AIR COMPRESSOR OF THE MULTICYLINDER RECIPROCATING TYPE

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2 Sheets-Sheet 1
This invention relates to air compressors of the multi-cylinder reciprocating type in which inlet and delivery passages are provided in each cylinder, each cylinder being controlled by one or more sleeve valves, and has for its object to provide improved means for unloading such compressors.

To this end, in an air compressor of the above type according to the present invention, there is combined with a cylinder group comprising two or more cylinders the movement of the pistons in which have such phase-relationship that the sum of the volumes of the compression spaces of such cylinders remains constant or only varies slightly throughout the cycle of operations, unloading mechanism comprising one or more valves (hereinafter termed unloading valves) whereby the working spaces of the cylinders in such group can be brought into direct communication with one another, and a non-return valve in the delivery passage leading from each cylinder or in a common delivery passage leading from two or more cylinders constituting the group or part of the group. It will thus be seen that when the unloading valve or valves are opened to bring the compression spaces of the cylinders of a group into communication, air will be caused by the pistons in such cylinders to flow backwards and forwards between these cylinders but no air will be delivered, while the non-return valve or valves will close the delivery passage or passages from the cylinders to prevent backflow of air into the cylinders from the delivery passage.

Preferably the action of the non-return valve or valves is such that whereas such valve or valves will be maintained continuously open during normal operation of the compressor in spite of cyclic variations in flow, the non-return valve or valves will close automatically when delivery of air by the compressor ceases, for example when the unloading valves are opened. Thus repeated opening and closing of the non-return valve or valves during normal operation of the compressor is prevented.

The unloading valves may be of various forms but conveniently the unloading mechanism comprises a spring-controlled poppet valve in each cylinder head adapted to move when opening in a direction away from the cylinder. The unloading poppet valves in the heads of the cylinders constituting each group control ports which communicate with a common passage or chamber so that when these poppet valves are opened the working chambers of all the cylinders in each group are brought into direct communication. In such a construction the passage or chamber connecting the ports controlled by the poppet valves conveniently constitutes or communicates with those portions of the normal delivery passages from the cylinders which lie on the side of the non-return valve or valves adjacent to the cylinders.

The means for opening the unloading valves may vary but in one arrangement these valves are adapted to be opened by one or more pistons each disposed within a cylinder and adapted to be acted upon by fluid pressure derived from the receiver or the like to which the compressor delivers air or gas. A single piston may control all the unloading valves for the cylinders constituting each group, or a separate piston may act on each valve, for example in the case of poppet valves by a direct connection between the valve stem and piston. In any case a relay valve may be provided which normally admits atmospheric pressure only to the cylinder or cylinders in which the piston or pistons for controlling the unloading valves act so that these valves remain closed, this relay valve operating automatically to cut off such cylinder or cylinders from atmospheric pressure and permit flow of air under pressure thereto from the receiver so as to open the unloading valves when the pressure in the receiver reaches or exceeds a predetermined value whereby the unloading valves are automatically opened whenever the pressure in the receiver exceeds a predetermined value and are automatically closed when this pressure drops below such predetermined value. Alternatively the arrangement may be such that the unloading valves are automatically opened when the pressure in the receiver exceeds one predetermined value but are not
automatically closed again until the pressure has dropped below some other and lower predetermined value, thus tending to prevent continual opening and closing of the unloading valves.

The invention may be carried into practice in various ways but one construction according to this invention is illustrated by way of example in the accompanying drawings, in which

Figure 1 is a sectional side elevation of a two-cylinder compressor according to this invention,

Figure 2 is a plan partly in section of the engine shown in Figure 1, and

Figure 3 is a section on the line 3—3 of Figure 2.

In the construction illustrated the compressor comprises a crank case A on which is mounted a cylinder block B containing two cylinders having cylinder liners B¹ and surrounded by a water jacket B² having an inlet passage B³ and an outlet passage B⁴.

In the lower end of each cylinder is a plug-like cylinder head D and an annular space D¹ is left between the lower end of each plug-like cylinder head and the upper end of its associated liner B¹ such space constituting the delivery port from the cylinder.

