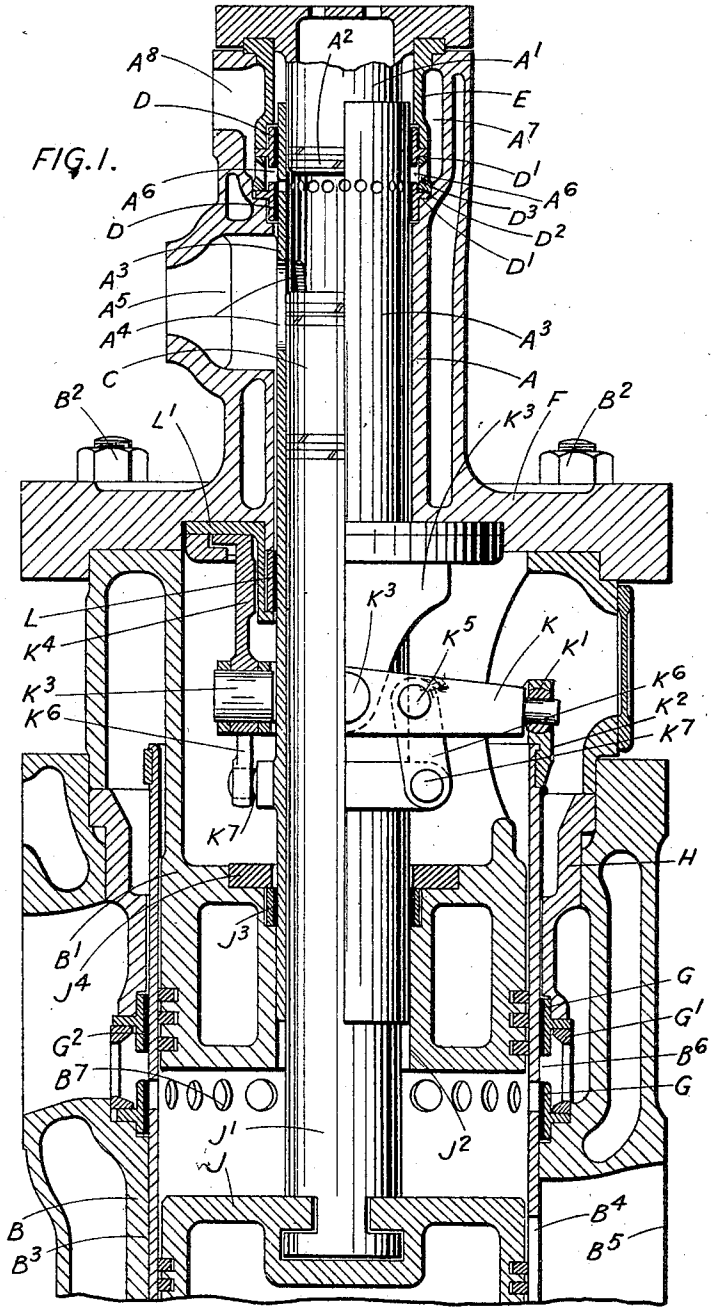
April 15, 1930. H. R. RICARDO 1,755,075

COMPRESSOR FOR AIR OR GAS

Filed Feb 25, 1928 3 Sheets-Sheet 1

FIG. 1.



Inventor

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April 15, 1930. H. R. RICARDO 1,755,075

COMPRESSOR FOR AIR OR GAS

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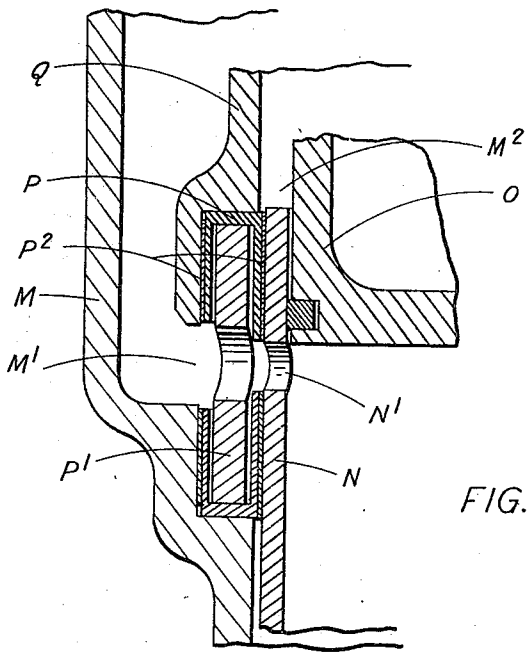


FIG. 2.

