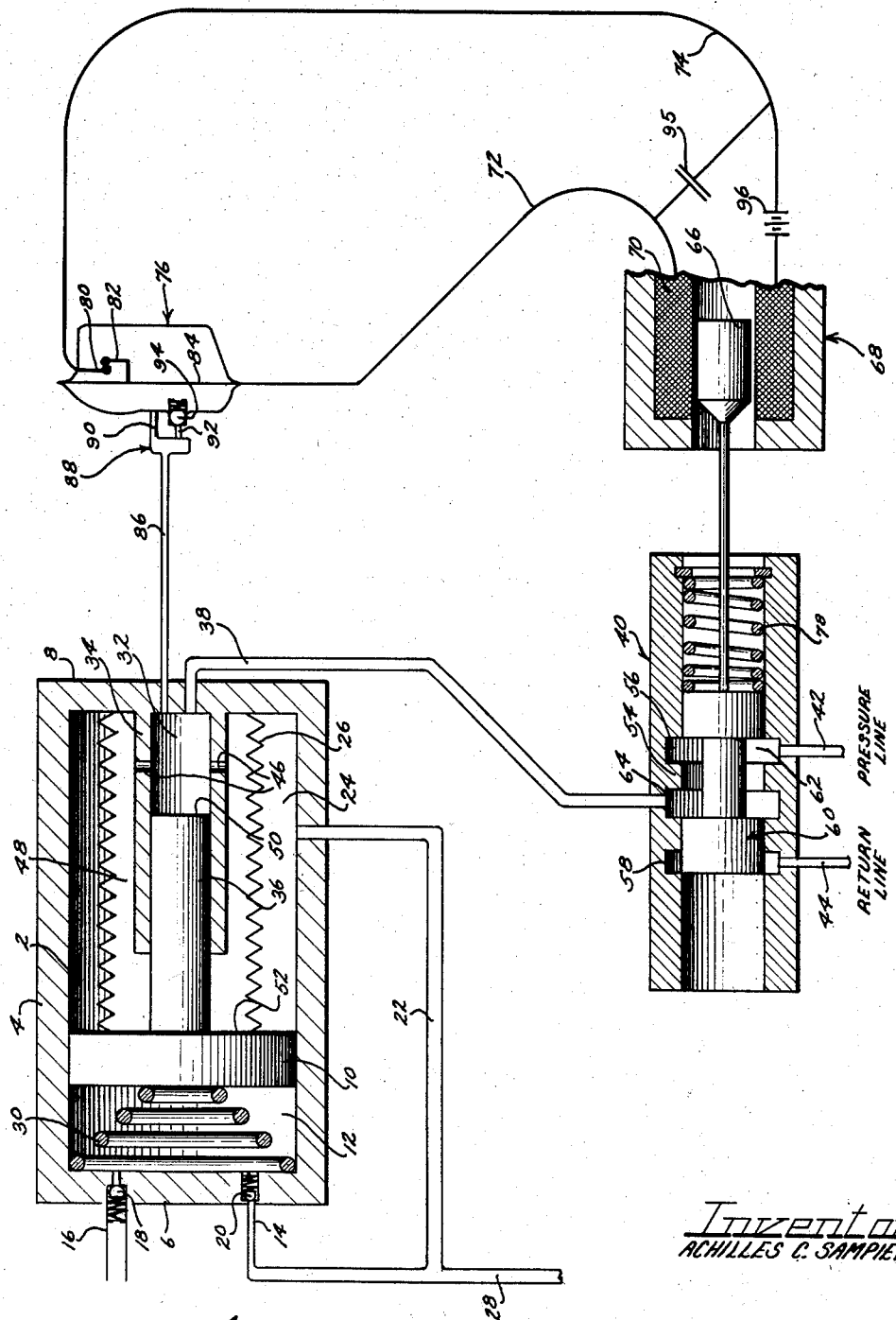
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HYDRAULICALLY OPERATED GAS COMPRESSOR

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HYDRAULICALLY OPERATED GAS COMPRESSOR

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The present invention relates to improvents in reciprocating gas compressors operated by pressurized fluid and to the combined controls for the compressor.