Disposed within each cylinder liner is a sleeve valve E the upper end of which lies around and is closed by the plug-like cylinder head D, packing rings E¹ being provided respectively in grooves in the cylinder head D and in the upper end of the cylinder liner B¹ to prevent escape of fluid between the sleeve valve E and these parts. Each sleeve valve is provided on the one hand with a series of slot-like inlet ports E² adapted to cooperate with the slot-like inlet ports C in the cylinder liner surrounding it and on the other hand with a ring of delivery ports E³ adapted to cooperate with the delivery port D¹. A piston F coupled by a connecting rod F² to a crank shaft F¹ mounted in bearings in the crank case A reciprocates directly with each sleeve, the cranks to which the two pistons F¹ are coupled being angularly displaced by 180°. A combined oscillating and reciprocating movement is imparted to each sleeve by mechanism, known in itself, comprising a crank pin G engaging a self-aligning bearing in a socket E⁴ on the sleeve E and carried by a gear wheel G¹ having a spindle G², the gear wheel G¹ being coupled through an intermediate gear wheel G⁴ to a gear wheel G¹ on the crank shaft F¹. The gearing is such that the gear wheel G¹ rotates at half the speed of the crank shaft F¹.

The arrangement of the ports in the sleeves E is such that the ports E² come into communication with the ports C and the ports E³ come into communication with the delivery port D¹ twice during each cycle of each sleeve valve E. Thus, assuming a valve E to be in the position shown for the valve in the left-hand cylinder of Figure 1, that is to say the position in which the valve has just completed one of the two portions of its movement which are mainly oscillatory and is about to begin that portion of its movement which is mainly reciprocating in an upward direction, this upward movement will first carry the ports E² into communication with the port D¹ so that delivery can take place through the ports E⁴ and D¹ during the last part of the travel of the piston in the upward direction. At the end of the upward movement of the piston, the continued upward movement of the sleeve will carry the ports E³ above the port D¹.

The movement of the sleeve now begins to be mainly oscillatory and this movement will cause the ports E² to be moved across the upper ends of the ports C as the piston descends so that air can be drawn in through the ports E², C. At or towards the end of the downward movement of the piston the ports E² will have been carried completely across and out of register with the ports C and the movement of the sleeve will begin to be mainly reciprocating in a downward direction so that as the piston again ascends the ports E² will move downwards into register with the port D¹ during the end portion of the upward stroke of the piston and will again be carried out of register with these ports when the piston reaches its upper dead centre. The movement of the sleeve will now be mainly oscillatory again and will cause the ports E² to move across the lower ends of the ports C during the subsequent suction stroke of the piston so that air can again be drawn in through the ports E² and C. It will therefore be seen that although the valve E is only operative at half crankshaft speed yet the delivery ports and suction ports are each opened twice during each valve cycle so as to connect the working chamber of each cylinder to the induction belt during each suction and to the delivery chamber during each delivery stroke.

The delivery ports D¹ communicate with annular delivery chambers H and these two chambers H communicate with one another and with a common delivery passage H² as shown in Figure 2. Formed in each plug-like cylinder head D is a port D² which is normally closed by a poppet valve D³ acted upon by a helical spring D⁴ and having a guide D⁵ through which its stem passes. The ports D² communicate with passages H⁵ which also communicate with the annular chambers H and the common delivery passage H². The common delivery passage H² communicates
with a delivery pipe $H_1$ through a non-return valve $H_2$ of the poppet type which is acted upon by a light spring $H_3$ tending to maintain it always closed and is controlled by a dash-pot device comprising a piston $H_4$ at one end of the valve stem having a small leakage passage indicated at $H_5$ and disposed within a cylinder $H_6$ filled with oil. The arrangement is such that the valve $H_2$ will be opened automatically by the pressure of air delivered by the compressor and the dash-pot device $H_6$, $H_7$ will prevent this valve closing under the action of its spring during cyclic variations in the delivery of air, but will permit the valve to close when the delivery of air ceases.

Secured to the upper end of the stem of each valve $D_3$ is a collar $J$ from which extend trunnions $J_1$ which are connected by links $J_2$ to a pivot pin $J_3$ which passes through an intermediate point in a lever $K$ one end of which is pivoted to a bracket $K_1$ on the cylinder head, while its other end bears on the upper end of a piston $L$ which is common to both levers $K$.