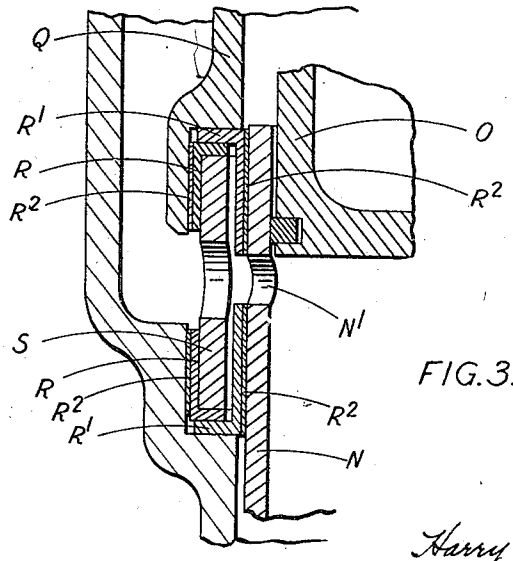


FIG. 3.

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April 15, 1930. H. R. RICARDO 1,755,075

COMPRESSOR FOR AIR OR GAS

Filed Feb. 25, 1928 3 Sheets-Sheet 3

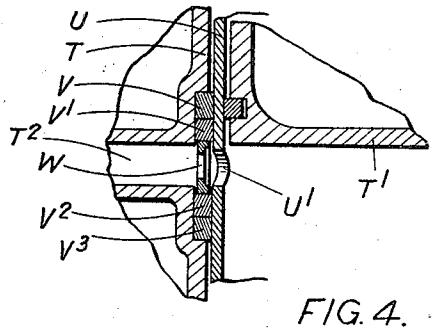


FIG. 4.

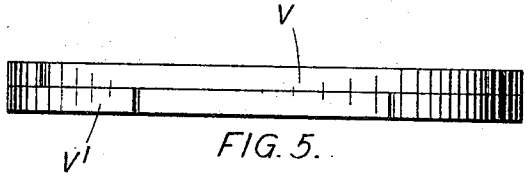


FIG. 5.

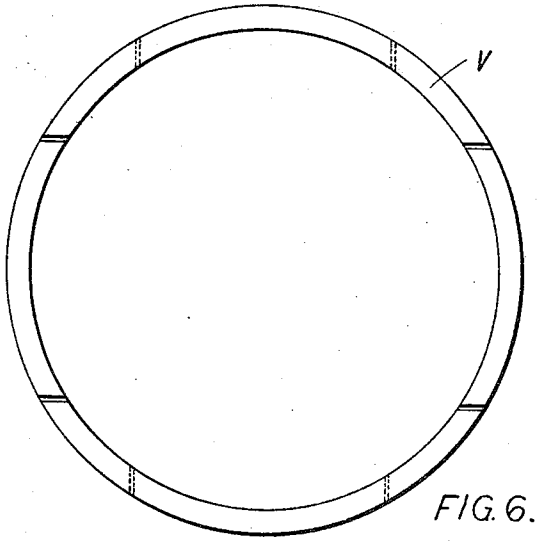


FIG. 6.

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Patented Apr. 15, 1930 1,755,075

UNITED STATES PATENT OFFICE

HARRY RALPH RICARDO, OF LONDON, ENGLAND

COMPRESSOR FOR AIR OR GAS

Application filed February 25, 1928, Serial No. 256,912, and in Great Britain March 3, 1927.

