipe 148 to the chamber 146 at the face of the piston 144 of the control device 112.

In addition, lubricant supplied to the passage 250 flows therefrom by way of the passage 266 to the chamber 264 at the face of the piston 262 of the pressure regulating valve device 260. Normally the valve carried by the piston 262 is held in seated position by the spring 270 to prevent the release of lubricant from the chamber 264 to the compressor crankcase 176, but if the lubricant pump supplies lubricant in a volume in excess of that required to lubricate the compressor and to operate the control device 112, the pressure of the lubricant in the chamber 264 will increase and the lubricant will move the piston against the spring 270 to release lubricant from the passage 250 and thereby reduce the pressure of the lubricant in this passage to the value determined by the spring 270.

Similarly, if the pressure of the lubricant in the passage 248 increases above a predetermined value because of the rapid supply of lubricant thereto by the pump, and the restricted flow of lubricant therefrom through the choke 249, the ball valve 254 will be moved against the spring 256 to permit the release of lubricant from the passage 248 until the pressure therein is reduced to a predetermined value.

The pressure release valve device 252 is adjusted so that it operates to prevent the release of lubricant from the passage 248 until the pressure of the lubricant therein is slightly greater than is required to move the piston 262 of the valve device 260 against the spring 270 when the fluid in the crankcase chamber 176 is at substantially atmospheric pressure, while the valve device 262 is adjusted so that with the crankcase chamber 176 substantially at atmospheric pressure, it will not release lubricant from the passage 250 until the pressure therein is slightly greater than is required to move the piston 144 of the control device 112 to the end of its range of movement against the spring 150.

Fluid is supplied to the chamber 146 in the control device 112 at a restricted rate because of the restricted flow capacity of the choke 249, and as a result, the piston 144 is moved slowly against the spring 150. On this movement of the piston 144 the end of the stem 151 engages the shoulder 155 on the member 153 so that force is exerted on the lever 142 to move the throttle valve 108 towards the open position. As the throttle valve is moved slowly, the engine will accelerate gradually, and the engine and the compressor driven thereby will not be subjected to severe strains.

On movement of the piston 144, the member 166 is also moved. The member 166 is initially moved relative to the valve 156, and when the piston 154 is moved almost to the end of its range of movement, the head 167 carried by the member 166 engages the valve 156 so that on further movement of the piston 154 the valve 156 is moved in the bore in which it is mounted to a position in which it cuts off communication between the passage 164 and the atmosphere, while the annular groove 158 in the valve 156 establishes communication between the passage 162 leading to the chamber 122, and the pipe 160 leading from the unloading means 170 for the compressor cylinders.

When the valve 156 is moved to this position, communication is established between the inlet manifold 104 of the engine and the unloading means 170 for the compressor cylinders and fluid flows to the inlet manifold from the chambers 186 of the unloading means. On a reduction in the pressure of the fluid in the chambers 186, the pistons 184 are moved upwardly against the springs 185 by the pressure of the atmosphere present in the inlet chamber 172, while the inlet valves 180 are moved to their seated positions by the springs 182 to load the compressor.

The compressor is now operated in the usual manner to compress fluid under pressure into the reservoir 103, while fluid to be compressed is drawn into the inlet chamber 172 past the open balanced valve device 195.

Restriction of air delivery and reduction in speed in accordance with increase in reservoir pressure

On an increase in the pressure of the fluid in the reservoir 103 there is a corresponding increase in the pressure of the fluid in the chamber 210 at the face of the diaphragm 205 of the control device 114. On an increase in the pressure of the fluid in the chamber 210 force is exerted through the diaphragm 205 upon the plunger 214 to move it against a spring 216, while movement of the plunger 214 is transmitted through the stem 220 to move the arm 201 about the pin 203.

On this movement of the arm 201 the valves 197 and 198 are moved toward their seats to restrict the rate of flow of fluid to the inlet chamber 172.