The piston $L$ is arranged within a cylinder $L_1$ having an opening $L_2$ at its lower end, a light helical spring $L_3$ acting on the lower end of the piston and serving always to maintain its upper end in contact with the ends of the levers $K$. The cylinder $L_1$ is located within a chamber $M$ partially filled with oil so that the opening $L_2$ is always below oil level and this chamber communicates through a passage $M_1$ with a valve whereby the chamber $M$ can be brought into communication with the atmosphere or with the pressure in the delivery pipe $H_3$ from the compressor.

This valve comprises a cylinder $N$ the lower end of which is connected by a pipe $N_1$ to the delivery pipe $H_3$. Arranged within the cylinder $N$ is a piston $N_2$ having a portion $N_3$ of reduced diameter so as to provide an annular chamber $N_4$ which communicates through a passage $N_5$ in the piston with the atmosphere and, when the valve is in the position shown in Figure 3 also communicates with the passage $M_1$ so that the chamber $M$ and hence the underside of the piston $L$ is subject only to atmospheric pressure. The piston $N_2$ carries a weight $N_3$ at its upper end which normally tends to maintain it in the position indicated in Figure 3, but when the pressure in the delivery pipe $H_3$ exceeds a predetermined value, this pressure will raise the piston $N_2$ so that its lower end uncovers the passage $M_1$ whereby air under pressure from the delivery pipe $N_3$ will be delivered to the chamber $M$ so that this pressure will act on the underside of the piston $L$ and thus raise this piston and thereby act through the levers $K$ to lift both the valves $D_1$.

The operation of the compressor is as follows. During normal operation air will be drawn during each suction stroke of each piston through the inlet ports $E_2$ and $C$ in its associated cylinder, and will be delivered during each delivery stroke through the ports $E_2$ and $D_1$ into the chambers $H$ and thence through the common delivery passage $H_1$ and the valve $H_4$ into the delivery pipe $H_5$. If, now, the pressure in the pipe $H_5$ exceeds a predetermined value, this pressure will act through the pipe $N_4$ on the piston valve $N_2$ so as to raise this piston valve and thereby admit air under pressure through the passage $M_1$ to the chamber $M$. This air will act through the opening $L_2$ on the piston $L$ so as to raise this piston and thereby act through the levers $K$ to open both the unloading valves $D_1$ against the action of their springs $D_3$.

Thus the compression spaces of the two cylinders will be brought, through the passages $H_2$ and the common delivery passage $H_3$, into communication with one another and since the cranks associated with the two pistons $F$ are angularly displaced $90^\circ$, it will be seen that with the two valves $D_3$ open, air will simply be caused to travel backwards and forwards between the compression spaces of the cylinders and no air will be delivered through the valve $H_2$ and pipe $H_3$. The valve $H_2$ will therefore close under the action of its spring so as to prevent back flow of air from the delivery pipe $H_3$ into the common delivery passage $H_3$.

If the air pressure in the delivery pipe $H_3$ drops, owing for example to the consumption of air, the piston valve $N_2$ will again move into the position indicated in Figure 3 so as to bring the chamber $M$ again into communication with the atmosphere. The piston $L$ will now descend under the action of the levers $K$ due to the force of the valve springs $D_3$ whereupon delivery of air by the compressor will again begin, the valve $H_2$ will be opened and the compressor will continue in operation until the pressure in the pipe $H_3$ again exceeds the predetermined value when the compressor will again automatically be unloaded as described above.

It is to be understood that although in the construction illustrated means are provided for unloading the compressor automatically when the compression pressure in the delivery pipe exceeds a predetermined value, the invention is not limited to such an arrangement but that unloading mechanism according to this invention may be operated either automatically or at will. Further, the invention may be applied to multi-cylinder reciprocating air compressors having more than two cylinders and in such cases the unloading may be effected by bringing the compression spaces of all the cylinders of the air compressor into communication with each other by bringing the compression spaces of two or more groups of cylinders into communication, the groups being selected so that the sum of the volumes of the compression spaces of the cy-
inders in each group remains substantially constant throughout the operation of the compressor.

What I claim as my invention and desire to secure by Letters Patent is—

1. A compressor for gas of the multi-cylinder reciprocating type including in combination at least one group of cylinders having inlet and outlet ports therein, each group including at least two cylinders, sleeve valves controlling the inlet and outlet ports, pistons in the cylinders the movements of which have such phase-relationship that the sum of the volumes of the compression spaces of the cylinders in each group remains within small limits the same throughout the cycle of operations, one or more valves whereby the working spaces of the cylinders in each group can be brought into continuous direct communication with one another, and a non-return valve in the delivery passage leading from each cylinder, the non-return valve being so constructed and arranged that whereas it will be maintained continuously open during normal operation of the compressor in spite of cyclic flow variations it will close automatically when delivery of fluid ceases.