The present invention contemplates the provision of a gas compressor employing a cylindrically shaped closed compression chamber with a reciprocating compression piston slidably mounted therein and operable in a compression and intake stroke to force compressed gas or the like out through a compressor delivery conduit, and to take in gas through a gas intake conduit, which is also connected to the back side of the piston, with the flow through the conduits being controlled by non-return check valves. Reciprocation of the piston is obtained through a smaller diameter piston extension slidably housed in a cylindrically hollow compressed fluid chamber within the main chamber to which compressed fluid is supplied by a control valve. Fluid leaks from the fluid chamber during the compression stroke of the piston through lateral openings to a chamber formed by a bellows attached to the fluid side of the piston and to the end of the chamber. The control valve alternately vents and admits pressurized fluid to the fluid chamber and is electrically operated by a pressure responsive switch which includes delay elements to insure that the piston will complete its compression and intake strokes before the control valve changes position.

An object of the invention is to provide a compressor in accordance with the above contemplated structure and operation wherein the flow of pressurized working fluid is regulated by an electrically operated control valve.

Another object of the invention is to provide an improved gas compressor wherein the working fluid is at a higher pressure than the compressed gas.

Another object of the invention is to provide an improved gas compressor wherein a compressing piston movable in a compression cylinder is employed and the operating force is increased for the latter portion of the stroke as the resistance of the compressed gases also increases.

A still further object of the invention is to provide an improved electrical control valve for the working fluid provided with time delay devices which permit the piston adequate time to move in its full compression and intake stroke.

Other objects and advantages will become more apparent with the teaching of the invention in the disclosure of the preferred embodiment in the specification, claims and drawing, in which:

The figure of the drawing illustrates the compressor and electrically operated control valve in vertical sectional view which is drawn partially in schematic form

to illustrate the structure and operation of the mechanism.

Although the invention is illustrated in its preferred form by certain structural features shown employed in a combination wherein particular advantages are enjoyed, it will be understood that the inventive features may be utilized in other surroundings and other embodiments utilizing the advantages of the features of the invention may be employed.

As shown in the drawing, the compressor includes a compression chamber 2, which is preferably cylindrical in shape and includes a cylindrical outer wall 4 with end walls 6 and 8 forming the gas and the working fluid ends of the compressor respectively. It will be understood that although the mediums referred to will be gas and fluid, that the compressor may be adapted to compressing other materials and mediums and the compressor may be operated by various types of compressed fluids. In the preferred form, as shown, the compressor may be used for air or for material such as refrigeration fluid and the working fluid employed may be oil. In the form shown, by way of example the compressor is particularly well adapted to use as a refrigeration compressor for an air conditioning unit in an automobile. In this utilization the unit may be mounted on the front of the vehicle where it can work in comparatively cool air. In this arrangement the working fluid is supplied by a pump operated by the automobile engine and the pressurized fluid can be piped to various locations in the vehicle to operate other fluid motors as well as the present compressor.

Compression is accomplished by a piston 10 slidably mounted within the compression chamber 2. The end 12 of the compression chamber 2 is on the gas side of the piston 10 and receives gas to be compressed through an intake conduit 14 and discharges the compressed gas out through delivery conduit 16. The delivery conduit leads to an accumulator or an expansion nozzle such as commonly used in a refrigeration compressor and return of the compressed gas between each compression stroke is prevented by a non-return valve 18, shown in the form of a spring loaded ball check valve. The ball will unseat with each compression stroke of the piston to permit the passage of compressed gas and will return to prevent the backflow of gas when the piston moves in the intake stroke.

