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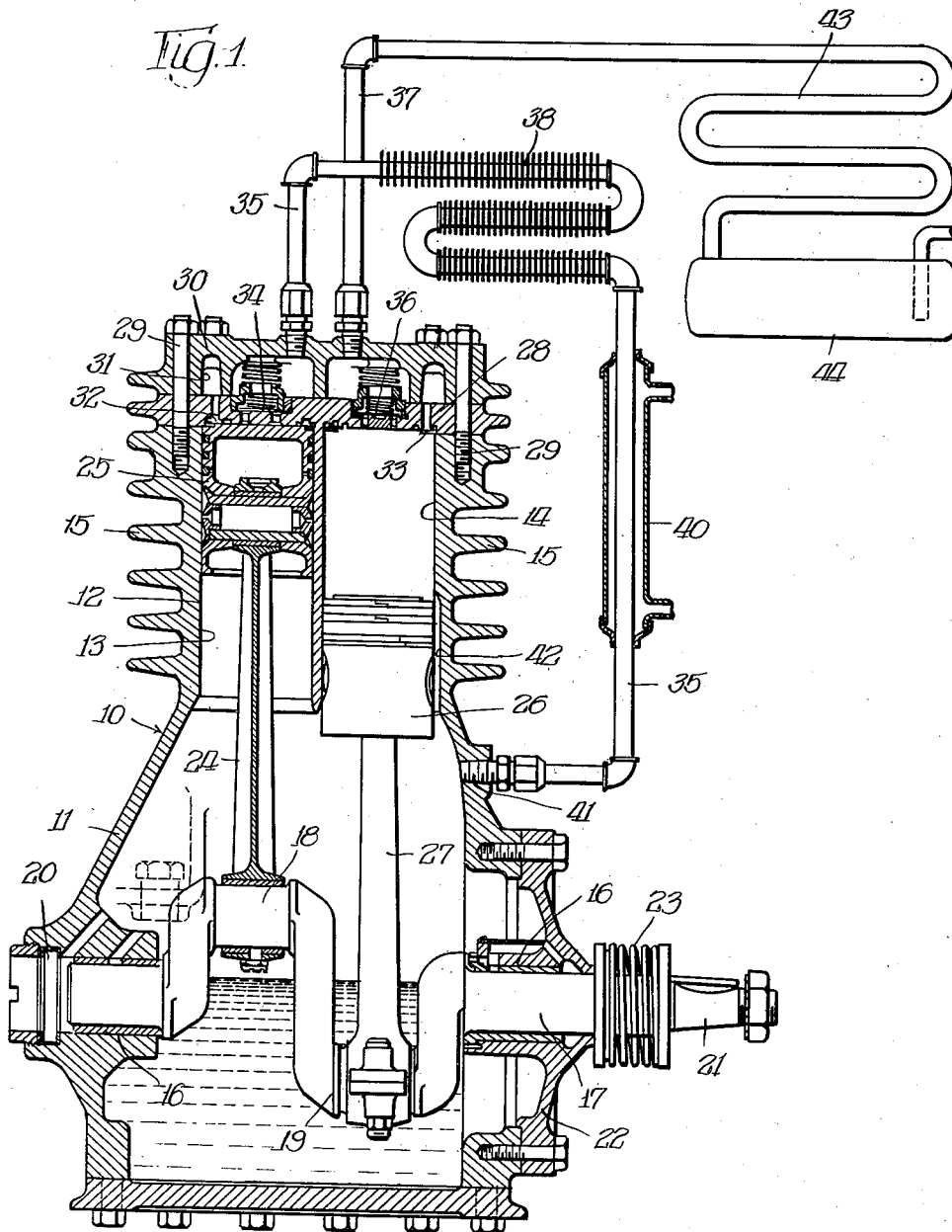
R. H. SWART

2,243,541

COMPOUND COMPRESSOR

Filed Aug. 2, 1939

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 2.

