May 28, 1929. B. S. AIKMAN 1,714,836

MEANS FOR AND METHOD OF COOLING COMPRESSORS

Filed April 2, 1927 3 Sheets-Sheet 1

Fig. 1.

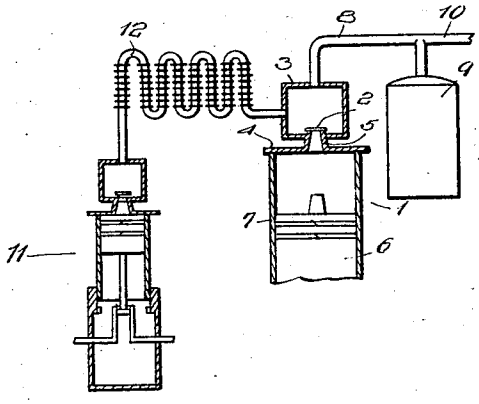


Fig. 2.

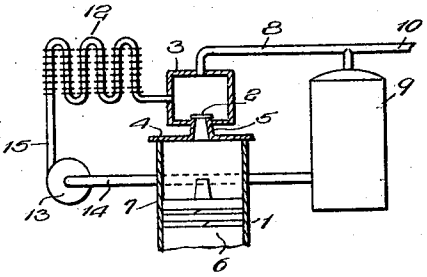


Fig. 3.

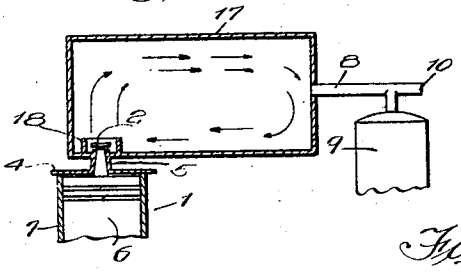


Fig. 4.

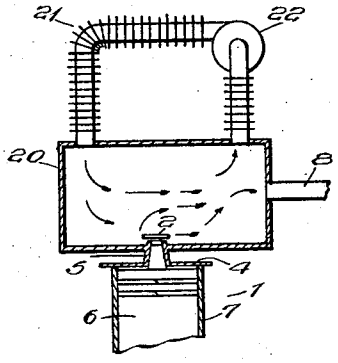


Fig. 5.

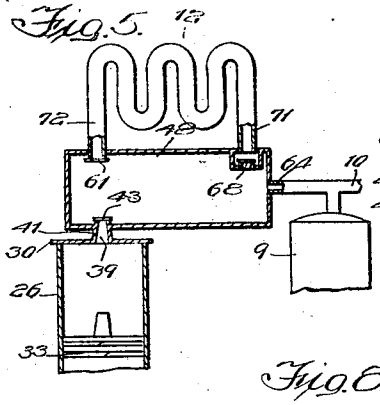


Fig. 6.

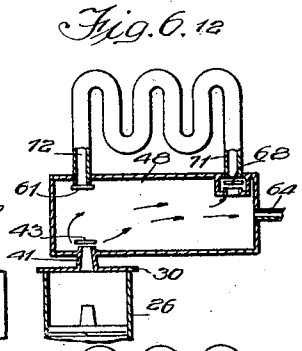


Fig. 7.

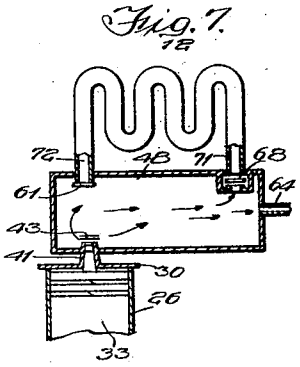
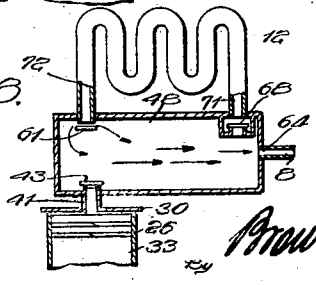


Fig. 8.



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MEANS FOR AND METHOD OF COOLING COMPRESSORS

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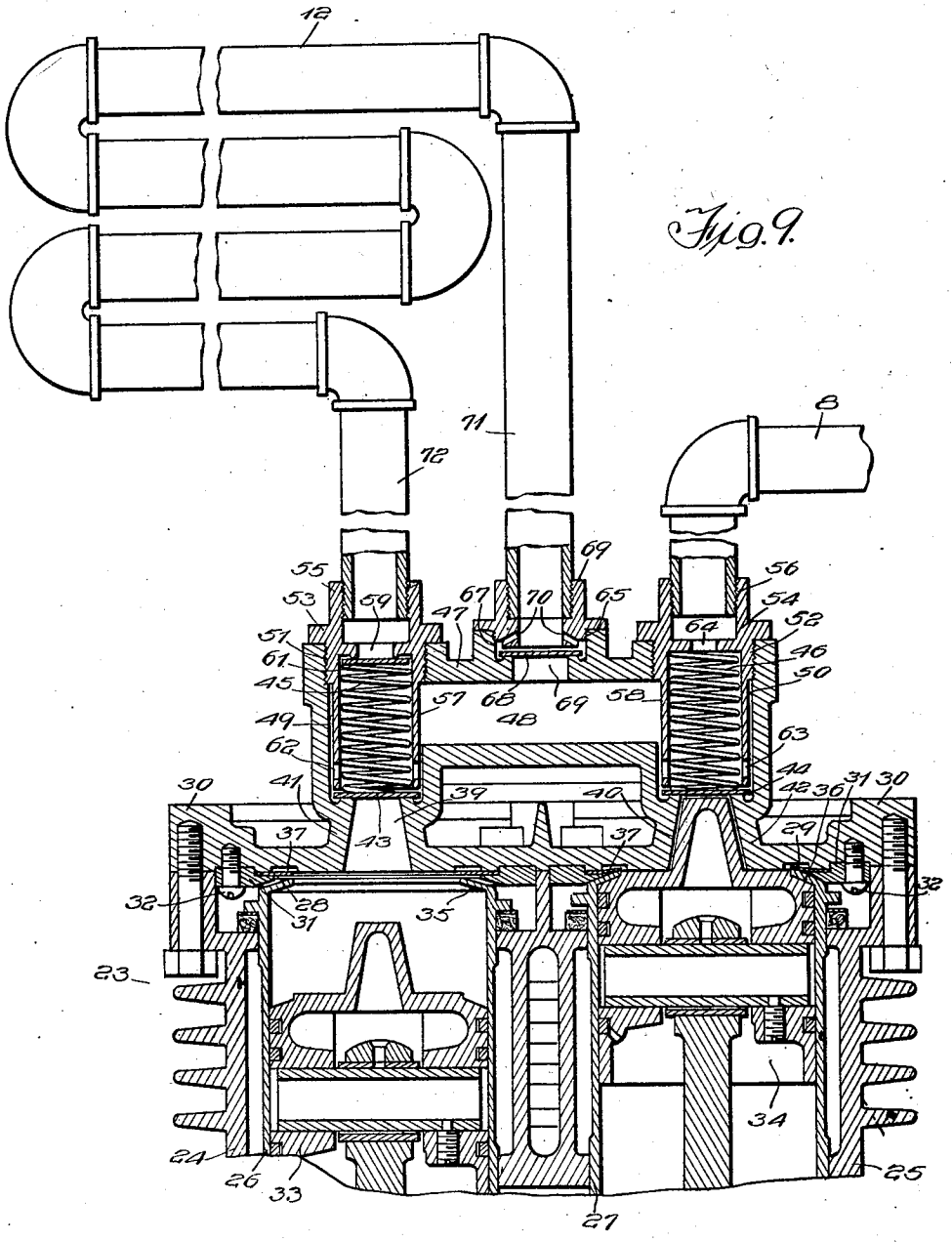