Similarly, the intake conduit 14 employs a non-return valve 20 which is also shown in the form of a spring loaded ball check valve. This valve opens to permit the intake of gas when the piston 10 moves in its intake stroke and closes when the piston moves in the compression stroke. The intake conduit 14 has a branch 22 which communicates with the compression chamber 4 in the zone 24, which is on the working fluid side of the piston 10. This permits the zone or chamber 24 to remain at the pressure of the intake fluid when the piston moves back and forth, and this chamber is isolated by the bellows 26, which will be described in detail later. Both conduits 14 and 22 connect to a common conduit 28 leading to a gass supply source which may be the low pressure side of a refrigeration expansion chamber.

The piston 10 is moved in its compression stroke by pressurized working fluid and is returned in the intake stroke by a coil helically shaped compression spring 30. This spring is located in the compression end 12 of the

compression chamber and will compress to a substantially flat form when the piston is at the full end of its compression stroke. The spring has sufficient strength to return the piston and force the working fluid out of the fluid chamber **32** in the intake stroke of the piston **10**.

The working fluid chamber **32** is defined by a cylindrically shaped wall **34** projecting into the compression chamber **2** from the wall **8** of the chamber. The hollow cyindrical wall defines the cylindrically shaped fluid chamber **32** which slidingly receives the piston extension **36**, which is smaller in diameter than the main piston **10** and which forces the piston in its compression stroke. The compression is designed to be operated by a working fluid at a higher pressure than the compression pressure. Thus the cross sectional area of this piston extension **36** is less than the piston **10**.

Working fluid is forced into the fluid chamber **32** through a conduit **38** leading from the control valve **40**. This conduit also permits the escape of venting of the working fluid when the piston extension **36** moves in the intake stroke and the pressurized fluid reaches the control valve **40** through a pressure line **42** and is vented through a return line **44**, which leads back to a reservoir. The pressurized working fluid may be provided from a pressure pump of any type well known to the art.

When pressurized working fluid enters the working fluid chamber **32** first to begin moving the piston extension **36** to the left as shown in the drawing, to move the piston **10** in its compression stroke, the piston extension **36** will move past the bleeder ports **46** which lead through the wall **34** of the working fluid chamber **32**. This permits the flow of working fluid into the assist chamber **48**. In the first portion of the compression stroke of the piston **10**, the gas is under low pressure and the piston is thus easily moved by the pressure of the working fluid against the small cross-sectional area of the end **50** of the piston extension. When the gas reaches a higher pressure, the movement of the piston **10** is assisted by the pressure of the working fluid on the surface **52** which is within the bellows enclosed assist chamber **48**. Thus the bleeder ports **48** will make available additional working area for the working fluid and will regulate the speed of travel of the compression piston. As the gas pressure increases the speed of travel of the piston would normally be slowed. The assist area **50** increases the force on the piston and makes its speed of travel more uniform over the full length of the compression stroke. The assist chamber is enclosed in the expansible bellows **26**, which coaxially surrounds the working fluid chamber **32** and which is attached at its ends to the piston **10** and the wall **8** of the compression chamber **2**. On the return or intake stroke of the piston **10** the fluid is forced out of the assist chamber **48** through the same bleeder openings **46**.

The control valve **40** is provided with a cylindrical valve chamber **54** having an annular pressure fluid groove **56** communicating with the pressure line. The cylindrical valve chamber also has an annular groove **58** communicating with the return line **44**. Within the chamber is slidably positioned a reciprocating valve spool **60**, which has a reduced center portion providing a passageway **62** which will permit communication between either the pressure groove **56** or the return groove **58**, and the delivery groove **64**, which communicates with the working fluid conduit **38**. When the valve spool **60** is in the position shown, the pressure line **42** is in communication with the working fluid conduit **38** to direct working fluid to the fluid chamber **32**. When the spool is moved to the left, as shown in the drawing, the passageway **62** permits communication between the working fluid conduit **38** and the return line **44** to permit the working fluid to leak out of the fluid chamber **32**, thereby allowing piston **10** to move to the right in its intake stroke.