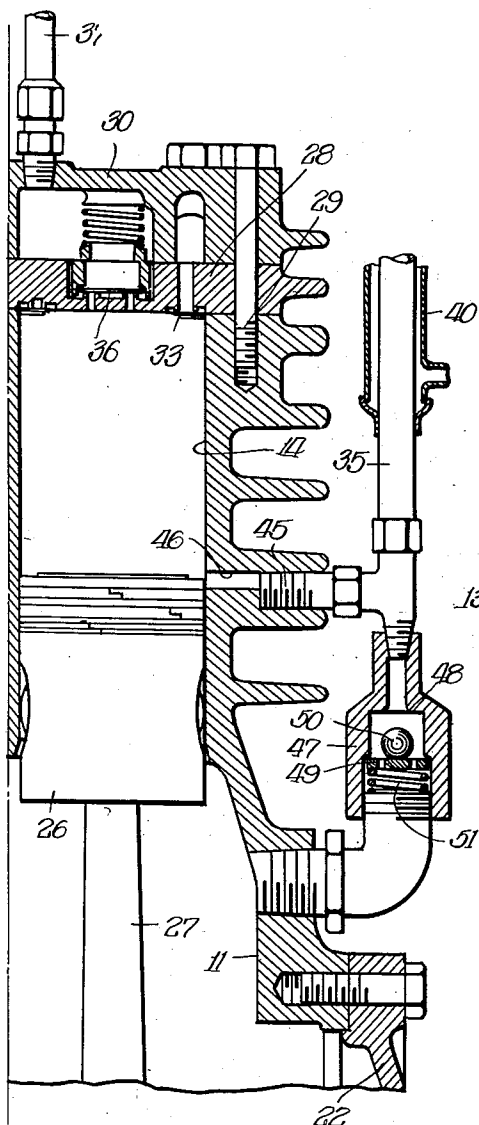
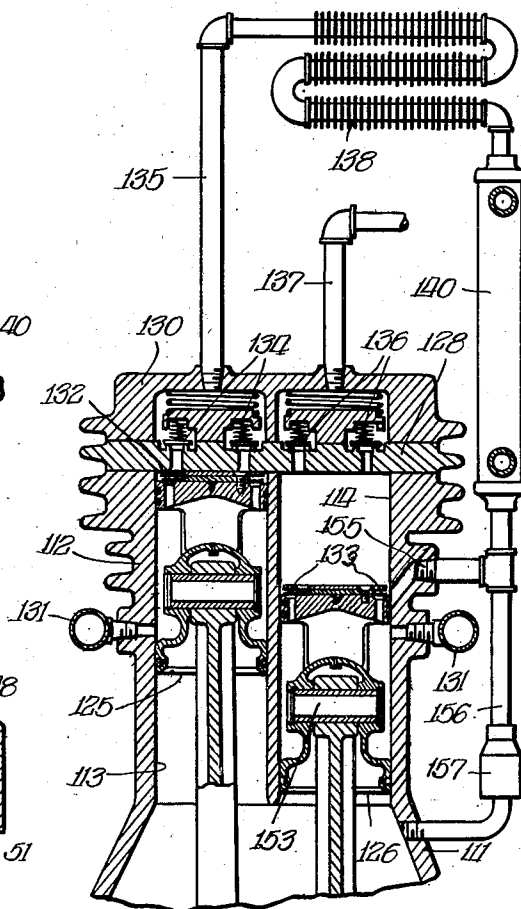


Fig. 3.



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UNITED STATES PATENT OFFICE

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COMPOUND COMPRESSOR

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8 Claims. (Cl. 230—198)

The invention relates to refrigeration compressors and has reference more particularly to a compound compressor for compressing gaseous refrigerant and the like in two or more stages.

In refrigerating systems where the required evaporating temperatures are low as, for example, below zero on the Fahrenheit scale, difficulties have always been encountered with the conventional single stage compressor. In such compressors the compression ratio is high and the effective displacement of the compressor is below that desired because of leakage and re-expansion of the gas in the clearance spaces. The over-all efficiency is therefore low. In addition the discharge temperatures are always high, due to the high compression ratio and this is conducive to poor valve operation as well as decomposition of oil and refrigerant in some cases. In large installations it is common practice to employ two compressors. However, in small systems using motors of from one-fourth to ten horse power the cost of installation and maintenance of two compressors is excessive. Accordingly, the invention contemplates improvements to a standard multiple cylinder compressor to provide a compound unit.

An object of the invention is to provide a compound compressor as above described wherein the compression ratio in all stages will be low with correspondingly high volumetric displacement and unusually low power consumption, and wherein the high pressure gas will be discharged at relatively low temperatures.

Another object resides in the provision of a compound compressor which will have particular application to low temperature systems and which will eliminate the difficulties heretofore encountered in maintaining a vacuum seal at the rotating shaft since the crank case pressure can be regulated to be above atmospheric at all times.