Fig 9.

Witness:
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May 28, 1929. B. S. AIKMAN 1,714,836

MEANS FOR AND METHOD OF COOLING COMPRESSORS

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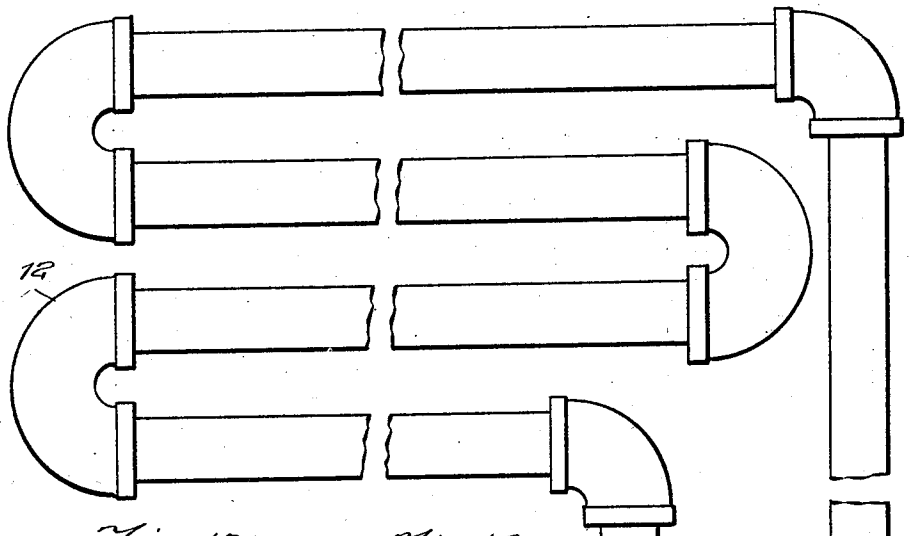


Fig. 12.

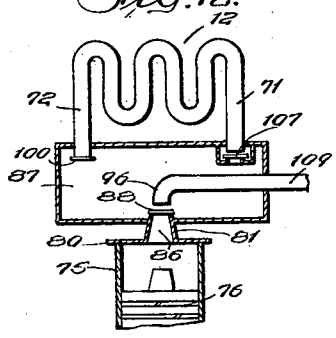


Fig. 11.

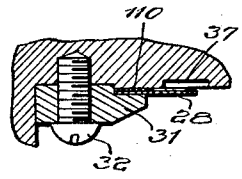
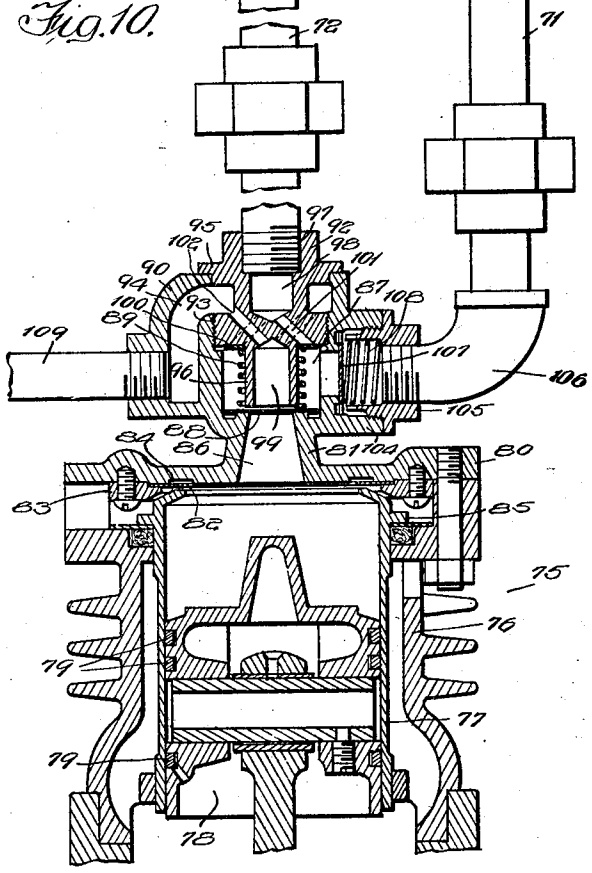


Fig. 10.



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Patented May 28, 1929. 1,714,836

UNITED STATES PATENT OFFICE.

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MEANS FOR AND METHOD OF COOLING COMPRESSORS.

Application filed April 2, 1927. Serial No. 180,433.

My invention relates to air compressors and more particularly to a method of and means for controlling the temperature of the same.

In the development of a high speed compressor there are a number of limitations which must be overcome. If it is attempted to speed up the conventional compressor the first thing which is encountered is a drop in volumetric efficiency due to imperfect valve action and other causes. This may be overcome at least in part, by mechanically actuated valves one form of which is shown in the Westinghouse-Berceuse compressor.

In my prior Patent No. 1,611,866 I have shown a sleeve valve actuated by ring friction which in addition to giving an exceptionally quick and sharp valve action provides a large valve opening and unusual opportunity for cooling by scavenging the cylinder during the intake stroke and also for supercharging the cylinder.

The compression is substantially adiabatic. This means that the head and the upper end of the cylinder walls are exposed to the maximum temperature of compression during only about one third of the time so that by the provision of the above valve action and forced air pressure cooling the head and upper cylinder walls may be kept from gaining too high a temperature from contact with the gases during compression. However, the discharge valve and pocket are in constant contact with the hot discharge gases.