On this reduction in the rate of flow of fluid to the inlet chamber 172, as the compressor continues to be operated, there will be a reduction in the pressure of the fluid in the inlet chamber 172, and fluid will flow thereto at a restricted rate from the crankcase chamber 176 through the passage 174 and the choke 175, thus producing a corresponding reduction in the pressure of the gas present in the crankcase chamber 176.

On this reduction in the pressure of the gas in the crankcase chamber 176, there is a corresponding reduction in the force exerted on the piston 262 of the pressure regulating valve device 260 in opposition to the force exerted thereon by the lubricant under pressure in the chamber 264. The piston 262 will thereupon be moved upwardly against the spring 270 and will open communication from the chamber 264 through the passage 268 to release lubricant from the passage 250 until the pressure of the lubricant remaining therein has been reduced by an amount substantially equal to the reduction in the pressure of the gas in the crankcase chamber 176.

On this reduction in the pressure of the lubricant in the passage 250 there is a corresponding reduction in the pressure of the lubricant in the chamber 146 at the face of the piston 144, and the piston 144 is moved by the spring 150 until the spring has expanded sufficiently to equalize the force exerted thereby on the piston 144 with the reduced pressure of lubricant in the chamber 146.

On this movement of the piston 144, the throttle valve 108 is moved away from the full open position toward the closed position to reduce the rate of flow of fuel to the engine, and thereby to reduce the rate at which the engine drives the compressor. At the same time, the member 166 is moved relatively to the valve 156, which remains in the position in which the groove 158 therein establishes communication between the passage 162 and the pipe 160 with the result that the compressor continues to be loaded. The compressor, therefore, will continue to be loaded and will be driven by the engine, but the speed of the engine and of the compressor will be reduced.

The degree of restriction in the rate of flow of fluid from the atmosphere to the inlet chamber 172 effected by the balanced valve device 195 will vary in accordance with the increase in the pressure of the fluid in the reservoir 103, and similarly the reduction in the pressure of the fluid in the inlet chamber 172, and in the crankcase chamber 176, will be varied in accordance with the pressure of the fluid in the reservoir 103.

The rate at which the engine 102 is supplied with fuel past the throttle valve 108 is governed by the pressure of the lubricant in the chamber 146, and this is controlled by the pressure regulating valve device 260 in accordance with changes in the pressure of the gas in the crankcase chamber 176.

It will be seen, therefore, that the degree of reduction in the supply of fuel to the engine will be in accordance with the increase in the pressure of the fluid in the reservoir 103.

On the reduction in the pressure of the fluid in the inlet chamber 172 as a result of operation of the balanced valve device 195, there is a reduction in the force exerted on the pistons 184 of the unloading means 170 and tending to hold them against the springs 182. The various parts of the equipment are arranged and proportioned, however, so that the pistons 184 will not be moved downwardly by the springs 182, assuming that the chambers 186 remain connected to the inlet manifold 104, until the pressure of the fluid in the inlet chamber 172, and therefore in the crankcase chamber 176, has been reduced below the value necessary to cause the pressure regulating valve device 260 to reduce the pressure of the lubricant in the passage 250 and the chamber 146 far enough to permit the piston 144 to be moved substantially to the end of its range of movement by the spring 150, and move the valve 156 to a position to connect the pipe 160 to the atmosphere.

The unloading means 170 associated with the compressor cylinders will not, therefore, be directly operated to unload the compressor in response to a reduction in the pressure of the fluid in the inlet chamber 172, but will be operated to unload the compressor only as a result of operation of the pressure regulating valve device 260 and of the control device 112 in response to a reduction in the pressure of the fluid in the inlet chamber 172.

At this time, however, as the flow of air from the atmosphere to the inlet chamber 172 is restricted, and as there is a reduction in the pressure of the fluid in the inlet chamber 172, a reduced amount of fluid will be supplied to the compression chambers of the compressor cylinders, thereby reducing the volumetric efficiency of the compressor, and also reducing the power required to drive the compressor.

As the supply of fuel to the engine, and the speed of the engine are reduced at this time, the power developed by the engine is reduced, but as the power required to drive the compressor is reduced, there is no danger that the engine will stall or be unable to operate the compressor.