Another object of the invention is to provide a multi-stage compressor wherein the gas from the first stage and which is at an intermediate pressure is cooled to improve the efficiency of the unit and which also has the desired effect of lowering the temperature of the high pressure gas discharged from the second stage.

With these and various other objects in view, the invention may consist of certain novel features of construction and operation as will be more fully described and particularly pointed out in the specification, drawings and claims appended hereto.

In the drawings which illustrate an embodi-

ment of the device and wherein like reference characters are used to designate like parts—

Figure 1 is a sectional view of a compound compressor constructed in accordance with the present invention;

Figure 2 is a fragmentary sectional view illustrating a modification embodying an oil return check valve; and

Figure 3 is a fragmentary sectional view illustrating the invention as applied to a compressor provided with pistons of the trunk type.

In the drawings, particularly Figure 1, the compound compressor 10 includes a crank case 11 and a cylinder portion 12 which provides vertically disposed cylinders 13 and 14. Said latter portion is provided on its exterior with heat radiating fins 15. Bearings 16 are located in the crank case for journalling the crank shaft indicated in its entirety by numeral 17 and which includes a crank portion 18 and a second crank portion 19 having a 180 degree relation therewith. One end of the crank shaft 17 terminates short of a fixed seal 20, whereas, said other end 21, which projects beyond the removable plate 22 of the crank case, is tapered for receiving the conventional fly wheel (not shown). Said end also receives the usual bellows seal 23 which seals this end of the rotating crank shaft with respect to the compressor so as to prevent escape of refrigerant gas from the crank case and to also prevent the entrance of air into said crank case.

The crank portion 18 of the crank shaft is operatively connected by the connecting rod 24 with a piston 25 having reciprocating movement within cylinder 13 and which forms the low pressure stage of the present compound compressor. In a similar manner crank portion 19 connects with piston 26 by means of connecting rod 27, said piston reciprocating within cylinder 14 and forming the high pressure stage of the present unit. The plate 28, which carries the inlet and outlet valves, respectively, for each cylinder, is bolted to the cylinder portion of the compressor by bolts 29 which additionally hold in place the head 30 of the compressor. Said head is provided with an annular suction passage 31 which receives the low pressure or suction gas returning from the evaporator. Having communication with this annular passage in the head are inlet valves 32 for the low pressure cylinder 13 and inlet valves 33 for the high pressure cylinder 14. The outlet valve 34 for cylinder 13 is located within a chamber in the head 30 to which is connected the outlet pipe 35. Said pipe there-

fore receives the compressed gas from the first stage of the present compressor. The outlet valve 36 for cylinder 14 is located within a similar chamber having connection with pipe 37 which receives the high pressure gas, or, in other words, the gas which has been compressed to condensing pressure.

In accordance with the invention the refrigerant gas flowing through pipe 35 is cooled either by water, air, or both. Therefore, a part of this pipe is provided with cooling fins 38 and a jacket 40 may also be located in association with said pipe for conducting water in contact with the same to further cool the compressed gas flowing through said pipe. As shown in Figure 1, said gas is delivered to the interior of the crank case at 41.

The gas within the crank case can escape only through the passage 42 located in the wall of cylinder 14 and which passage extends a short distance above the top of piston 26 when said piston is in its lowermost position. When the piston is located in its lowermost position the gas in the crank case will flow into cylinder 14 and as a result of upward movement of said piston the gas is further compressed, to be eventually discharged at a high pressure through the outlet valve 36 into the tube 37. At the end of tube 37 a condenser indicated in its entirety by numeral 43 is provided for condensing the refrigerant gas into its liquid form which is eventually delivered to the receiver 44.

In the compound compressor of Figure 1 it will be observed that refrigerant gas at suction pressure is drawn in by both cylinders as the pistons of said cylinders move downwardly since each cylinder is provided with an inlet valve for said low pressure gas. In cylinder 13 this low pressure gas is compressed and delivered by the outlet valve 34 to the inter-cooler comprising the fins 38, which cool the gas by dissipating the heat to the air, and the water jacket 40 which removes heat from the gas by bringing relatively cool water in contact with pipe 35. In this form of the invention the gas from the cylinder 13, which is at an intermediate pressure, is supplied to the crank case of the compressor and periodically removed therefrom by the pumping action of the high pressure stage comprising piston 26 operating within cylinder 14. The gas within the crank case is therefore above atmospheric pressure at all times, which eliminates difficulties heretofore encountered in maintaining a vacuum seal between the rotating crank shaft and its compressor. Due to the pressure within the crank case no air will be drawn in and the conventional shaft seal 23 will also prevent escape of refrigerant gas along the rotating crank shaft 17.