2. A compressor for gas of the multi-cylinder reciprocating type including in combination at least two cylinders having inlet and outlet ports therein, each group including at least two cylinders, sleeve valves controlling the inlet and outlet ports, pistons in the cylinders, the movements of which have such phase-relationship that the sum of the volumes of the compression spaces of the cylinders remains within small limits the same throughout the cycle of operations, one or more valves whereby the working spaces of the cylinders can be brought into continuous direct communication with one another, and a non-return valve in the delivery passage leading from each cylinder.

3. A compressor for gas of the multi-cylinder reciprocating type including in combination at least one group of cylinders having inlet and outlet ports therein, each group including at least two cylinders, sleeve valves controlling the inlet and outlet ports, pistons in the cylinders, the movements of the pistons in each group having such phase-relationship that the sum of the volumes of the compression spaces of the cylinders in each group remains within small limits the same throughout the cycle of operations, one or more valves whereby the working spaces of the cylinders can be brought into continuous direct communication with one another, and a non-return valve in the delivery passage leading from each cylinder, and a dashpot so controlling the non-return valve that whereas it will be maintained continuously open during normal operation of the compressor in spite of cyclic variations it will close automatically when delivery of fluid ceases.

4. A compressor for gas of the multi-cylinder reciprocating type including in combination at least two cylinders having inlet and outlet ports therein, sleeve valves controlling these ports, pistons in the cylinders the movements of which have such phase-relationship that the sum of the volumes of the compression spaces of the cylinders remains within small limits the same throughout the cycle of operations, one or more valves whereby the working spaces of the cylinders can be brought into continuous direct communication with one another, and a non-return valve in the delivery passage leading from each cylinder, and a dashpot so controlling the non-return valve that whereas it will be maintained continuously open during normal operation of the compressor in spite of cyclic variations it will close automatically when delivery of fluid ceases.

5. A compressor for gas of the multi-cylinder reciprocating type including in combination at least one group of cylinders having inlet and outlet ports therein, each group including at least two cylinders, sleeve valves controlling the inlet and outlet ports, pistons in the cylinders, the movements of the pistons in each group having such phase-relationship that the sum of the volumes of the compression spaces of the cylinders in each group remains within small limits the same throughout the cycle of operations, one or more valves whereby the working spaces of the cylinders in each group can be brought into continuous direct communication with one another, and a non-return valve in the delivery passage leading from each cylinder.
tion:ship that the sum of the volumes of the compression spaces of the cylinders in each group remains within small limits the same throughout the cycle of operations, a spring-controlled poppet valve in each cylinder head adapted to move when opening in a direction away from the cylinder, the poppet valves in the heads of the cylinders constituting each group communicating with a common passage through which, when these poppet valves are open, the working chambers of all the cylinders in each group are brought into direct communication, a delivery passage leading from the common passage and a non-return valve in this delivery passage.

8. A compressor for gas of the multi-cylinder reciprocating type including in combination at least two cylinders having inlet and outlet ports therein, sleeve valves controlling these ports, pistons in the cylinders the movements of which have such phase-relationship that the sum of the volumes of the compression spaces of the cylinders remains within small limits the same throughout the cycle of operations, a spring-controlled poppet valve in each cylinder head adapted to move when opening in a direction away from the cylinder, poppet valves in the heads of the two cylinders communicating with a common passage through which, when the poppet valves are open, the working chambers of the two cylinders are brought into direct communication, a delivery passage leading from the common passage and a non-return valve in the delivery passage.

9. A compressor for gas of the multi-cylinder reciprocating type including in combination at least two cylinders having inlet and outlet ports therein, sleeve valves controlling these ports, pistons in the cylinders the movements of which have such phase-relationship that the sum of the volumes of the compression spaces of the cylinders remains within small limits the same throughout the cycle of operations, a spring-controlled poppet valve in each cylinder head adapted to move when opening in a direction away from the cylinder, poppet valves in the heads of the two cylinders communicating with a common passage through which, when the poppet valves are open, the working chambers of the two cylinders are brought into direct communication, a delivery passage leading from the common passage and a non-return valve in the delivery passage, and a dashpot controlling the non-return valve so that whereas it will be maintained continuously open during normal operation of the compressor in spite of cyclic flow variations it will close automatically when delivery of fluid ceases.