Proportionate increase in speed in response to reduction in reservoir pressure with compressor loaded

If while the compressor continues to be operated there is a reduction in the pressure of the fluid in the reservoir 103, the balanced valve device 195 will be operated by the diaphragm 205 and the spring 216 to permit an increase in the rate of flow of fluid from the atmosphere to the inlet chamber 172. There will, therefore, be an increase in the pressure of the fluid in this chamber, and a corresponding increase in the pressure of the gas in the crankcase chamber 176, while the pressure regulating valve device 260 will be operated to increase the pressure maintained on the lubricant in the passage 250 and the chamber 146, and the piston 144 will be moved against the spring 150 to further open the throttle valve 108 and increase the rate at which the engine drives the compressor.

As a result of the increased flow of fluid from the atmosphere to the inlet chamber 172, there will be an increase in the supply of fluid to the compressor cylinders and a corresponding increase in the volumetric efficiency of the compressor, while more power will be required to drive the compressor. As the rate of supply of fuel to the engine is increased at this time, the engine develops more power and is able to carry the increased load, and the compressor is operated to compress fluid into the reservoir 103 at a more rapid rate.

Unloading of compressor in response to high reservoir pressure

If the pressure of the fluid in the reservoir 103 increases to a predetermined relatively high value, the force exerted by the fluid under pressure in the chamber 210 at the face of the diaphragm 205 will be great enough to move the diaphragm 205 and the plunger 214 against the spring 216 far enough to cause the valves 197 and 198 to be moved adjacent to their seats to greatly restrict the flow of fluid from the atmosphere to the passage 192 and the inlet chamber 172, thereby producing a substantial reduction in the pressure of the fluid in the inlet chamber 172 and in the crankcase chamber 176.

During this reduction in the pressure of the gas in the crankcase chamber 176 there will be a corresponding reduction in the force exerted on the piston 262 of the pressure regulating valve device 260 in opposition to the force exerted thereon by the lubricant in the chamber 264, and the piston 262 will thereupon be moved against the spring 270 so as to open communication through the passage 268 to permit the release of lubricant from the passage 250 to the crankcase chamber until the pressure of the lubricant in the passage 250 is reduced a substantial amount.

As there has been a substantial reduction in the pressure of the gas in the crankcase chamber 176, the pressure regulating valve device 260 will permit the pressure of the lubricant in the passage 250 to reduce a substantial amount. The pressure of the lubricant in the passage 250 will be permitted to reduce to a value such that the lubricant under pressure in the chamber 146 at the face of the piston 144 is unable to hold this piston against the opposing force of the spring 150, and the piston will be moved to the left, as viewed in Fig. 2, substantially to the end of its range of movement by the spring 150.

After the piston has moved a predetermined amount in this direction, the member 166 engages the valve 156 and moves it to a position in which the annular groove 158 therein no longer establishes communication between the passage 162 and the pipe 160, and in which the valve opens communication between the passage 164 and the atmosphere.

Fluid from the atmosphere will thereupon flow through the passage 164 and the pipe 160 to the unloading means 170 associated with the compressor cylinders, and on an increase in the pressure of the fluid supplied to the unloading means, the pistons 184 thereof will be moved downwardly, and will engage the ends of the stems of the intake valves 180 to move them against the springs 182 away from their seats so as to unload the compressor.

On this movement of the piston 144 force is exerted through the spring 168 to move the arm 142 and close the throttle valve 108. At this time, as the engine 102 is running, the piston 120 is held in its inner position against the spring 125, and the arm 140 thereon does not oppose movement of the arm 142 by the spring 168. The shoulder 155 on the member 153 is maintained in engagement with the end of the stem 151 of the piston 144, therefore, and the arm 142 is moved farther toward the throttle closed position than the position in which it is shown in Fig. 2 of the drawings, while the throttle valve 108 will be more nearly in the closed position. The rate of supply of fuel to the engine will be reduced to the minimum, therefore, but the engine will not stall as the compressor 101 will be unloaded before the supply of fuel to the engine is reduced to the minimum rate.