The spool **60** of the control valve **40** is electrically controlled and is connected to the core **66** of a solenoid **68**. The solenoid coil **70** connects to a circuit having leads **72** and **74**, which is controlled by pressure operated switch **76**. When the solenoid coil **70** is energized, the valve is moved to the position shown in the drawing wherein the pressure line **42** is in communication with the pressure chamber **32**; and when the coil is deenergized, the coil compression spring **78** pushes the valve spool to the left to cause the fluid conduit **38** to communicate with the return line **44** for the delay of pressure within the working fluid chamber **32**.

The pressure switch **76** for energizing the solenoid **68** has a fixed contact **80**, and a movable contact **82**, which is mounted on a movable diaphragm **84** within the housing of the pressure switch. The diaphragm is exposed to the pressure in the working fluid chamber **32** and for this purpose a conduit **86** is provided. In the conduit **86** is a rapid flow, slow return apparatus **88**. This apparatus causes the pressure responsive switch to respond immediately to an increase in pressure in the working fluid chamber **32** and to return slowly with a decrease in pressure. This causes a rapid opening of the contacts **80**, **82** with admission of working fluid to the chamber **32** and a slow closing of the contacts when the working fluid pressure is permitted to decay from the chamber **32**. The rapid flow, slow return apparatus **88** is illustrated as comprising a Y-branch in the conduit **86** with a first small passageway **90** and a second larger passageway **92** having a ball check valve **94** therein. The ball check valve **94** opens when the fluid pressure flows from the chamber **32** to the pressure responsive switch and closes when the fluid flows in the opposite direction. Thus, when the pressure increases in the working fluid chamber **32**, the diaphragm **84** immediately moves to open the contacts **80** and **82**, and when the pressure drops and the fluid drains from the chamber **32**, the ball check valve **94** will close making only the small passageway **90** available for the return of fluid and there will be a substantial delay in the return of the diaphragm **48** to its normal position before the contacts **80** and **82** close. The effect of this operation is to give the piston **10** time to return when the control valve **40** vents the fluid to the return line **44**.

The apparatus **88** provides a time delay for the piston **10** to return in its intake stroke, and the electrical storage means **94** avails a time delay for the piston to move in its compression stroke.

The electrical storage means **94** is shown in the form of a condenser connected across the leads **72** and **74** to the solenoid **70**. When the switch contacts **80** and **82** open to interrupt the flow of current from a battery **96** or the like to the solenoid, the charge on the condenser **94** will maintain the solenoid energized for a short period of time to hold the control valve spool **60** in its position. When the condenser has become discharged the solenoid plunger **66** is released and the valve spool **60** moves to the vent position.

To explain the operation of the time delay devices **88** and **94**, assume that the piston **10** is in its right hand position with the piston extension **36** fully extended into the working fluid chamber **32**. At this point the switch contacts **80** and **82** are closed to energize the solenoid **68** and move the valve spool **60** to the right admitting pressurized working fluid to the chamber **32**. This immediately pressurizes the chamber **32** moving the piston **10** to the left and also immediately pressurizes the pressure switch **76** opening the contacts **80** and **82**. Breaking the circuit through the contacts **80** and **82** will not immediately de-energize the solenoid and it will remain energized until the condenser **94** discharges. This maintains the valve spool in the pressurized position until the piston **10** moves to the end of its compression stroke. By this time the solenoid will have become de-energized and the spring **78** will move the valve spool to the left venting the working fluid pressure chamber **32**. This immediately drops the pressure in the chamber **32** and drops the pressure in the conduit **86** leading to the pres-

sure switch 76. The check valve 94 will close, however, and the slow bleed of fluid within the pressure switch through the passageway 90 will permit a time delay before the contacts 80 and 82 will close. This will give the spring 30 time to push the piston 10 back to the end of its intake stroke. At that time the contacts will close and the valve spool 60 will again move to its pressurized position for the beginning of a renewed cycle of operation.

Although the overall operation of the device will be clear from the foregoing description of the elements and the detailed discussion of the operation of the electrical control for the control valve 40, a summary of operation will be helpful in understanding the objectives and advantages of the invention.