10. A compressor for gas of the multi-cylinder reciprocating type including in combination at least one group of cylinders having inlet ports and outlet ports therein, the outlet ports communicating with one another through a common delivery chamber, each cylinder group including at least two cylinders, sleeve valves controlling the inlet and outlet ports, pistons in the cylinders in each group the movements of which have such phase-relationship that the sum of the volumes of the compression spaces of the cylinders in each group remains within small limits the same throughout the cycle of operations, one or more valves whereby the working spaces of the cylinders in each group can be brought into continuous direct communication with the common delivery chamber, at least one delivery passage leading from this chamber, and a non-return valve in each of the said delivery passages.

11. A compressor for gas of the multi-cylinder reciprocating type including in combination two cylinders having inlet ports and outlet ports which communicate with a common delivery chamber, sleeve valves controlling the inlet and outlet ports, pistons in the cylinders the movements of which have such phase-relationship that the sum of the volumes of the compression spaces of the cylinders remains within small limits the same throughout the cycle of operations, one or more valves whereby the working spaces of the cylinders can be brought into continuous direct communication with the common delivery chamber, a delivery passage leading from such chamber, and a non-return valve in the delivery passage.

12. A compressor for gas of the multi-cylinder reciprocating type including in combination two cylinders having inlet ports and outlet ports which communicate with a common delivery chamber, sleeve valves controlling the inlet and outlet ports, pistons in the cylinders the movements of which have such phase-relationship that the sum of the volumes of the compression spaces of the cylinders remains within small limits the same throughout the cycle of operations, one or more valves whereby the working spaces of the cylinders can be brought into continuous direct communication with the common delivery chamber, a delivery passage leading from such chamber, and a non-return valve in the delivery passage.

13. A compressor for gas of the multi-cylinder reciprocating type including in combination at least one group of cylinders having inlet and outlet ports therein, the group including at least two cylinders, sleeve valves controlling the inlet and outlet ports, pistons in the cylinders in each group the movements of which have such phase-relationship that the sum of the volumes of the compression...
sion spaces of the cylinders in each group re-
mains within small limits the same through-
out the cycle of operations, one or more of
these spaces whereby the working spaces of the
cylinders in each group can be brought into
continuous direct communication with one
another, a non-return valve in the delivery
passage leading from each cylinder, and
means for automatically opening the unload-
ing valves for bringing the spaces of the
cylinders in each group into continuous di-
rect communication comprising at least one
control cylinder, a piston in each control cy-
ylinder, an operative connection between this
piston and an unloading valve and means for
delivering to each cylinder fluid under
pressure from the receiver to which the comp-
pressor delivers gas.

14. A compressor for gas of the multi-
cylinder reciprocating type including in
combination at least one group of cylinders
having inlet and outlet ports therein, each
group including at least two cylinders, sleeve
valves controlling the inlet and outlet ports,
pistons in the cylinders in each group the
movements of which have such phase-rela-
tionship that the sum of the volumes of the
compression spaces of the cylinders in each
group remains within small limits the same
throughout the cycle of operations, a spring-
controlled poppet valve in each cylinder head
adapted to move when opening in a direction
away from the cylinder, the poppet valves
in the heads of the cylinders constituting
each group communicating with a common
passage through which, when these poppet
valves are opened, the working cham-
ers of the two cylinders are brought into
direct communication, a delivery passage
leading from the common passage a non-
return valve in the delivery passage, and
means for opening the poppet valves com-
prising at least one control cylinder, a pist-
on in each control cylinder, an operative
connection between this piston and a poppet
valve and means for delivering fluid under
pressure to each control cylinder from the
receiver to which the compressor delivers
gas.