This invention relates to compressors for air or gas of the reciprocating piston type in which the inlet port or ports or both the inlet and delivery ports are controlled by a sleeve valve disposed within the cylinder, this valve directly surrounding but being separate from the piston which reciprocates within it and having motion imparted thereto both about and in the direction of its axis. The sleeve preferably controls both the inlet and the delivery ports and may be operated at either crankshaft speed or half crankshaft speed, an automatic non-return delivery valve, preferably controlled by a dashpot device, being in some cases provided either in series or parallel with the sleeve valve controlled delivery port or ports, such an automatic valve being more particularly employed when the compressor is adapted to work under varying delivery pressure conditions.

The object of the invention is to effect certain improvements in such compressors which will tend to reduce the risk of leakage taking place past the sleeve and generally to increase the efficiency of the apparatus.

According to the present invention the cylinder has a single annular delivery port or ring of delivery ports extending around the cylinder and controlled by the sleeve, and sealing rings are provided respectively above and below the delivery port or ports. The lower ring which bears against the outer surface of the sleeve is supported by the cylinder but the upper ring or rings can either be supported by the cylinder to engage the outer surface of the sleeve or by the cylinder head to engage the inner surface of the sleeve.

Preferably each sealing ring is of the kind described in the specification of the present applicant's application for Letters Patent of the United States of America Serial No. 182,885, filed 11th April, 1927, and comprises an undivided ring of hard metal the wearing surface of which is coated with a layer or lining of relatively plastic or fusible metal such as white or other metal as used in ordinary bearings.

In one construction the upper and lower sealing rings are supported by the cylinder and engage the outer surface of the sleeve, these sealing rings preferably being so placed that they constitute the upper and lower edges of the outlet port or ports in the cylinder wall. In such a construction one or more supplementary sealing rings carried by the cylinder head may also be provided engaging the interior surface of the sleeve.

The sealing rings may be of various forms, but where, as is preferred, they constitute the upper and lower edges of the outlet port, they may each conveniently be in the form of an annular trough-like member of substantially U-shaped cross-section, the interior of which is open to the delivery pressure, while its walls are relatively thin so that this pressure can force the sides of the trough outwards so that it makes close contact with the sleeve valve. In such a construction each sealing ring may either be formed as an integral trough-like member or may be constituted by two annular members each of substantially L-shaped cross-section, these members having relatively thin walls and being placed together so as to form a composite sealing ring of annular trough-like construction.

Further, when the sealing rings themselves constitute the upper and lower edges of the delivery port or ports, the side of each sealing ring which is remote from the delivery port or ports conveniently engages with the edge of a circumferential slot in the cylinder wall while the adjacent edges of the rings are engaged respectively by the upper and lower edges of a perforated ring or distance piece extending around the cylinder between the sealing rings, the delivery air or gas passing through the perforations in this ring.

The invention may be applied to either single stage compressors or to compressors of the two or other multi-stage type. Further in some cases one or more sealing rings may be provided below the cylinder inlet ports such an arrangement being particularly desirable for example in the second or later stages of a two or multi-stage compressor or in a compressor used for refrigerating or other puposes in which the inlet air or gas is above atmospheric pressure, and serving

to reduce the tendency for such air or gas to leak away downwards between the cylinder and sleeve.

The invention may be carried into practice in various ways but four alternative constructions according to this invention are illustrated by way of example in the accompanying drawings, in which

Figure 1 is a vertical section through the high pressure cylinder and the upper portion of the low pressure cylinder of a two-stage air compressor employing one arangement of outlet ports and undivided sealing rings according to this invention, this air compressor being of the kind in which the high pressure cylinder is mounted upon the low pressure cylinder,

Figure 2 is a section on an enlarged scale showing one alternative arrangement according to this invention employing undivided sealing rings,

Figure 3 shows another alternative arrangement according to this invention also on an enlarged scale employing unsplit sealing rings,

Figure 4 shows a still further alternative arrangement according to this invention employing divided sealing rings,

Figure 5 is a plan of one of the rings employed in the construction shown in Figure 4, and

Figure 6 is a side elevation of the ring shown in Figure 5.