In my Patent No. 1,632,262 I have shown how the hot compressed gases in the discharge valve pocket may be removed substantially from thermal relation to the head of the compressor. This prevents to a large degree the backward flow of heat from the discharge valve pocket to the cylinder head and walls. It does not prevent the contact of the hot gases with the discharge valve itself and the valve seat. Hence when the compressor is run at a high speed there is a tendency for the heat of the gases in the discharge valve pocket to carbonize the oil which is carried over with the discharged air. As a result the discharge valve does not remain tight. Also the heat may injure the discharge valve and cause it to break. It is possible to limit the temperature rise by the use of a cooling agent but in many cases cooling water is not available or is too expensive and air as a cooling medium is inadequate except at too great a cost.

In accordance with the present invention I provide means for cooling the compressed gas in the exhaust valve pocket. By this means the only serious remaining condition limiting the continuous operation of a compressor at full motor speed, i. e., as high as 1800 R. P. M. is relieved and a compressor made and operated according to my invention can be operated continuously without danger of deterioration of the parts or of the lubricating oil.

The theory upon which my invention is based is that by diluting the hot compressed gases with a cooling fluid at substantially the same pressure it is possible to hold down to a safe temperature the gases in the discharge valve pocket. In the preferred form of my invention I inject cool compressed air but obviously a liquid or other media might be employed.

The gases as they leave the valve pocket are preferably discharged into a receiver from which they are led through the distributing pipes to the various points of release or consumption. The overall rate of consumption is less than the delivery rate of the compressor. The gas is delivered from the cylinder of the compressor in impulses, or strokes, which for instantaneous values, exceed the average delivery rate of the compressor. According to the prefered embodiment of my invention I employ the difference between instantaneous rates of flow of the delivery impulses and the average rate of consumption to perform one or both of two useful functions, first of which is forced mixing or dilution of the gas delivered during the impulse or a portion of the same with other gases in the discharge pocket or system, and the second is a movement of a part of the gases of each impulse through a predetermined path in at least a part of which a heat loss is caused to occur.

In an early form of my invention I provide a large valve pocket in the form of a tank mounted directly upon the neck of the discharge passage. This tank is so large that heat is radiated or carried off from the walls thereof fast enough to keep the gases in the same at a safe temperature. The incoming hot impulse of gases set up an agitation and mixing of the same with the cooler contents of the tank or valve pocket so

that the average temperature is within safe limits. The mixture is discharged in part to the points of consumption but the remainder in the valve pocket tank throws off enough heat before the next stroke impulse to provide the diluting cooling medium.

According to the preferred form I divide such enlarged pocket into functionally separable parts so as to increase the effectiveness of each for performing its function. In order to improve the heat radiating or heat dissipating function I form one part as a length of relatively small diameter pipe or tube, and cause at least a part of the compressed gases discharged from the cylinder to pass therethrough. As compared with the enlarged tank of my earlier form, this pipe is far more efficient in throwing off heat, because of the greater ratio of surface to cubical contents, because of the ability to utilize thin walls, and because of greater speed of gas travel in contact with said walls.

Another part is a receiving and mixing chamber communicating with the cooling pipe and in conjunction with these two parts I provide flow directing means for directing the flow of the hot compressed gas into the cooling pipe and controlling such flow so as to mix the same with some of the cooled gas which has passed through said pipe.

The volume of these parts is so related to the displacement of the cylinder that the charge of gas discharged upon each stroke will cause sufficient increase in pressure in the chamber to create the desired circulation.

According to my invention the heat of the gases is dissipated at a point remote from the discharge valve and remote from the cylinder head or walls, so that the temperature of these parts will not build up to a dangerous point but instead will remain cool. Obviously, the internal cooling thus effected may be supplemented by other cooling means, for example, in the preferred form of my invention I cool the cylinder walls, head and the mixing chamber, part of the discharge chamber with an air blast as shown in my aforesaid Patent No. 1,611,866 or I may cool the head and neck of the discharge passage and also the mixing chamber with a water jacket or water bath.

In addition to the above improvements my present invention includes an improved valve seat for cooperation with the upper end of the sleeve which forms the intake valve. In the earlier forms of my invention I provided a seat formed of a ring of solid but yielding material set in the bottom of the cylinder head. According to the present invention I provide a thin metallic plate in the form of an annular ring the outer edge of which is mounted on and sealed to the head. The inner edge is free and overhangs a recess communicating with the compression space of the cylinder. The internal flange of the sleeve engages the free margin of said plate. These two flanges are thereby held substantially in equilibrium by the pneumatic pressure regardless of the absolute value of the same while the tightness of the joint is insured by the opposing pneumatic pressures in addition to the normal ring friction.

Unloading is generally unnecessary for starting the compressor of my invention because if leakage of its discharge valve should occur, the pressure of the gas in the cylinder opens the intake valve by pushing down the piston and it, by ring friction, immediately opens the sleeve valve, hence the compressor cannot start overloaded.

Now in order to acquaint those skilled in the art with the manner of constructing and operating a device in accordance with my invention I shall describe in connection with the accompanying drawings a specific embodiment of the same.

In the drawings:

Figure 1 is a diagram of elementary means and mode of operation for practicing my invention;

Fig. 2 is a diagram of a development of the same;

Fig. 3 is a diagram of a modified embodiment of my invention;

Fig. 4 is a similar diagram of a further modification;

Figs. 5, 6, 7 and 8 are diagrams showing the mode of operation of the mechanism disclosed in Fig. 9;

Fig. 9 is a vertical longitudinal section through the upper ends of the cylinders, the discharge valve pockets and valves of an embodiment of my invention;

Fig. 10 is a similar section of a modified form of my invention;

Fig. 11 is an enlarged sectional view through the intake valve structure showing a modified form of the same; and

Fig. 12 is a diagram illustrating the operation of the device shown in Fig. 10.

Referring now to Fig. 1, I have shown the compressor 1 as provided with a discharge check valve 2 in a discharge check valve chamber or pocket 3 separated from the head 4 by the hollow neck 5. The piston 6 reciprocates in the cylinder sleeve 7 which forms the intake valve in conjunction with the head 4 all as disclosed in my co-pending Patent No. 1,632,262, of June 14, 1927. From the discharge valve chamber 3 the discharge pipe 8 leads to the usual reservoir 9 and to the distributing main 10 which leads to the point of consumption or release of the compressed air.