15. A compressor for gas of the multi-
cylinder reciprocating type including in
combination at least two cylinders having
inlet and outlet ports therein, sleeve valves
controlling these ports, pistons in the cylin-
ders the movements of which have such phase-rela-
tionship that the sum of the volumes of the
compression spaces of the cylinders remains
within small limits the same throughout the
cycle of operations, a spring-
controlled poppet valve in each cylinder head
adapted to move when opening in a direc-
tion away from the cylinder, the ports con-
trolled by the poppet valves in the heads of
the two cylinders communicating with a
common passage through which, when the
poppet valves are opened, the working cham-
ers of the two cylinders are brought into
direct communication, a delivery passage
leading from the common passage a non-
return valve in the delivery passage, and
means for opening the poppet valves com-
prising at least one control cylinder, a pist-
on in each control cylinder, an operative
connection between this piston and a poppet
valve and means for delivering fluid under
pressure to each control cylinder from the
receiver to which the compressor delivers
gas.

16. A compressor for gas of the multi-
cylinder reciprocating type including in com-
bination at least one group of cylinders hav-
ing inlet and outlet ports therein, the group
including at least two cylinders, sleeve valves
controlling the inlet and outlet ports, pis-
tons in the cylinders in each group the move-
ments of which have such phase-relation-
ship that the sum of the volumes of the com-
pression spaces of the cylinders in each group
remains within small limits the same
throughout the cycle of operations, one or
more valves whereby the working spaces of
the cylinders in each group can be brought
into continuous direct communication with
one another, a non-return valve in the de-

delivery passage leading from each cylinder,
means for automatically opening the un-
loading valves for bringing the compression
spaces of the cylinders in each group into
continuous direct communication comprising
at least one control cylinder, a piston in each
control cylinder, and an operative con-
nexion between this piston and an unloading
valve, and means for delivering to each con-
trol cylinder fluid under pressure from the
receiver to which the compressor delivers gas
comprising a valve which normally admits
atmospheric pressure only to the said con-
trol cylinder but when the pressure in the
receiver reaches a predetermined value acts
automatically to cut off the control cylinder
from atmospheric pressure and permit flow of
gas thereto from the receiver.

17. A compressor for gas of the multi-
cylinder reciprocating type including in com-
bination at least one group of cylinders hav-
ing inlet and outlet ports therein, each group
including at least two cylinders, sleeve valves
controlling the inlet and outlet ports, pis-
tons in the cylinders in each group the move-
ments of which have such phase-relation-
sipship that the sum of the volumes of the com-
pression spaces of the cylinders in each group
remains within small limits the same through-
out the cycle of operations, a spring-con-
trolled poppet valve in each cylinder head
adapted to move when opening in a direc-
tion away from the cylinder, the poppet valves
in the heads of the cylinders constituting
each group communicating with a common
passage through which, when these poppet
valves are opened, the working cham-
ers of the two cylinders are brought into
direct communication, a delivery passage
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valves are opened, the working chambers of all the cylinders in each group are brought into direct communication, a delivery passage leading from such common passage a non-return valve in the delivery passage, means for opening the poppet valves comprising at least one control cylinder, a piston in each control cylinder, an operative connection between this piston and a poppet valve and means for delivering fluid under pressure to each control cylinder from the receiver to which the compressor delivers gas, and means for controlling the flow of fluid under pressure from the receiver in each control cylinder, comprising a valve which normally admits atmospheric pressure only to the said control cylinder but when the pressure in the receiver reaches a predetermined value acts automatically to cut off the control cylinder from atmospheric pressure and permit flow of gas thereto from the receiver.

18. A compressor for gas of the multi-cylinder reciprocating type including in combination at least two cylinders having inlet and outlet ports therein, sleeve valves controlling these ports, pistons in the cylinders the movements of which have such phase-relationship that the sum of the volumes of the compression spaces of the cylinders remains within small limits the same throughout the cycle of operations, a spring-controlled poppet valve in each cylinder head adapted to move when opening in a direction away from the cylinder, the poppet valves in the heads of the two cylinders communicating with a common passage through which, when the poppet valves are opened, the working chambers of the two cylinders are brought into direct communication, a delivery passage leading from the common passage a non-return valve in the delivery passage, means for opening the poppet valves comprising at least one control cylinder, a piston in each control cylinder and operative connection between this piston and a poppet valve and means for delivering fluid under pressure to each control cylinder from the receiver to which the compressor delivers gas, and means for controlling the flow of fluid under pressure from the receiver in each control cylinder, comprising a valve which normally admits atmospheric pressure only to the said control cylinder but when the pressure in the receiver reaches a predetermined value acts automatically to cut off the control cylinder from atmospheric pressure and permit flow of gas thereto from the receiver.

In testimony whereof I have signed my name to this specification.

HARRY RALPH RICARDO.