In the construction illustrated in Figure 1, the compressor comprises a high pressure cylinder A which is conveniently water-cooled and is mounted upon a low pressure cylinder B also conveniently water-cooled. The high pressure cylinder A is provided with a cylinder head A^1 in the form of a hollow water-cooled plug extending into the cylinder and provided with sealing rings A^2.

Disposed within the cylinder A is a sleeve valve A^3 within which reciprocates a piston C, the sleeve valve extending upwards so that its upper end moves within the annular space between the cylinder head A^1 and the cylinder wall. The sleeve valve may have various types of motion but in the construction illustrated is adapted to have a combined oscillating and reciprocating motion imparted to it by mechanism hereinafter described, this mechanism being adapted to operate for example at half crankshaft speed.

The sleeve A^3 has inlet ports A^4 formed as helical slots, these ports being adapted to register with similar helical ports A^5 in the wall of the cylinder A as shown. The inlet ports are adapted to open when the sleeve is at or near the ends of its axial stroke, i. e. when its motion is mainly oscillatory. The cylinder A towards its upper end is conveniently provided as shown with a single delivery port A^6 communicating with an annular chamber A^7 out of which leads a delivery passage A^8. The delivery port A^6 conveniently extends as an unbroken circumferential slot around the cylinder and is provided immediately above and below it with sealing rings D carried by the cylinder A and engaging the outer surface of the sleeve valve A^3. With such an arrangement a part D^1 of the upper sealing ring D engages with the upper edge of the slot A^6 and a corresponding part of the lower sealing ring engages with the lower edge of the slot. In the intermediate portion of the annular opening A^6 lies a radially perforated ring or distance piece D^2 extending around the cylinder between the two sealing rings D and bearing on the parts D^1 so as to maintain the rings D in position, the air or gas delivered being adapted to pass out between the sealing rings and through the perforations D^3 in the ring D^2. Thus the sealing rings themselves constitute in effect the edges of the delivery port so that there is no dead space on either side of this port.

To permit of the sealing rings D being placed in position or removed, the upper edge of the circumferential slot A^6 is conveniently constituted by the lower edge of a tubular distance piece E secured to the top of the cylinder A and retained in position by the cylinder head A^1 being clamped down thereon.

The cylinder A is carried by and conveniently formed integral with a base plate F which bears on the upper end of the plug-like water-cooled cylinder head B^1 of the low pressure cylinder B and is connected by bolts B^2 to the cylinder B so as to clamp the cylinder head B^1 in position. Mounted to move within the cylinder B is a sleeve valve B^3 adapted to be operated in known manner by gearing from the crankshaft in such a way that it has a combined oscillating and reciprocating motion. The sleeve B^3 is operated for example at half crankshaft speed by mechanism comprising a driving pinion mounted in a bearing in the crank case and carrying an eccentric pin which engages a self-aligning bearing in the sleeve adjacent to its skirt, this pin being driven from a driving pinion on the crankshaft either directly or through intermediate gearing. It is not considered necessary to illustrate this mechanism since it is of well-known type and forms no part of the present invention.

The sleeve valve B^3 is provided with slot-like inlet ports B^4 similar to the ports A^4 in the sleeve A^3 adapted to register with inlet ports B^5 in the cylinder B, these inlet ports opening when the sleeve is at or near the ends of its axial stroke, i. e. when its motion is mainly oscillatory.

The cylinder B towards its upper end is

provided with an annular delivery port B^6 extending as an unbroken circumferential slot around the cylinder as shown and adapted to register during the middle portion of the reciprocating motion of the sleeve in each direction with a ring of delivery ports B^7. The delivery port B^6 is formed between two sealing rings G constructed and arranged in a similar manner to the rings D in the high pressure cylinder A. Thus the sealing rings G are each of substantially T-section and are separated by a perforated ring G^1 which is interposed between them and serves to maintain them in engagement respectively with a suitable recess in the cylinder A and with the lower edge of a tubular distance piece H mounted within the cylinder and held in place by the cylinder head B^1 as shown.