It will be understood that by this time the high pressure of fluid in the reservoir 103 will have effected operation of the control device 114 substantially to cut off the flow of atmospheric air by way of the passage 192 to the inlet passage 172 of the compressor, assuming that no fluid under pressure has meanwhile been withdrawn from the reservoir 103. Since the operation of the compressor has already created a partial vacuum in the inlet passage as hereinbefore explained, it will be apparent that the sub-atmospheric pressure likewise prevailing in the crankcase chamber 176 of the compressor causes continued operation of the lubricant pressure regulating device 260 to maintain the reduced pressure of lubricant in the passage 250 and consequently in the chamber 126 of the control device 112. The control device 112 thus continues to cause engine 102 to operate the unloaded compressor 101 at the minimum speed as long as the pressure of fluid in the reservoir 103 remains at a value high enough to hold the balanced valve device 195 in closed position.

Operation upon reduction in reservoir pressure with compressor unloaded

If at this time there is a reduction in the pressure of the fluid in the reservoir 103 as a result of the withdrawal of fluid under pressure therefrom, the diaphragm 205 and the plunger 214 will be moved downwardly by the spring 216, while the valves 197 and 198 will be moved away from their seats. The compressor 101 will continue to be unloaded, however, as the inlet valves thereof are held away from their seats by the unloading means associated therewith.

On movement of the valves 197 and 198 away from their seats fluid from the atmosphere is permitted to flow to the passage 192, and thence to the inlet chamber 172, from which it flows by way of the passage 174 and the choke 175 to the crankcase chamber 176 to increase the pressure of the gas in the crankcase chamber 176.

On an increase in the pressure of the gas in the crankcase chamber 176 there is an increase in the force exerted on the piston 262 of the pressure regulating valve device 260 to move it towards the seated position to restrict the release of lubricant from the passage 250 to the crankcase chamber. This results in an increase in the pressure of the lubricant in the passage 250 corresponding to the increase in the pressure of the gas in the crankcase chamber 176, while there is a corresponding increase in the pressure of the lubricant in the chamber 146 at the face of the piston 144 of the control device 112.

On this increase in the pressure of the lubricant in the chamber 146, the piston 144 is moved against the spring 150 so as to move the throttle valve towards the open position to increase the rate of supply of fuel to the engine, and increase the rate at which the engine drives the compressor.

When the pressure of the fluid in the reservoir 103 has reduced to a predetermined relatively low value, the balanced valve device 195 will be operated to supply fluid from the atmosphere to the inlet chamber 172 and the crankcase chamber 176, thereby increasing the pressure of the fluid in the chamber 176 sufficiently to operate the pressure regulating valve device 260 for permitting creation of a pressure in the passage 250, and in the chamber 146, high enough to cause the piston 144 and member 166 to move the valve 156 to a position to again effect loading of the compressor. The compressor will thereupon be loaded in the manner described in detail above, and will thus again operate to compress fluid under pressure into the reservoir 103 to increase the pressure of the fluid therein.

When the engine 102 is stopped and does not drive the compressor 101, the lubricant pump of the compressor is not operated and will not supply lubricant under pressure to the passage 250, and the lubricant under pressure present therein will leak therefrom until the pressure of the lubricant remaining is at a relatively low value. On this reduction in the pressure of the lubricant in the passage 250 there is a similar reduction in the pressure of the lubricant in the chamber 146 at the face of the piston 144, and this piston is moved to the left to the end of its range of movement by the spring 150, while the member 166 engages the valve 158 and moves it to a position to open communication between the atmosphere and the passage 164 so that air from the atmosphere may flow to the unloading means of the compressor to effect unloading of the cylinders of the compressor.

In addition, when the engine 102 is not operated, the pressure of the fluid in the intake manifold 104 thereof will increase to atmospheric pressure, and there will be a similar increase in the pressure of the fluid in the chamber 122 of the control device 112 with the result that the spring 125 will move the piston 120 to the right until its movement is prevented by engagement with the stop, not shown. The member 140 will engage the lever 142 and move it to open the throttle valve 8 a small amount, while the piston 120 will operate through the lever 132 to move the choke 110 to the closed position. As the choke is automatically closed as soon as the engine ceases to operate, the choke will be in the position to facilitate starting of the engine when it is desired to again operate the engine.