When the piston 26 reaches the limit of its stroke in a downward direction the passage 42 is uncovered and gas at intermediate pressure will flow into the cylinder 14. As described, said piston has already drawn into the cylinder a charge of low pressure gas through the inlet valve 33. This low pressure gas is accordingly compressed to intermediate pressure and which compression is done at the expenditure of no mechanical work, thereby effecting a very important gain in over-all efficiency. On the upward stroke of the piston 26 the gas within cylinder 14 is further compressed and discharged through valve 36 to the condenser as described.

An important feature of the present compound compressor is that the compression ratio for both stages is relatively low. In the first stage the

gas at suction pressure is compressed to an intermediate pressure. The relatively small difference between the suction and discharge pressures of this first stage produces a high volumetric displacement therefor and which is at a relatively low temperature. The inter-cooler removes sufficient heat from the gas so as to prevent overheating of the compressor and as described serious difficulties at the seal are eliminated by maintaining the crank case at a pressure above atmospheric. The compression ratio of the second stage is also low since the gas is compressed from an intermediate pressure to a condensing pressure. There is also a mechanical gain in this stage as a result of the admission to the cylinder of said intermediate pressure gas, which raises the charge in the cylinder to said intermediate pressure, and the temperature of the gas when discharged is relatively low as a result of the inter-cooler which removes considerable heat from the gas following its compression in the first stage.

In Figure 2 the intermediate pressure gas from the inter-cooler is delivered by the connection 45 and passage 46 directly to the high pressure cylinder 14 instead of being first delivered to the crank case of the compressor. This is desirable due to the fact that some compressors operate with a high oil level and with the design shown in Figure 1 considerable oil may be carried along with the gas into the high pressure cylinder. The modification of Figure 2 additionally includes an oil return check valve comprising a tubular body portion 47 having a valve seat 48 adapted to be closed by the ball valve 49. Said ball valve when not in contact with its seat will rest on the perforated plate 50 yieldingly held against a stop shoulder by the coil spring 51. The oil return check valve allows an intermediate pressure to prevail within the crank case of the compressor and also permits oil removed from the intermediate pressure gas to be returned to said crank case. However, even though the oil may be highly agitated in the crank case, it is impossible for any oil to work past the check valve during operation of the compressor, and also upon starting up of the compressor, oil will be held within the crank case since the crank pressure is reduced very gradually due to the fact that the check valve will close immediately upon the suction pressure being reduced.

In Figure 3 the features of the present invention have been applied to a compressor having pistons of the trunk type. In this type of compressor the crank case 111 has the usual cylinder portion 112 providing a cylinder 113 forming a low pressure stage and a cylinder 114 for the high pressure stage. The outlet valve 134 for the cylinder 113 is located within a chamber in the head 130 of the compressor, which chamber has connection with outlet tube 135, which receives the gas that has been compressed to an intermediate pressure. The structure is similar for the outlet valve 136 for cylinder 114 which is located within a chamber in the head 130 of the compressor connecting with pipe 137 receiving the high pressure gas, or, in other words, the gas that has been compressed to condensing pressure.

In this form of the invention the low pressure suction gas is admitted to the cylinders by valves located in the respective pistons. The tube conducting the low pressure or suction gas from the evaporator and delivering the same to the compressor is indicated at 131 and it will be observed that said tube has connection so as to deliver

the gas to cylinder 113 and also cylinder 114. The trunk type pistons 125 and 126 for both stages are similar, each piston journaled a crank pin 153 for operatively connecting thereto its respective connecting rod. In piston 125, which reciprocates within cylinder 113, inlet valves 132 are provided and similar valves 133 are located in piston 126 for the high pressure cylinder 114. It will be observed that both pistons are so constructed as to be in communication at all times with the suction gas supply tubes 131. Accordingly, as said pistons move downwardly within their cylinder their respective inlet valves will be caused to admit a supply of suction gas which is drawn in to fill the cylinders.