A piston J reciprocates within the sleeve B^3 of the low pressure cylinder and the piston C of the high pressure cylinder is conveniently operated directly from the piston J through a suitable piston rod J^1 constituting in effect an extension of the piston J and passing through a suitable bore J^2 in the cylinder head B^1. The sleeve valve A^3 of the high pressure cylinder also extends downwards around the piston rod J^1 into the bore J^2 and is engaged on its outer surface by a sealing ring J^3 held in place by a suitable plate J^4 and serving to form a fluid-tight joint between the cylinder head B^1 and the lower end of the sleeve valve A^3.

The mechanism for operating the sleeve valve A^3 may vary but conveniently as shown this sleeve valve is operated from the sleeve valve B^3 by means of a lever K one end of which engages a self-aligning bearing K^1 mounted in a ring K^2 connected to the upper end of the sleeve B^3 while its other end is pivoted at K^3 to a tubular member K^4, rotatably supported on the base plate F, as shown, so as to be capable of rocking about an axis coincident with that of the sleeve A^3. An intermediate point K^5 in the lever K is connected by means of a link K^6 to a stud K^7 rigidly mounted on the sleeve A^3. With this arrangement the combined oscillating and reciprocating motion of the sleeve B^3 is transmitted through the lever K to the sleeve A^3 so that a corresponding motion is imparted to this latter sleeve. In the right-hand portion of Figure 1 of the drawings the mechanism for transmitting motion from the sleeve B^3 to the sleeve A^3 is shown in elevation while in the left-hand portion of this figure such mechanism is shown in section for the sake of clearness, the section being taken through the pivot K^3 in the vertical plane passing through its axis.

In the arrangement shown wherein the compressor is of the two-stage type, the air entering through the port A^5 is above atmospheric pressure and it is desirable therefore to prevent this air from escaping downwards past the sleeve A^3. To this end a sealing ring L may be provided engaging the sleeve A^3 at a point below the ports A^4 as shown, this sealing ring being mounted for example between the lower end of the cylinder A and a member L^1 constructed as shown so as to engage the lower edge of the sealing ring and maintain it in position.

The sealing rings D, G, J^3 and L may be of various forms but preferably are unbroken and are provided on their rubbing surfaces with a layer of relatively plastic or fusible metal such as white or other metal used in ordinary bearings, as described in the specification of the present applicant's United States of America patent application above referred to. Further, each ring is conveniently mounted so that it is free to move radially relatively to the outer cylindrical member which supports it.

In the alternative arrangement shown in Figure 2, M is the cylinder of a sleeve valve air compressor the sleeve N of which is provided with a ring of delivery ports N^1 adapted to register during the delivery period with an annular slot M^1 formed in the cylinder, the upper end of the sleeve moving within the annular space M^2 formed between the cylinder wall and a plug-like cylinder head indicated at O. In this arrangement sealing rings P are carried by the cylinder immediately above and below the delivery port N^1 and engage the sleeve N these rings being of substantially U-section as shown and engaging respectively a slot formed in the cylinder M and a tubular member Q which is conveniently arranged and supported in a similar manner to the member E shown in Figure 1. Arranged between the rings P is an annular perforated distance piece P^1 extending around the cylinder and serving to maintain the rings P in position, the air or gas delivered through the ports N^1 passing through the perforations in the distance piece P. In the arrangement above described the inner and outer circumferential surfaces of the rings P are conveniently coated with a plastic or fusible metal such as white or other metal used in ordinary bearings as shown at P^2.

With the arrangement shown in Figure 2 it will be seen that the pressure of the gas delivered through the ports N^1 will act on the interior of the inner and outer circumferential walls of the rings P and will thus tend to spread such walls. In this way the pressure of the gas always tends to maintain the circumferential walls of the rings P in contact with the parts with which they engage.

The construction illustrated in Figure 3 is similar to that illustrated in Figure 2 except that instead of employing rings as shown at P in Figure 2, sealing rings are employed each comprising two parts R, R^1, each of sub-

stantially L-section these rings being separated and maintained in position by a suitable annular perforated distance piece S interposed between them. In this arrangement it will be seen that as in the construction shown in Figure 2, the pressure of air delivered through the ports N^1 will act on the circumferential walls of the members R and R^1 constituting the rings and will thus tend to force these parts into contact respectively with the sleeve N and with the member Q, thus tending to maintain a gas-tight joint. In this arrangement also the circumferential parts of the members R and R^1 are conveniently coated with a plastic or fusible metal such as white metal, as shown at R^2.