The control switch 40 has the valve spool 60 in the position shown in the drawing when the solenoid 72 is energized by closing of the contacts 80 and 82. This admits pressurized working fluid to the chamber 32, whereupon the piston extension 36 is pushed to the left moving the piston 10 to the left forcing compressed gas through the gas delivery conduit 16 and closing the check valve 20 to the intake conduit. When the piston extension 36 passes the bleeder holes 46, working fluid bleeds into the chamber 48 surrounded by the bellows 26 to act on the area 52 aiding in moving the piston 10 in its compression stroke.

At the end of the compression stroke the condenser 94 will have discharged its stored charge and the de-energization of the solenoid 70 will permit the valve spool 60 to be moved to the left by the spring 78. This will vent pressure from the working chamber 32 permitting the spring 30 to move the piston 10 back through its intake stroke forcing the working fluid out of the fluid chamber 32.

During movement of the piston 10 in either direction the zone 24 outside of the expansible bellows 26 is maintained at a neutral pressure by permitting the gas to flow through conduit 22 into or out of the supply conduit 28.

Thus, it will be seen that I have provided an improved compressor which attains the objectives and advantages hereinbefore set forth. The compressor utilizes an improved electrically controlled valve for supplying the working fluid and operates evenly and smoothly from a working fluid at a higher pressure than the gas to be compressed. The compressor is capable of being assembled into a compact unit and can be located in a small operating space and is reliable and capable of an extended operating life without the need of adjustment or repair.

I have, in the drawing and specification, presented a detailed disclosure of the preferred embodiment of my invention, but it is to be understood that I do not intend to limit the invention to the specific form disclosed, but intend to cover all modifications, changes and alternative constructions and methods falling within the scope of the principles taught by my invention.

I claim as my invention:

1. A gas compression pump and control operator assembly comprising in combination a gas compression chamber, a piston mounted in the chamber for reciprocation in an intake and discharge stroke, valve means communicating with the chamber at a gas side of the piston for intake and delivery of compressed gas, a bellows connecting between a fluid side of the piston and the chamber, a chamber extension projecting into the chamber on the fluid side of the piston, a piston extension slidably positioned in the chamber extension to form a fluid operating chamber, fluid bleed openings communicating between the fluid operating chamber and the interior of the bellows, a control valve communicating with the fluid expansion chamber and adapted to direct a pressurized fluid into the fluid chamber for the compression stroke or to vent the chamber for the intake stroke of the piston, an electrical operating means for the valve, a pressure responsive switch electrically connected to said electrical valve operating means and connected to the fluid operating chamber, a fluid return delay valve connected between the pressure responsive switch and the fluid chamber and operative to retard the breakdown of the pressure in the switch with a reduction of pressure in the fluid chamber to thereby permit the piston to move in its return stroke, spring biasing means moving the piston in its intake stroke, and an electrical condenser connected across the electrical valve operating means and continuing a supply of electricity to the valve operating means after the pressure responsive switch is opened with an increase of pressure in the fluid chamber to thereby allow time for the piston to move in its compression stroke after the pressure has increased within the fluid operating chamber.

2. A fluid operated gas compressor comprising a compression chamber, a piston slidably mounted therein for gas compression by a reciprocating movement, gas valve means communicating with the chamber at the gas side of the piston for the intake of gas and the discharge of compressed gas, fluid valve means communicating with the chamber at the fluid side of the piston to alternately vent and direct a supply of pressurized fluid into the chamber to reciprocate the piston, spring means continually urging the piston to move in its intake stroke, fluid valve operating means connected to operate said fluid valve means to alternate the position thereof and operate the piston, and a pressure responsive means connected to the compression chamber at the fluid side of the piston and responsive to the pressure therein and connected to control the valve operating means to alternate the position of the fluid valve with predetermined pressure change and operate the piston.