In cylinder 113 the suction gas is compressed to an intermediate pressure, and which is discharged through outlet valve 134 to tube 135. The intercooler including the fins 138 and the water jacket 140 lowers the temperature of this intermediate pressure gas flowing through 135 and as shown in Figure 3 said cool gas is delivered to the high pressure cylinder as at 155. This auxiliary inlet port is uncovered when the piston 126 approximately reaches the limit of its stroke in a downward direction and the charge of low pressure gas within said cylinder is thereupon initially compressed by the gas at intermediate pressure, which flows into and fills the cylinder, raising the pressure to that of said intermediate gas. This is a clear gain in energy and is an important factor in over-all efficiency of the present compound compressor. On the return stroke of the piston the charge is compressed to a condensing or discharge pressure and forced through outlet valves 136, to be eventually delivered to the condenser and receiver for the liquid refrigerant.

In this form of the invention the intermediate pressure gas from the intercooler is also conducted to the crank case of the compressor for the purpose of maintaining within the crank case a pressure which will be above atmospheric. The connection 156 includes the oil return check valve 157 embodying the same internal structure as the check valve disclosed in connection with Figure 2. The purpose of the oil return check valve is to permit an intermediate pressure to prevail within the crank case of the compressor and also permit oil removed from the intermediate pressure gas to be returned to the crank case. Also the check valve prevents oil from foaming out of the crank case and into the high pressure cylinder whenever the compressor is started.

The several advantages of the form of compressor shown in Figure 1 are likewise attained by the compound unit of Figure 3. Both cylinders operate on a relatively low ratio of compression and the volumetric displacement is therefore high. By cooling the gas at intermediate pressure sufficient heat is abstracted therefrom so as to maintain the high pressure gas at a relatively low discharge temperature. Also as a result of the connection to the crank case of the compressor a pressure is maintained in said crank case which is at all times above atmospheric, and any oil removed from the intermediate pressure gas can be returned although oil from the crank case is effectively prevented from flowing in an opposite direction.

The invention is not to be limited to or by details of construction of the particular embodiment thereof illustrated by the drawings as various other forms of the device will of course

be apparent to those skilled in the art without departing from the spirit of the invention or the scope of the claims.

What is claimed is:

1. In a multi-stage compressor, a pair of cylinders disposed side by side and each having a piston operating therein, one cylinder comprising the low pressure stage of the compressor and operating to compress low pressure gas to an intermediate pressure, the other cylinder comprising the high pressure stage and having an inlet valve for said low pressure gas and an auxiliary inlet port for admitting thereto said intermediate pressure gas, whereby both gases are compressed by said other cylinder to a high discharge pressure, said auxiliary inlet port comprising a passage in the wall of said cylinder communicating with the crank case at its lower end and having its upper end positioned so that the port is uncovered at the end of the suction stroke pressure gas to the crank case of the compressor, and means for conducting said intermediate pressure gas to the crank case of the compressor.

2. In a multi-stage compressor, a pair of cylinders disposed side by side and each having a piston operating therein, one cylinder comprising the low pressure stage of the compressor and operating to compress low pressure gas to an intermediate pressure, the other cylinder comprising the high pressure stage and having an inlet valve for said low pressure gas and an auxiliary inlet port for admitting thereto said intermediate pressure gas, whereby both said gases are compressed by said other cylinder to a high discharge pressure, said auxiliary inlet port comprising a passage in the wall of said cylinder communicating with the crank case at its lower end and having its upper end positioned so that the port is uncovered at the end of the suction stroke, means for conducting said intermediate pressure gas to the crank case of the compressor, and other means associated therewith for cooling said gas.

3. In a multi-stage compressor, a low pressure cylinder and a high pressure cylinder each having pistons operating therein, an inlet valve for each cylinder for admitting low pressure gas to each cylinder during the suction stroke of the piston operating therein and which is compressed to an intermediate pressure in said low pressure cylinder, outlet valves for the cylinders respectively, an auxiliary inlet port located in the high pressure cylinder and positioned so that the said port is uncovered at the end of the suction stroke, means conducting said intermediate pressure gas to said inlet port whereby said intermediate pressure gas is supplied to the high pressure cylinder after the same has drawn in a charge of low pressure gas, and whereby both charges are further compressed to a high pressure, means cooling said intermediate pressure gas, and means using said last mentioned gas to maintain a pressure within the crank case of the compressor.