By the improvement disclosed in said co-pending application and the use of the sleeve valve as disclosed in my aforesaid prior patent, I have found it possible to operate the compressor without undue heating of the

cylinder head and cylinder walls including the intake sleeve valve 7 so that the compressor may be operated continuously at high speed. However, the hot gases in the discharge valve chamber 3 heat the walls of said chamber and the discharge check valve 2 to such a high temperature that the oil which is carried over in the air from the cylinder is carbonized and deposited upon the discharge check valve 2 resulting in leakage and further heating and in some cases resulting in deterioration and leakage of the valve 2 due to the heating and carbonization of the oil.

If it is attempted to operate the compressor with very little lubricating oil, so as to carry a minimum over into the discharge check valve 3, difficulty is encountered because insufficient lubrication of the piston and cylinder results in heating of those parts.

I have conceived the novel step of injecting a cooling medium directly into the discharge check valve chamber in a compressor of this character, or, in a compressor of any character in which the difficulty due to heating arises.

In most compressors of the prior art the discharge valve chamber is mounted directly upon the head and this accentuates the difficulty of the transmission of heat from the hot gases back to the cylinder head and thence to the walls.

But my proposed novel step of injecting a cooling medium directly into this discharge check valve chamber, overheating is avoided.

The injection of a cool medium, such as cold compressed air or suitable gas, or even a liquid such as water, may be performed by any suitable apparatus.

In the present case I have shown another compressor 11 of smaller size assume, for example, of one-half the displacement of the compressor 1, arranged to deliver compressed air therefrom through a heat radiator or heat dissipating device 12 so that the air from the compressor 11 is cooled in its passage from the compressor 11 to the discharge check valve chamber 3 of the main compressor 1.

In such case, the small compressor 11 presents the difficulty of cooling, although this might be accomplished by means of cooling water which would be much less than required to cool the compressor 1 in view of the large amount of heat which may be thrown off at the radiator 12.

The discharge pipe from the radiator 12 opens into the discharge valve chamber 3 of the main compressor 1 and the cold air which is injected into said chamber dilutes and cools the compressed air from the main compressor with the result that the temperature never builds up inside the chamber to a dangerous point.

The compressor 11 may be of the same character as the compressor 1 in details of construction or it may be of any preferred form, or, if a medium other than a compressible gas is employed, it may constitute a pump for liquid.

I believe it is broadly new to inject such a cooling fluid medium directly into the discharge valve chamber of a compressor.

Instead of having a separate compressor to raise the cooling medium to the desired pressure, I may take compressed air or other gas previously compressed, cool the same and inject the cooled gas into the discharge valve chamber.

Thus, for example, in Fig. 2 I provide a pump or blower 13 which is connected by an intake pipe 14 with the compressed air receiver 9 and a discharge pipe 15 leading to the radiator 12 which in turn discharges into the discharge check valve chamber 3. By this construction the compressor 1 discharges gas at a suitable discharge pressure into the chamber 3 from whence it is led through pipe 8 to the receiver 9. The gas may to some extent be cooled in transit from the chamber 3 to the receiver 9 but the gas in the pocket 3 naturally is at a maximum temperature. I then take gas from the receiver 9 at the compression pressure to the pump or blower 13 and by means of the pump or blower 13 impel or drive the same through the radiator 12 to cool the same and then discharge it into the discharge valve chamber 3. By this means a continuous circulation of compressed gas is maintained and due to the dissipation of heat at the radiator 12 the compressed gas in the discharge valve chamber 3 is reduced to a suitable temperature below the danger point.

Since the gas which performs the cooling function in Fig. 2 is a part of the original compressed gas circulated so as to be cooled and mingled with the hot charge of gas delivered from the cylinder 7 at each stroke of the compressor, I have conceived the possibility of creating such circulation within the discharge valve chamber itself making the discharge chamber of sufficient volume as shown in Fig. 3 and of sufficient superficial cooling surface to throw off heat to the surrounding medium rapidly enough to maintain the temperature in the chamber 16 below the danger point. As shown in Fig. 3 I mount a relatively large tank, which may be sufficiently large to take the place of the usual receiver, directly on the cylinder head 4 connecting the same to the top of the neck 5. The discharge check valve 2 is surrounded by a deflector 18 causing the gases discharged from the cylinder 7 to be directed upwardly to the top of the tank 17 in the same direction in which they would naturally arise due to difference in temperature. The superficial area of the tank 17 is great

enough to cause a cooling of the gases in contact therewith and as a result of the injection of the impulse or charge of gases from the cylinder 7 at a particular stroke of the piston 6 the incoming charge of gas is caused to create a circulation within the tank 17 so that said incoming charge of hot gases is mixed with cooler gases and diluted thereby to a sufficient degree to hold the temperature of the mass below the danger point. If a separate receiver 9 is desired it may be employed but the tank 17 may serve both as the valve chamber and the receiver and in small units it is entirely practical to mount the tank thus directly on the head and thereby secure cooling of incoming impulses of gases directly in said tank and use said tank at the same time as a reservoir or receiver. In larger sizes or capacities of compressors it is obvious that since the volume increases as the cube of the dimension of the tank whereas the surface increases only as the square of the same, the tank becomes unwieldy and I propose therefore in accordance with the next step of development, to divide the tank into two parts according to the two functions.

Accordingly, I reduce the volume of the tank which forms the discharge valve chamber to any suitable size and provide a cooling pipe or conduit 21 in which a circulation or flow is maintained by means of a blower or pump 22 the cooling pipe 21 being provided with sufficient surface to dissipate the required amount of heat for maintaining the contents of the chamber 20 well below the danger point in temperature.

In this case the disadvantage is the maintenance of the pump or blower 22 to maintain the circulation.

I have conceived as the next step of my development that this circulation may be maintained by the velocity or pressure of the incoming charge itself.

An embodiment of this principle of operation is shown in Fig. 9 and is shown diagrammatically in Figs. 5 to 8 inclusive.

I shall first describe the actual structure which I have employed and which is shown in Fig. 9 and shall then explain the mode of operation in connection with the diagrams of Figs. 5 to 8 inclusive.

In Fig. 9 I have shown a two-cylinder compressor 23 of the type disclosed in my above mentioned patent and for the sake of simplicity have omitted the crank case and crank. The compressor 23 includes the cylinders 24 and 25 provided with suitable radiating fins and provided with intake valve sleeves 26 and 27 mounted for a short reciprocating movement in said cylinders 24 and 25 and cooperating with valve seats 28 and 29 held against the bottom of the head 30 by suitable clamping rings 31, 31 and screws 32.

The sleeve valves 26 and 27 constitute, at the same time, the active cylinder walls in which the pistons 33 and 34 move, these pistons having suitable metal, or the like, packing rings for maintaining compression and which serve by their friction to shift the sleeves 26 and 27 as explained in my aforesaid patent. The valve sleeves are provided at their upper ends with inturned flange members 35, 36 which cooperate with the yielding seats 28 and 29 to form a tight closure for the cylinder upon the compression stroke.