3. A fluid operated gas compressor comprising a compression chamber, a piston slidably mounted therein for gas compression by a reciprocating movement, gas valve means communicating with the chamber at the gas side of the piston for the intake and discharge of compressed gas, fluid valve means communicating with the chamber at the fluid side of the piston to alternately vent and direct a supply of pressurized fluid into the chamber to reciprocate the piston, spring means continually urging the piston to move in its intake stroke, electrical means for operating the fluid valve means and periodically alternating its position to admit pressurized fluid to the compression chamber to move the piston in the compression stroke and subsequently relieving the pressure in the chamber whereby said piston will be returned in its intake stroke, and a pressure responsive switch means connected to be responsive to the pressure on the fluid side of the piston connected to the electrical means to operate the valve means and drive the piston.

4. A piston operated compressor comprising a reciprocating piston operable by a pressurized working fluid and movable in a compression stroke and an intake stroke, a chamber in which the piston is slidably mounted, fluid valve means communicating with the chamber and movable between positions to alternately admit pressurized fluid to the chamber to move the piston in its compression stroke or to relieve the pressure and permit the piston to move in its intake stroke, spring means continually urging the piston to move in its intake stroke, electrical means for operating the fluid valve means and periodically alternating its position, and a pressure responsive switch connected to said chamber and electrically connected to said electrical valve operating means to operate the valve and admit fluid to said chamber at low pressure and release fluid from the chamber at high pressure whereby the piston is caused to reciprocate.

5. A fluid operated gas compressor comprising a compression chamber, a piston slidably mounted therein for gas compression by a reciprocating movement, gas valve means communicating with the chamber at the gas side of the piston for the intake and discharge of compressed

gas, fluid valve means communicating with the chamber at the fluid side of the piston to alternately vent and direct a supply of pressurized fluid into the chamber to reciprocate the piston, means for moving the piston in a gas intake stroke when the fluid side is vented, and fluid valve operating means connected to the compression chamber at the fluid side of the piston and responsive to pressure therein, said valve operating means admitting pressurized fluid after a first time delay period after the pressure has dropped in the chamber and venting the chamber after a second time delay period to relieve the pressure after the pressure has increased in the chamber, said first time delay period being a fixed period independent of piston position.

6. A piston operated compressor comprising a reciprocating piston operable by a pressurized working fluid and movable in a compression stroke and an intake stroke, a chamber in which the piston is slidably mounted, fluid valve means communicating with the chamber and movable between positions to alternately admit pressurized fluid to the chamber to move the piston in its compression stroke or to relieve the pressure and permit the piston to move in its intake stroke, means for moving the piston in an intake stroke when the fluid side is vented, electrical valve operating means connected to the fluid valve means for changing its position, a pressure responsive switch connected to said chamber and electrically connected to said electrical valve operating means to operate the valve and admit fluid to said chamber at low pressure and release fluid from the chamber at high pressure whereby the piston is caused to reciprocate, and delay means operative to delay the operation of the fluid valve means after the switch operates at one of said pressures to permit the piston to move its full stroke.

7. A piston operated compressor comprising a reciprocating piston operable by a pressurized working fluid and movable in a compression stroke and an intake stroke, a chamber in which the piston is slidably mounted, fluid valve means communicating with the chamber and movable between positions to alternately admit pressurized fluid to the chamber to move the piston in its compression stroke or to relieve the pressure and permit the piston to move in its intake stroke, means for moving the piston in an intake stroke when the fluid side is vented, electrical valve operating means connected to the fluid valve means for changing its position, a pressure responsive switch connected to said chamber and electrically connected to said electrical valve operating means to operate the valve and admit fluid to said chamber at low pressure and release fluid from the chamber at high pressure whereby the piston is caused to reciprocate, delay means operative to delay the operation of the fluid valve means when the switch operates at a predetermined maximum pressure to permit the piston to move its full compression stroke, and a valve in the connection between the pressure responsive switch and the chamber to delay the drop of pressure in the switch when the pressure in the chamber drops to cause the switch to delay the operation of the fluid valve means to permit the piston to move its full intake stroke.