4. In a compound compressor, a pair of cylinders each having a piston operating therein, an inlet port for each cylinder having communication with a source of low pressure gas for admitting said low pressure gas to its respective cylinder during the suction stroke of the piston operating therein, an outlet valve for each cylinder, the said outlet valve for one of said cylinders discharging said gas at an intermediate pressure, an auxiliary inlet port located in the other cylinder and positioned so that the port is uncovered when the piston of its cylinder reaches the limit of its suction stroke, and means connecting the outlet

valve of said first mentioned cylinder with said inlet port whereby gas at an intermediate pressure is supplied by said inlet port to the other cylinder and is compressed thereby along with the charge of low pressure gas.

5. In a compound compressor, a pair of cylinders each having a piston operating therein, an inlet valve for each cylinder having communication with a source of low pressure gas for admitting said low pressure gas to its respective cylinder during the suction stroke of the piston operating therein, an outlet valve for each cylinder, the outlet valve for one cylinder delivering said gas at an intermediate pressure, an auxiliary inlet port located in said other cylinder and positioned so that the port is uncovered when the piston of its cylinder reaches the limit of its suction stroke, means connecting the said inlet port with the outlet valve of the first mentioned cylinder whereby gas at an intermediate pressure is supplied by said inlet port to said other cylinder and is compressed along with a charge of low pressure gas, and other means for cooling the intermediate pressure gas while the same is being conducted from its outlet valve to the inlet port.

6. In a multi-stage compressor, a pair of cylinders disposed side by side and each having a piston operating therein, one cylinder comprising the low pressure stage of the compressor and having an inlet valve for admitting low pressure gas and an outlet valve for discharging said gas at an intermediate pressure, the other cylinder comprising the high pressure stage and also having an inlet valve for admitting low pressure gas and an outlet valve for delivering gas at the final discharge pressure, an auxiliary inlet port associated with said high pressure cylinder for admitting to said cylinder at the end of the suction stroke the intermediate pressure gas from said low pressure cylinder, whereby a charge of low pressure gas and a charge of said intermediate pressure gas are compressed in the high pressure cylinder to the final discharge pressure of the compressor, and means for cooling the intermediate pressure gas before the same is delivered to said high pressure cylinder.

7. In a multi-stage compressor, a pair of cylinders

disposed side by side and each having a piston operating therein, one cylinder comprising the low pressure stage of the compressor and having an inlet valve for admitting low pressure gas and an outlet valve for discharging said gas at an intermediate pressure, the other cylinder comprising the high pressure stage and also having an inlet valve for admitting low pressure gas and an outlet valve for delivering gas at the final discharge pressure, an auxiliary inlet port associated with said high pressure cylinder for admitting to said cylinder at the end of the suction stroke the intermediate pressure gas from said low pressure cylinder, whereby a charge of low pressure gas and a charge of said intermediate pressure gas are compressed in the high pressure cylinder to the final discharge pressure of the compressor, and means constructed and arranged to maintain a pressure within the crank case of the compressor approximating said intermediate pressure.

8. In a multi-stage compressor, a pair of cylinders disposed side by side and each having a piston operating therein, one cylinder comprising the low pressure stage of the compressor and having an inlet port for admitting low pressure gas and an outlet valve for discharging said gas at an intermediate pressure, the other cylinder comprising the high pressure stage and also having an inlet valve for admitting low pressure gas and an outlet valve for delivering gas at the final discharge pressure, an auxiliary inlet port associated with said high pressure cylinder for admitting to said cylinder at the end of the suction stroke the intermediate pressure gas from said low pressure cylinder, whereby a charge of low pressure gas and a charge of said intermediate pressure gas are compressed in the high pressure cylinder to the final discharge pressure of the compressor, a connection from said inlet port to the interior of the crankcase of the compressor whereby oil in said intermediate gas may drain to the crankcase, and a check valve in said connection permitting the oil to flow to the crankcase but preventing flow of oil in an opposite direction.

RICHARD H. SWART.

CERTIFICATE OF CORRECTION.

Patent No. 2,243,541.

May 27, 1941.

RICHARD H. SWART.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, second column, line 22, claim 1, strike out the words and syllable "stroke, and means for conducting said interme-" and insert the same after the word "suction" in line 20, same claim; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 8th day of July, A. D. 1941.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.