The yielding seats 28 and 29 are composed of rings or annular plates of thin relatively resilient metal, the outer edges of which are clamped by the rings 31 against the adjacent surface of the cylinder head, the inner edges of these rings being relatively free and overlying small annular depressions or grooves 37 closed at their outer edges by the edges of the rings 28, 29 and open at their inner edges into the interior of the cylinder. It will be observed that by this means when the piston is on the compression stroke the sleeve valve is closed against the yielding seat 28 or 29 as the case may be, the internal pressure within the cylinder acts both upon the flange of the valve sleeve and upon the back of the yielding metal ring which forms its seat. In this manner a relatively large but substantially balanced force is secured to maintain a tight closure of the valve against its seat. Preferably, the internal diameter of the valve sleeve is slightly greater than the external diameter of the groove 37 so that there is a slight component upon the sleeve valve to hold it against its seat in excess of the pressure acting upon the back of the yielding valve seat.

The head member 30 is preferably a one-piece casting provided with the two discharge passageways 39 and 40 formed thru the necks 41 and 42 respectively.

Valve seats are formed at the upper ends of the passageways 39 and flat disc check valve 43 and 44 are held upon the seats by compression springs 45 and 46.

The two necks 41 and 42 are joined by an integral casting 47 in which there is formed the chamber 48 at the center and chambers 49 and 50 at the ends thereof.

The casting 47 is provided with threaded sockets 51 and 52 into which are threaded sleeve members 53 and 54 providing pipe sockets 55 and 56 at their upper ends and having extended barrels 57 and 58 at their lower end respectively.

Intermediate the socket 55 and at the upper end of the barrel 57 there is provided a port 59 surrounded by the valve seat and served by a disc valve 61 pressed to its seat by the spring 45.

At its lower end the barrel 57 is provided

with perforations 62. These barrel members 57 and 58 fit closely in the chambers 49 and 50 so as to leave a thin annular space between them and the wall of the casting 47. The perforations 62 in the sides of the barrel 57 are disposed below the point at which the central chamber 48 joins the end chamber 49.

Likewise, the barrel 58 fits closely the walls of the chamber 50 leaving a thin annular space between them and perforations 63 establish communication between the inside of the valve 58 and said thin annular space. The perforations 63 are likewise disposed below the point at which the chamber 48 joins said end chamber 50.

A relatively restricted passageway 64 is formed through the central part of the sleeve member 54 to establish restricted communication between the delivery pipe 8 and the interior of the barrel 58. A separate restricting member is not necessary as the pipe 8 may be of sufficient length or sufficiently small to provide such resistance to flow as will let the impulses of pressure in the chamber 48 rise to a value that will open the valve 68 and force air through the radiator 12.

The casting 47 has preferably at its center, another pipe socket 65 in which there is threaded a sleeve member 66, this sleeve member extending down into a valve pocket 67 in which there is disposed the flat disc check valve 68 seating on a suitable valve seat at the bottom of said valve chamber 67 over a port 69 which communicates with the chamber 48.

While the end of the sleeve member 66 extends in close proximity to the disc valve 68, passageways 70 extend through the side walls of the same into the valve pocket 67 so that although the valve 68 might be raised against the end of the sleeve 66 communication between the pipe 71 and the valve chamber 67 is not interrupted.

The pipe 71 forms the inlet to the radiator coil 12 and pipe 72 forms the outlet of the same.

The valve 68 is designed to lift at a small difference of pressure between the interior of the chamber 48 and the interior of the pipe 71.

I shall now described in connection with Figs. 5 to 8 the fundamental operation involved in this embodiment.

Assume in Fig. 5 that the piston 33 is at the bottom of its stroke and just beginning to compress the charge of air or other gas in the cylinder 26 driving the same up past the discharge check valve 43 into the chamber 48. Assume that the parts are started cold and that any desired pressure prevails in the chamber 48 in the radiator 12 connected thereto and in receiver 9 from which the delivery pipe 10 leads to the point of consumption.

The capacity of the compressor is always made greater than the mean rate of consumption in a properly designed installation. The discharge of gases begins to occur as shown in Fig. 6 as the piston 33 reaches the position where the gas in the cylinder is compressed to a point great enough to overcome the back pressure on the check valve 43 and the check valve 43 is lifted and gas under a higher pressure than that prevailing in the chamber 48 is discharged thereinto.

The construction 64 in the delivery passageway to the pipe 8 offers a slight obstruction to flow so that there is a tendency for the pressure to build up in the chamber 48 more rapidly than would otherwise be the case. This constriction 64 is not strictly necessary but it assists in the operation desired and the obstruction which it offers is only to the peak rate of flow of gas therethrough and it forms no appreciable restriction to the normal rate of flow such as the piston is designed to have under normal consumption of compressed air. As a result of the pressure building up in the chamber 48 some of the pressure naturally passes through said constriction and to the receiver 9 tending to raise the pressure in the same and in the delivery system. Another part of the charge of gase delivered by the piston thereupon raising the check valve 68 leading to the pipe 71 and to radiator 12 and causing a flow of a part of the charge into the radiator 12 as shown in Fig. 7.

The flow occurs through the check valve 68 which readily opens on a slight difference in pressure. The check valve 61 faces in the same direction and it therefore prevents flow of compressed gas into the radiator through the pipe 72. As a result, at the end of the stroke the chamber 48 and the inlet end of the radiator 12 are charged with hot gas under pressure. When the piston has passed the top of its stroke the check valve 43 closes and the suction stroke occurs.

Thereupon due to the continued flow of gas from the chamber 48 through the restriction 64 to the receiver 9 and to the delivery pipe 10, the pressure in the chamber 48 drops below the pressure in the radiator 12 with the result that there is a discharge of pressure from the cold end of the radiator 12 into the chamber 48 so that a dilution and mixing of the cold air delivered by the radiator 12 with the hot air in the chamber 48 occurs.

The proportions shown in the diagrams are not accurate since it is desirable to have the capacity of the radiator 12 greatly in excess of the chamber 48 so that a relatively large volume of gas will be exposed to cooling in the radiator 12 and hence, a consider-

able proportion of the volume of each stroke will pass through said radiator. This, of course, is a matter of design, the desideratum being to pass sufficient air through the radiator to secure the necessary cooling and dilution to maintain the temperature of the chamber 48 and connected part below any dangerous value.