In the construction illustrated in Figures 4, 5 and 6, T is the cylinder of a sleeve valve air compressor having a plug-like cylinder head T^1, for example similar to that illustrated in Figures 1 and 2, the sleeve valve U of which is provided with a ring of delivery ports U^1 adapted to register during the delivery period with an annular slot T^2 in the cylinder wall. In this construction two sealing rings V, V^1 are disposed in a recess in the cylinder wall immediately above the slot T^2 and two similar sealing rings V^2, V^3 are disposed in a similar recess immediately below this slot.

Instead of the upper end of the cylinder wall being constituted by a removable tubular distance piece such as the distance piece E shown in Figure 1, this portion of the cylinder is formed integral with the lower portion thereof. In order to allow the rings V, V^1, V^2, V^3 to be removed and replaced these rings are each formed in four parts, these parts being arranged so that the gaps in adjacent rings are staggered as shown in Figures 5 and 6. A perforated distance piece W is disposed between the rings V^1, V^2 and serves to maintain them in position in their recesses as shown, the compressed air or gas passing through the perforations in this distance piece.

In some cases instead of providing a removable tubular distance piece such as the member E shown in Figure 1, or providing divided sealing rings such as those shown in Figures 4, 5 and 6, undivided sealing rings may be employed and the cylinder may be formed in two parts separable in a transverse plane passing through the delivery port T^2 so as to allow for the insertion and removal of the rings.

It is to be understood that the details of construction and the form of sealing ring used may vary within wide limits without departing from this invention. Thus for example although in the constructions particularly described the sealing rings are coated over their rubbing surfaces with plastic or fusible metal, they are not necessarily so coated. Further, the invention is not limited to sleeve valve air compressors in which the sleeves have a combined oscillating and reciprocating motion but may be applied to such air compressors in which the sleeves have either a plain reciprocating motion or a plain rotary or oscillating motion, the compressors being either of the single stage or of the multi-stage type.

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

1. A sleeve valve compressor for gas including in combination, a cylinder having an annular delivery port, a sleeve valve within the cylinder having a ring of delivery ports adapted to register with the annular delivery port during the delivery period, a piston reciprocating within the sleeve valve, mechanism for imparting motion to the sleeve valve, a sealing ring mounted in a recess in the cylinder and engaging the exterior of the sleeve, this ring being so disposed as to constitute the lower edge of the annular delivery port, and means for preventing axial movement of the ring relatively to the cylinder.

2. A sleeve valve compressor for gas including in combination, a cylinder having an annular delivery port, a sleeve valve within the cylinder having a ring of delivery ports adapted to register with the annular delivery port during the delivery period, a piston reciprocating within the sleeve valve, mechanism for imparting motion to the sleeve valve, sealing rings mounted in recesses in the cylinder so as to constitute the upper and lower edges of the annular delivery port and engaging the exterior of the sleeve, and means for preventing axial movement of the rings relatively to the cylinder.

3. A sleeve valve compressor for gas including in combination, a cylinder having an annular delivery port, a sleeve valve within the cylinder having a ring of delivery ports adapted to register with the annular delivery port during the delivery period, mechanism for imparting motion to the sleeve valve, a piston reciprocating within the sleeve valve, sealing rings mounted in recesses in the cylinder so as to constitute the upper and lower edges of the annular delivery port and engaging the exterior of the sleeve, and an annular perforated distance piece disposed in the outlet port between the rings and serving to maintain the rings in their recesses, the gas delivered passing through the perforations in this distance piece.

4. A sleeve valve compressor for gas including in combination, a cylinder having an annular delivery port, a sleeve valve within the cylinder having a ring of delivery ports adapted to register with the annular delivery port during the delivery period, a piston reciprocating within the sleeve valve, mechanism for imparting motion to the sleeve valve, a sealing ring mounted in a recess in the cyl-

inder and engaging the exterior of the sleeve this ring being so disposed as to constitute the lower edge of the annular delivery port and comprising an annular trough-like member the interior of which is open to the delivery pressure and having such relatively thin walls that this pressure tends to force the inner circumferential wall of the ring into contact with the sleeve, and means for preventing axial movement of the ring relatively to the cylinder.