It will be seen that the throttle valve 108 of the engine, and the means for unloading the compressor are controlled by the piston 144 of the control device 112, and that this piston is subject to lubricant supplied from the lubricating system of the compressor. On a reduction in the pressure of the lubricant supplied thereto this piston moves to a position to reduce the rate of supply of fuel to the engine to the minimum, and thereby causes the engine to be operated at the idling speed, and at the same time conditions the unloading means to unload the compressor. As a result, therefore, if the lubricating system of the compressor should fail for any reason, the compressor will be automatically unloaded to relieve it of work at a time when it is not properly lubricated, while the engine will be operated at the idling speed.

While one embodiment of the improved compressor control system provided by this invention has been illustrated and described in detail, it should be understood that the invention is not limited to these details of construction, and that numerous changes and modifications may be made without departing from the scope of the following claims.

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

1. In combination, an internal combustion engine having a carburetor associated therewith, the engine having an inlet passage through which fluid is supplied from the carburetor to the engine, a throttle valve controlling communication through said inlet passage, a choke valve controlling the flow of fluid from the atmosphere to the carburetor, and means subject to and operated on a predetermined increase in the pressure of the fluid in the inlet passage for closing said choke valve and for partially opening said throttle valve.

2. In combination, a fluid compressor having an inlet passage associated therewith through which fluid to be compressed is supplied to the compressor, an internal combustion engine for driving the compressor, said engine having a fuel supply device associated therewith, a movable member for controlling the rate of supply of fuel to the engine by said device, a liquid circulating system operated in accordance with the speed of the compressor, means responsive to the pressure of the liquid in said system for controlling the movable member, means responsive to the pressure of the fluid compressed by the compressor for controlling the rate of supply of fluid to said inlet passage thereof, and means responsive to the pressure of the fluid in said inlet passage for controlling the pressure of liquid in said circulating system.

3. In combination, a fluid compressor having an inlet passage associated therewith through which fluid to be compressed is supplied to the compressor, an internal combustion engine for driving the compressor, said engine having a fuel supply device associated therewith, a movable member for controlling the rate of supply of fuel to the engine by said device, unloading means for the compressor, a liquid circulating system operated in accordance with the speed of the compressor, means responsive to the pressure of the liquid in said system for controlling said movable member and for also controlling said unloading means, means responsive to the pressure of the fluid compressed by the compressor for controlling the rate of supply of fluid to said compressor inlet passage, and means responsive to the pressure of the fluid in said inlet passage for controlling the pressure of the liquid in said circulating system.

4. In combination, a fluid compressor, an internal combustion engine for driving said compressor, said engine having a carburetor associated therewith and having an inlet passage through which fluid is supplied to said engine from the carburetor, a throttle valve controlling communication through said inlet passage, a choke valve controlling the flow of air from the atmosphere to said carburetor, means subject to and operated on a predetermined increase in the pressure of the fluid in said engine inlet passage for closing said choke valve and for partially opening the throttle valve, and means responsive to the pressure of the fluid compressed by the compressor for also opening said throttle valve.

5. In combination, a fluid compressor, an internal combustion engine for driving said compressor, said engine having a carburetor associated therewith and having an inlet passage through which fluid is supplied to said engine from the carburetor, a throttle valve controlling communication through said inlet passage, a choke valve controlling the flow of fluid from the atmosphere to said carburetor, means subject to and operated on a predetermined increase in the pressure of the fluid in said engine inlet passage for closing said choke valve and for partially opening the throttle valve, and means responsive to the pressure of the fluid compressed by the compressor for also opening said throttle valve without affecting the position of the choke valve.