While the above diagrams give a simplified picture of what occurs in the structure of Fig. 9, I wish to call attention to the fact that Fig. 9 embodies certain refinements of operation and certain details of structure omitted in the diagram which are, however, of advantage in the operation of the device.

In the operation of the specific structure shown in Fig. 9 assume that the piston 34 has just completed its discharge stroke. During its discharge stroke the valve 44 was lifted against the bottom of the extending barrel 58 and the gas, under compression in the charge delivered by the piston, flows partly around the barrel 58 and into the chamber 48 and partly through the opening 63 into the interior of the barrel 58 up through the restricted opening 64 and to the delivery pipe 8.

The compressed gas which flows into the chamber 48 lifts the check valve 68 and passes up through the pipe 71 into the radiator 12. As the piston 34 has completed its stroke it descends on the suction stroke and the piston 33 begins to rise.

During the time that the piston 33 is rising and increasing the pressure in its cylinder to the desired delivery pressed, compressed air flows through the delivery pipe 8.

During this time that the piston 33 is raising the pressure in its cylinder to the discharge pressure, there is an outflow of compressed gas through the pipe 8 to supply the demand or to equalize pressures between the chamber 48 and the delivery system, including the reservoir or receiver 9. The relatively large volume of compressed gas in the radiator 12 and connected pipe which was charged to the maximum prevailing in the chamber 48, or substantially said pressure, tends at once to equalize with the pressure in the chamber 48 and to do so it opens the discharge check valve 61 from the port 59, cold or relatively cold compressed air then passing down through the barrel 57 and emerging through the opening 62 into the narrow space in close contact with the walls of the chamber 49 so as to cool the same effectively. Thus, the radiator 12 operates between impulses to deliver relatively cold compressed air into the discharge valve pocket to supply the demand of the system in parallel with the receiver 9. The cooled air after its discharge from around the barrel 57 passes through the chamber 48 and then passes down between the barrel 58 and the adjacent wall of the chamber 50 through the opening 63 up through the barrel 58, through the constriction 64 and out to the delivery pipe 8. In this manner the variations in pressure in the chamber 48 are employed to create a circulation of sufficient of the air of each impulse of hot compressed gases to keep the discharge valve chambers and the connected head at a temperature below the danger point.

Obviously, additional cooling means such as a blast of air or a water jacket may be employed without departing from the spirit and scope of this invention.

It is to be observed that in the embodiment shown in Fig. 9, a part only of the hot impulse per stroke is passed through the radiator 12. In Fig. 10 I have shown an embodiment in which all of the air of per stroke is passed through the radiator to cool the same.

The theory of the device is diagrammatically illustrated in Fig. 12.

Referring now to the structure shown in Fig. 10, the compressor 75 is shown as provided with the cylinder 76 having a suitable admission sleeve valve and cylinder liner 77 in which the piston 78 is reciprocated, this piston having suitable piston rings 79 which by their friction serve to shift the sleeve valve 77. The cylinder 76 has the head 80 bolted thereto and the head 80 has the plate valve seat 82 secured to the bottom face of the same by means of the clamping ring 83, this plate valve seat having its inner rim extending over a groove 84 in the same manner as disclosed in connection with Fig. 9. The valve sleeve 77 has a collar or ring 85 formed thereon to engage a suitable stop at the top of the cylinder for limiting the downward motion of the valve sleeve.

The head 80 has a discharge passageway 86 formed through the neck 81 leading to a discharge valve chamber 87, a discharge check valve 88 in the form of a small disc valve seating over the port formed at the upper end of the passageway 86. A suitable coil spring 89 tends to seat the check valve 88. The chamber 87 is formed in a casting 90 which is an extension of the neck 81 and a plug fitting 92 being threaded down into a threaded socket 93 to close the top of the chamber 87. The casting 90 embodies the chamber 94 adjacent to and partly surrounding the chamber 87. The upper end of the chamber 94 is closed by a flange 95 on said fitting 92 and the fitting being threaded into the socket 93 and having a barrel 96 extending down in close relationship with the disc check valve 88. The end of the barrel 96 is so close to the valve 88 that when the valve is raised it closes off the end of the barrel 96.

The fitting 92 has a pipe socket 97 in the upper end thereof and a main drill passageway 98 extending down to a point adjacent the drill passageway 99 in the

barrel member 96. The barrel member 96 forms a guide for an annular plate valve 100 which annular plate valve seats over the ports 101 which are diagonal drill holes extending from the drill passageway 98 to the chamber 87. The spring 89 is guided on the barrel 96 and serves the dual purpose of holding the check valve 88 on its seat and the check valve 100 likewise, on its seat over the passageway 101.

The drill passageway 99 in the barrel 96 communicates with the chamber 94 through one or more passageways 102.

The body or casting 90 has a boss 104 provided with a pipe socket in which is fitted a plug or thimble 105, this thimble being in turn, threaded to receive the pipe connection, in this case, the elbow 106. The hollow boss 104 has a valve passageway 10 formed therethrough communicating with the chamber 87 and this passageway is controlled by a suitable check valve 107 held to its seat in the inner end of the bore of the boss 104 by a spring 108.

In this manner the pipe 71 which leads to the inlet end of the radiator 12 communicates with the check valve chamber 87 through the check valve 107. Likewise, the pipe 72 which is on the delivery end of the radiator 12 communicates with the chamber 87 through the ring check valve 100. The check valve 88 which is the discharge check valve for the compressor 75 plays between the barrel 96 which in reality is the inner end of the air delivery pipe 109, and it seats on the upper end of the passageway 86.

The fundamental operation of this embodiment is illustrated in the diagram of Fig. 12. It can be seen that when the piston 76 drives a charge of compressed air into the chamber 87 the check valve 88 is raised and is held over the lower end of the barrel 96 which is, in reality, the inner end of the delivery pipe 109. The charge of compressed air which is then delivered into the chamber 87 is discharged through the check valve 107 into the pipe 71 and thence into the radiator 12 which comprises a relatively large volume.

As soon as the piston has reached the top of its stroke and compression ceases, the valve 88 is again seated over the port 86 opening the lower end of the barrel 96 and therefore opening the air delivery pipe to permit the compressed air previously discharged from the cylinder into the chamber 87 and into the radiator 12, to pass out through the barrel 96 and pipe 109 to the rest of the system.