8. A piston operated compressor comprising a reciprocating piston operable by a pressurized working fluid and movable in a compression stroke and an intake stroke, a working fluid chamber in which the piston is slidably mounted, fluid valve means communicating with the chamber and movable between positions to alternately admit pressurized fluid to the chamber to move the piston in its compression stroke or to relieve the pressure and permit the piston to move in its intake stroke, means for moving the piston in an intake stroke when the fluid side is vented, electrical valve operating means connected to the fluid valve means for changing its position, a pressure responsive switch connected to said chamber and electrically connected to said electrical valve operating means to operate the valve and admit fluid to said chamber at low pressure and release fluid from the chamber at high pressure whereby the piston is caused to reciprocate, delay means operative to delay the operation of the fluid valve by the switch with a first pressure change in the fluid chamber to permit the piston to move a full stroke, and an electrical storage means connected to be charged when said switch is closed and discharging over a relatively short delay period to continue energization of the electrical valve operating means after the switch is opened with a second pressure change in the chamber whereby the piston will complete its second stroke before operation of the valve.

9. A gas compressor assembly comprising a reciprocating piston operable by a pressurized working fluid and movable in a closed compression chamber in which the piston is slidably mounted, gas valve means communicating with the chamber at the gas side of the piston for the intake and discharge of compressed gas, a bellows of smaller cross-sectional area than the chamber connected between the piston and the end of the compression chamber opposite the gas valve means to form a fluid chamber isolated from the compression chamber wall, fluid valve means communicating with the interior of the bellows to alternately vent and direct a supply of pressurized fluid into the bellows to reciprocate the piston, means for moving the piston in a gas intake stroke when the fluid side is vented, and fluid valve operating means connected to the fluid valve means and operative to periodically change the position of the valve to reciprocate the piston.

10. A gas compressor assembly comprising a reciprocating compressing piston operable by a pressurized working fluid and movable in a compression stroke and an intake stroke, a compression chamber in which the piston is slidably mounted, a working fluid chamber, an operating piston extension connected to the compressing piston slidably received by the fluid chamber, gas valve means communicating with the compression chamber at the gas side of the compressing piston, fluid valve means communicating with the working fluid chamber to alternately vent and direct a supply of pressurized fluid into the chamber to reciprocate the compressing piston and operating piston, means for moving the piston in a gas intake stroke when the fluid side is vented, fluid valve operating means connected to the fluid valve means and operative to periodically change the position of the valve to reciprocate the piston, an assist chamber exposed to the compressing piston, and means to supply working fluid to the assist chamber at a predetermined point in the travel of the operating piston whereby the area of the compressing piston exposed to the assist chamber will aid in moving the piston for the remainder of the compression stroke.

11. A gas compressor assembly comprising a reciprocating working piston operable by a pressurized working fluid and movable in a compression stroke and an intake stroke, a tubular member having an elongated inner first working fluid chamber in which the piston is slidably mounted, an elongated closed gas compressing chamber surrounding said tubular member and extending parallel thereto, a compressing piston slidably mounted in the compressing chamber, said compressing piston having a gas side and a fluid side with the working piston connected to the fluid side, a bellows of smaller cross-sectional area than the compressing chamber connected to the fluid side of the compressing piston and to the end of the compressing chamber and surrounding said tubular member to form a second working fluid chamber within the bellows, a conduit communicating between the compressing chamber on the gas side of the piston and the fluid side outside of said bellows and also communicating with a supply of gas, a reverse flow preventing valve in the conduit preventing escape of gas from the compressing chamber on the gas side of the piston, a gas delivery conduit leading from the compressing chamber on the gas side of the

compressing piston, valve means closing the delivery conduit for the intake stroke of the compressing piston, fluid valve means communicating with the interior of the bellows and with the interior of said tubular member to alternately vent and direct a supply of pressurized working fluid into the bellows and tubular member to reciprocate the working piston and drive the compressing piston, means for moving the compressing piston in its gas intake stroke, and fluid valve operating means connected to the fluid valve means and operative to periodically change the position of the valve to reciprocate the pistons.

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