6. Automatic control apparatus for a compressor and an internal combustion engine arranged to operate said compressor to deliver fluid under pressure to a receiving reservoir, said apparatus comprising means operative in accordance with variations in the pressure of fluid in the reservoir to vary the volumetric efficiency of the compressor, and means responsive to variations

in said volumetric efficiency to effect corresponding variations in the rate of supply of fuel to said engine.

7. In an internal combustion engine of the class having an intake manifold through which fuel may be supplied to the engine cylinders by a carburetor device, a throttle valve controlling communication through said intake manifold and a choke valve controlling the supply of air to the carburetor; a control mechanism comprising automatic means for operating the throttle valve including a spring adapted normally to bias said valve toward its closed position, and movable abutment means subject to variations in fluid pressure in the intake manifold and operative by the partial vacuum maintained therein when the engine is running to open said choke valve, said abutment means being operative when the fluid pressure in said manifold is increased upon stopping of the engine to close said choke valve and to hold said throttle valve in partially open position.

8. In a fluid compressing equipment including a compressor having a fluid intake passage, a variable speed driving motor therefor, and a receiving reservoir, the combination of valve means responsive to the pressure of fluid in the reservoir for controlling admission of fluid to said compressor intake passage, control mechanism operable to govern the speed of operation of said motor, and fluid pressure responsive means controlled in accordance with variations in the fluid pressure in said compressor intake passage for controlling operation of said control mechanism.

9. In a fluid compressing equipment including a compressor having a fluid intake passage, a variable speed driving motor therefor, and a receiving reservoir, the combination of unloader means for unloading the compressor, valve means responsive to the pressure of fluid in the reservoir for controlling admission of fluid to said compressor intake passage, control mechanism operable to condition said unloader means to load or unload the compressor and to govern the speed of operation of said motor simultaneously, and fluid pressure responsive means controlled in accordance with variations in the fluid pressure in said compressor intake passage for controlling operation of said control mechanism.

10. In a fluid compressor having an inlet passage and means for compressing fluid supplied therethrough into a reservoir, the combination therewith of a fluid inlet control device comprising a casing having a supply chamber communicating with the inlet passage and provided with a pair of concentrically aligned valve seats, a pair of rigidly connected valve discs respectively cooperating with said seats and adapted for simultaneous movement toward or away from said seats to control admission of fluid to said inlet passage, the seating face of one of said valve discs being subject to fluid pressure in said supply chamber while the seating face of the other valve disc is subject to fluid pressure in said inlet passage for balancing said valve discs against pressure variations, and fluid pressure operated means responsive to an increase in the pressure of fluid in the reservoir for moving said valve discs toward seated position to reduce the volumetric efficiency of the compressor.

11. In a fluid compressing equipment including a compressor, a variable speed driving motor therefor and a receiving reservoir, in combination, a primary unloader device operative in accordance with an increase or a decrease in the pressure of fluid in the receiving reservoir for gradually unloading or loading the compressor, a secondary unloading means cooperative with the compressor independently of said primary unloader device, mechanism controlling the speed of operation of said motor and operative in accordance with the degree of loading or unloading effected by said primary unloader device for correspondingly increasing or reducing the speed, and control means operable by said mechanism to control said secondary unloading means, said control means being operated to maintain said secondary unloading means in compressor loading position upon operation of said mechanism to increase the motor speed to a maximum, and to maintain said secondary unloading means in unloading position upon operation of said mechanism to decrease the motor speed to a minimum.

12. In a fluid compressing equipment including a compressor, a variable speed driving motor therefor and a receiving reservoir, in combination, a valve device operative in accordance with an increase or a decrease in the pressure of fluid in the receiving reservoir for gradually restricting or increasing inlet flow of fluid to the compressor, unloading means associated with the compressor, mechanism controlling the speed of operation of said motor and operative in accordance with the decrease or increase in inlet flow of fluid effected by operation of the valve device for correspondingly increasing or reducing the speed, and control means operable by said mechanism to control said unloading means, said control means being operated to maintain said unloading means in compressor loading position upon operation of said mechanism to increase the motor speed to a maximum, and to maintain said unloading means in unloading position upon operation of said mechanism to decrease the motor speed to a minimum.

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