During the delivery stroke of the compressor the air which did not pass out the pipe 109 is charged into the relatively small chamber 87 and from thence it passes through the check valve 107 which opens up into the radiator 12 to charge the radiator with the hot compressed gas. This flow occurs through the check valve 107 and pipe 71 to the radiator 12, the check valve 100 preventing flow through the pipe 72 from the chamber 87. After the delivery of the individual charge at the end of the discharge stroke of the compressor cylinder, the valve 88 is forced down by the spring 89 over the end of the passage 86 and at the same time opening fully the lower end of the barrel 96 so that the compressed gas in the chamber 87 can pass out through the delivery pipe 109. This lowers the pressure in the chamber 87 and as a consequence, the check valve 100 opens up and the gas contained in the radiator 12 expands and the cool gas passes through the pipe 72 through the passageways 101 past the check valve 100 into the chamber 87 surrounding the barrel 96 and under the end of said barrel and up through the drilled passageway 99 and the diagonal passageways 102 into the external chamber 94 and from thence to the delivery pipe. As a result of this inflowing of cold air from the pipe 72 the discharge check valve chamber is scavenged of hot compressed gas and is cooled by a flow of relatively cold compressed gas therethrough.

The check valve 88 may be made to seat tightly over the lower end of the barrel 96 if desired, and thereby all of the gas or substantially all of the gas delivered by the compressor is passed through the radiator 12 before it is discharged through the delivery pipe 109.

Any tendency for the valve 88 to stick on the bottom of the barrel member 96 may be overcome by the relatively larger area of the valve than the area of the lower end of the barrel 96 and also, if desired, a small leakage port may be formed through the barrel member 96 to tend to equalize pressure inside and outside of the barrel 96 in the chamber 87. It will be seen that the cold gas is delivered directly in contact with the parts which are subject to contact with the hot gases so that a complete cooling and scavenging of the hot pocket is secured.

In Fig. 11 I have shown a form of ring seat in which, in addition to the plate 28 forms the actual contacting seat for contact with the flange of the valve sleeve, I provide a spring backing ring 110 which has radial slots cut therein to form fingers to give the plate 28 spring backing substantially uniformly around its inner periphery.

This form of the valve seat has the same advantages heretofore recited.

The form of the invention herein shown in Fig. 3 is claimed in a separate application, Serial No. 181,104, filed Apr. 5, 1927.

I do not intend to be limited to the details shown or described.

I claim:

1. The method of limiting the temperature

rise of the exhaust valve of a compressor which comprises mixing the hot gas delivered past said valve upon the compression stroke of the compressor with cool gas at substantially the same pressure.

2. In a compressor having a discharge valve and valve chamber the method of limiting the temperature rise of the valve and valve chamber which comprises discharging a charge of gas compressed and heated by the compression stroke of the compressor into said chamber past said valve, then moving a part of the same through a path in which heat is abstracted therefrom, then mixing a portion of said cooled gases with the hot compressed gases of a subsequent stroke.

3. The method of cooling a hot charge of compressed gas discharged from a compressor cylinder which comprises passing a first portion of the charge to a point of consumption, passing a second portion of the charge into a cooling chamber and thereafter passing said second portion when cooled into contact with the first portion of a succeeding stroke.

4. The method of cooling a hot charge of compressed gas discharged from a compressor cylinder which comprises dividing said charge into two portions passing the first portion to a point of consumption, cooling the second portion, and mixing said cooled portion with a succeeding hot charge.

5. In combination in a compressed air system, a compressor having a cylinder, a discharge valve and a chamber for said discharge valve, a delivery pipe leading from said chamber and means for cooling a portion of the gas compressed by the cylinder and means for circulating the cooled compressed gas in contact with the discharge valve before said gas enters the delivery pipe.

6. The method of operating a gas compressor to limit the temperature rise of the same, which comprises compressing successive charges substantially adiabatically and discharging the heated charges in succession from the cylinder, dividing the charges issuing from the cylinder into two portions, diluting the first portion with cool gases under pressure and passing the same to a point of consumption and cooling the second portion and mixing said second cooled portion with the first portion of a succeeding charge.

7. In combination, a compressor having a cylinder, an inlet valve, a discharge passageway and a chamber in communication with said passageway, a discharge valve for said passageway, a gas delivery pipe, communicating with said chamber, said chamber having a sufficiently large superficial area to dissipate the heat of the gases to a safe value below the carbonizing point of lubricating oil and means for directing the flow of the gases discharged from the cylinder about said chamber to cause a circulation of the hot gases in contact with the heat dissipating walls.

8. In combination with a compressor cylinder having a piston, an air inlet valve, a discharge passageway, a discharge valve chamber communicating with said passageway, a discharge check valve for said passageway, said chamber comprising a cooling passageway and a mixing chamber, and a compressed gas delivery conduit leading from said discharge valve chamber.

9. In combination, a compressor cylinder having a piston, an air inlet valve, a discharge passageway, a mixing chamber communicating with said passageway, a check valve for said passageway and a cooling passageway communicating at both ends with said mixing chamber and a compressed gas delivery conduit leading from said discharge valve chamber.

10. In combination, a mixing chamber having a normally open restricted outlet, means periodically injecting charges of hot compressed gas into said chamber, a cooling passageway communicating at both ends with said mixing chamber and flow directing means for directing a part of each incoming charge of hot gas through said passageway.

11. In combination, a mixing chamber having an outlet, a receiver connected to said outlet, a gas compressor cylinder having a discharge passageway communicating with said chamber, a check valve controlling said communication, a cooling passageway communicating at both ends with said chamber, said compressor delivering successive charges into said chamber at a rate of delivery in excess of the normal rate of flow from the chamber into said receiver to raise the pressure in said chamber to a value above that of the pressure in said cooling passageway to cause a part of each charge to flow into said cooling passageway.

12. In combination, a mixing chamber having an outlet, a receiver connected to said outlet, a gas compressor cylinder having a discharge passageway communicating with said chamber, a check valve controlling said communication, a cooling passageway communicating at both ends with said chamber, said compressor delivering successive charges into said chamber at a rate of delivery in excess of the normal rate of flow from the chamber into said receiver to raise the pressure in said chamber to a value about that of the pressure in said cooling passageway to cause a part of each charge to flow into said cooling passageway, and means for directing flow through said passageway in a predetermined direction.

13. In combination, a mixing chamber having an inlet and an outlet, remote from the inlet means for periodically injecting charges of hot compressed gas through said

inlet, a cooling conduit communicating at both ends with said chamber and having its outlet end adjacent the aforesaid inlet to the chamber.

14. In a compressor the combination of a compressor cylinder, a piston therein, a head for the cylinder having a hollow neck providing a discharge passageway, said piston having a projection extending into said passageway, a chamber at the end of the neck, a check valve in said chamber for controlling said passageway, said chamber having a heat dissipating wall and means for directing hot compressed gas discharged by the piston from the cylinder in a predetermined path in contact with said heat dissipating wall.