5. A sleeve valve compressor for gas including in combination, a cylinder having an annular delivery port, a sleeve valve within the cylinder having a ring of delivery ports adapted to register with the annular delivery port during the delivery period, a piston reciprocating within the sleeve valve, mechanism for imparting motion to the sleeve valve, sealing rings mounted in the cylinder so as to constitute the upper and lower edges of the annular delivery port and engaging the exterior of the sleeve, each sealing ring comprising an annular trough-like member the interior of which is open to the delivery pressure and having such relatively thin walls that this pressure tends to force the inner circumferential wall of the ring into contact with the sleeve, and means for preventing axial movement of the rings relatively to the cylinder.

6. A sleeve valve compressor for gas including in combination, a cylinder having an annular delivery port, a sleeve valve within the cylinder having a ring of delivery ports adapted to register with the annular delivery port during the delivery period, a piston reciprocating within the sleeve valve, mechanism for imparting motion to the sleeve valve, sealing rings mounted in recesses in the cylinder so as to constitute the upper and lower edges of the annular delivery port and engaging the exterior of the sleeve, each sealing ring comprising an annular trough-like member the interior of which is open to the delivery pressure and having such relatively thin walls that this pressure tends to force the inner circumferential wall of the ring into contact with the sleeve, and an annular perforated distance piece disposed in the outlet port between the rings and serving to maintain the rings in their recesses, the gas delivered passing through the perforations in the distance piece.

7. A sleeve valve compressor for gas including in combination, a cylinder having an annular delivery port, a sleeve valve within the cylinder having a ring of delivery ports adapted to register with the annular delivery port during the delivery period, a piston reciprocating within the sleeve valve, mechanism for imparting motion to the sleeve valve, a removable tubular member constituting the upper portion of the inner wall of the cylinder, the annular delivery port being formed between the lower end of this tubular member and the upper end of the lower portion of the inner cylinder wall, sealing rings disposed in recesses respectively in the lower end of the tubular member and the upper end of the lower portion of the inner cylinder wall so as to constitute respectively the upper and lower edges of the annular delivery port, these rings engaging the exterior of the sleeve, and an annular perforated distance piece disposed in the outlet port between the rings and serving to maintain them in their recesses as set forth.

8. A sleeve valve compressor for gas including in combination, a cylinder having an annular delivery port, a sleeve valve within the cylinder having a ring of delivery ports adapted to register with the annular delivery port during the delivery period, a piston reciprocating within the sleeve valve, mechanism for imparting motion to the sleeve valve, a removable tubuluar member constituting the upper portion of the inner wall of the cylinder, the annular delivery port being formed between the lower end of this tubular member and the upper end of the lower portion of the inner cylinder wall, sealing rings disposed in recesses respectively in the lower end of the tubular member and the upper end of the lower portion of the inner cylinder wall so as to constitute respectively the upper and lower edges of the annular delivery port, these rings engaging the exterior of the sleeve, and an annular perforated distance piece disposed in the outlet port between the rings and serving to maintain them in their recesses, each sealing ring comprising an annular trough-like member the interior of which is open to the delivery pressure and having such relatively thin walls that this pressure tends to force the inner circumferential wall of the ring into contact with the sleeve.

9. A sleeve valve compressor for gas including in combination, a cylinder, a sleeve valve within the cylinder, the cylinder having an annular delivery port with which registers a ring of delivery ports in the sleeve during the delivery period and inlet ports disposed below the annular delivery port and adapted to register with inlet ports in the sleeve during the inlet period, a piston reciprocating within the sleeve valve, mechanism for imparting motion to the sleeve valve, a sealing ring mounted in a recess in the cylinder and engaging the exterior of the sleeve, this ring being so disposed as to constitute the lower edge of the annular delivery port, means for preventing axial movement of the ring relatively to the cylinder and at least one sealing ring mounted in a recess in the cylinder and engaging the sleeve at a point below the inlet ports for the purpose set forth.