15. In a compressor the combination of a cylinder having a head, a piston for the cylinder, said head having a discharge passageway, a discharge valve chamber and a discharge check valve in said chamber, and means for injecting cool compressed gas into said chamber to cool the same during the operation of the compressor.

16. In combination with a compressor having a discharge valve chamber, means for injecting a cooling fluid directly into said chamber.

17. In combination with a compressor having a discharge valve chamber, a closed radiator communicating at each end with said chamber.

18. In combination in a compressor, a discharge valve chamber, a discharge passageway leading thereto, a discharge valve controlling said passageway, a conduit having one end extending into proximity to said valve and at its other end leading out of the chamber and means for passing relatively cool compressed gas through the conduit and in contact with the discharge valve.

19. In combination in a compressor, a cylinder, a discharge valve chamber, a discharge passageway leading from the cylinder to the chamber, a discharge valve controlling the passageway and being exposed to the gas in the chamber, a compressed gas delivery pipe communicating with said chamber and a cooling conduit for compressed gas communicating with said chamber and said delivery pipe.

20. In a compressor, the combination of a cylinder, a piston therefor, a discharge valve, a discharge valve chamber, and means to scavenge the discharge valve chamber with cool gas at substantially the same pressure as the compressed gas delivered by said piston and cylinder.

21. In combination, a gas compressor having a working cylinder for compressing gas, said cylinder having a discharge passage for delivering compressed gas from the cylinder; said discharge passage having an enlargement forming a pocket, means for injecting cool gas into said pocket to cool the walls of the same, said cool gas being compressed to substantially the same pressure as the gas delivered through said discharge passageway from the working cylinder.

22. In combination, in a gas compressor, a working cylinder, a discharge valve therefor, a chamber for said discharge valve, a compresssed gas delivery conduit communicating with said chamber, means for cooling a portion of the compressed gas delivered by the cylinder into said chamber, and means for directing said cooled gas into thermal contact with said discharge valve.

23. In a gas compressing system, the combination of a chamber having a valved inlet, a delivery pipe leading therefrom, a reservoir connected to the delivery pipe, means for discharging charges of hot compressed gas into said chamber to raise the pressure therein temporarily, and a cooling chamber communicating with the first chamber and adapted to receive and cool a portion of the compressed gas of each charge delivered to the first chamber, said cooling chamber being adapted to feed cooled compressed gas back into the first chamber during intervals between charges of hot gas, the flow of gas into said second chamber occurring during the temporary rise of pressure occasioned by an incoming charge of hot gas.

24. In a gas compressing system, the combination of a chamber having a valved inlet, a delivery pipe leading therefrom, a reservoir connected to the delivery pipe, means for discharging charges of hot compressed gas into said chamber to raise the pressure therein temporarily, and a cooling chamber communicating with the first chamber and adapted to receive and cool a portion of the compressed gas of each charge delivered to the first chamber, said cooling chamber being adapted to feed cooled compressed gas back into the first chamber during intervals between charges of hot gas, the flow of gas into said second chamber occurring during the temporary rise of pressure occasioned by an incoming charge of hot gas, said chambers being connected by two openings, and means for controlling the direction of flow of gas through said openings.

25. In combination, a compressed gas system comprising a compressor having a cylinder, a piston therefor, a discharge valve for the cylinder, a chamber for said discharge valve, a delivery pipe leading from the chamber, means for cooling some of the gas compressed by the cylinder and piston, and means for directing the cooled gas against the discharge valve to cool the same.

26. The method of limiting the temperature rise of the discharge valve and valve chamber of a gas compressor which comprises, dissipating heat from the compressed gases and then bringing the cooled gases

back into thermal contact with the valve in the valve chamber.

27. The method of limiting the temperature rise of the discharge valve and valve chamber of a gas compressor which comprises, intermittently injecting charges of hot gas through said valve into the valve chamber and between said intermittent injections bringing cool gas at substantially the same pressure into thermal contact with the discharge valve.

28. The method of limiting the temperature rise of the discharge valve and valve chamber of a gas compressor which comprises, moving a stream of cool fluid into the chamber and into thermal contact with the valve entirely outside of the compression chamber of the compressor.

29. The method of limiting the temperature rise of the discharge valve of a gas compressor which comprises discharging a current of cool fluid into the compressed gas in contact with the valve and wholly outside the compression chamber of the compressor.

30. In combination, a pair of alternately operating compressor cylinders each having a discharge valve and a chamber therefor, said chambers being connected by a passageway, a compressed gas cooling radiator having its inlet end connected to said passageway and its discharge end connected to one of said valve chambers, and a compressed gas delivery conduit connected to said other valve chamber.

31. In a compressor, a cylinder having a longitudinally shiftable sleeve valve member, a piston in the sleeve valve member, a head member connected to the cylinder, said head member forming a closure for the sleeve member, and a thin sheet metal ring forming a seal between said members when the sleeve member is shifted longitudinally, and having one margin secured to one member and the other margin engaging the other member upon movement of the valve member toward the head member.

32. In a compressor, a cylinder having a sleeve, a piston in the sleeve, a head for the cylinder forming a closure with the sleeve, a sheet metal ring secured at its outer peripheral margin to the head and having its inner peripheral margin spaced from said head and engageable by the sleeve.

33. In a compressor, a cylinder having a sleeve, a piston in the sleeve, a head for the cylinder forming a closure with the sleeve, a sheet metal ring secured at its outer peripheral margin to the head, the head having a groove under the inner peripheral margin of said ring, said ring being engageable by said sleeve.

34. In a device of the class described, a head member having an annular seat, a ring valve having its outer margin resting on said seat, and a clamping ring for holding said margin on said seat, said head having an annular clearance space lying under the inner margin of said ring to permit pneumatic pressure to act upon the side of said ring adjacent the head.

35. In combination, a head member having an annular seat, a ring valve having its outer margin resting on said seat, a clamping ring for holding said margin on said seat, said head having an annular clearance space lying under the inner margin of said ring to permit pneumatic pressure to act upon the side of said ring adjacent the head, and a sleeve valve movable into and out of engagement with the inner margin of said ring to control the admission of gas into the interior of said sleeve valve.

36. In a device of the class described, a head member having an annular seat, a ring valve having its outer margin resting on said seat, and a clamping ring for holding said margin on said seat, said head having an annular clearance space lying under the inner margin of said ring to permit pneumatic pressure to act upon the side of said ring adjacent the head, said sleeve valve having an inturned flange at its upper end for engagement with the inner marginal portion of said ring, the pneumatic areas exposed by said ring and by said flange being substantially equal.

In witness whereof, I hereunto subscribe my name this 31st day of March, 1927.

BURTON S. AIKMAN.