10. A sleeve valve compressor for gas in-

cluding in combination, a cylinder, a sleeve valve within the cylinder, the cylinder having an annular delivery port with which registers a ring of delivery ports in the sleeve during the delivery period and inlet ports disposed below the annular delivery port and adapted to register with inlet ports in the sleeve during the inlet period, a piston reciprocating within the sleeve valve, mechanism for imparting motion to the sleeve valve, sealing rings mounted in recesses in the cylinder so as to constitute the upper and lower edges of the annular delivery port and engaging the exterior of the sleeve, means for preventing axial movement of the rings relatively to the cylinder, and at least one sealing ring carried by the cylinder and engaging the sleeve at a point below the inlet ports for the purpose set forth.

11. A sleeve valve compressor for gas including in combination, a cylinder, a sleeve valve within the cylinder, the cylinder having an annular delivery port with which registers a ring of delivery ports in the sleeve during the delivery period and inlet ports disposed below the annular delivery port and adapted to register with inlet ports in the sleeve during the inlet period, a piston reciprocating within the sleeve valve, mechanism for imparting motion to the sleeve valve, a sealing ring carried by the cylinder and engaging the exterior of the sleeve, this ring being so disposed as to constitute the lower edge of the annular delivery port and comprising an annular trough-like member the interior of which is open to the delivery pressure and having such relatively thin walls that this pressure tends to force the inner circumferential wall of the ring into contact with the sleeve, means for preventing axial movement of the ring relatively to the cylinder and at least one sealing ring carried by the cylinder and engaging the sleeve at a point below the inlet ports for the purpose set forth.

12. A sleeve valve compressor for gas including in combination, a cylinder, a sleeve valve within the cylinder, the cylinder having an annular delivery port with which registers a ring of delivery ports in the sleeve during the delivery period and inlet ports disposed below the annular delivery port and adapted to register with inlet ports in the sleeve during the inlet period, a piston reciprocating within the sleeve valve, mechanism for imparting motion to the sleeve valve, sealing rings mounted in the cylinder so as to constitute the upper and lower edges of the annular delivery port and engaging the exterior of the sleeve, each sealing ring comprising an annular trough-like member the interior of which is open to the delivery pressure and having such relatively thin walls that this pressure tends to force the inner circumferential wall of the ring into contact with the sleeve, means for preventing axial movement of the rings relatively to the cylinder, and at least one sealing ring carried by the cylinder and engaging the sleeve at a point below the inlet ports for the purpose set forth.

13. A sleeve valve compressor for gas including in combination, a cylinder, a sleeve valve within the cylinder, the cylinder having an annular delivery port with which registers a ring of delivery ports in the sleeve during the delivery period and inlet ports disposed below the annular delivery port and adapted to register with inlet ports in the sleeve during the inlet period, a piston reciprocating within the sleeve valve, mechanism for imparting motion to the sleeve valve, a removable tubular member constituting the upper portion of the inner wall of the cylinder, the annular delivery port being formed between the lower end of this tubular member and the upper end of the lower portion of the inner cylinder wall, sealing rings disposed in recesses respectively in the lower end of the tubular member and the upper end of the lower portion of the inner cylinder wall so as to constitute the upper and lower edges of the annular delivery port, these rings engaging the exterior of the sleeve, an annular perforated distance piece disposed in the delivery port between the rings and serving to maintain them in their recesses and at least one sealing ring carried by the cylinder and engaging the sleeve at a point below the inlet ports for the purpose set forth.

14. A sleeve valve compressor for gas including in combination, a cylinder, a sleeve valve within the cylinder, the cylinder having an annular delivery port with which registers a ring of delivery ports in the sleeve during the delivery period and inlet ports disposed below the annular delivery port and adapted to register with inlet ports in the sleeve during the inlet period, a piston reciprocating within the sleeve valve, mechanism for imparting motion to the sleeve valve, a removable tubular member constituting the upper end of the inner wall of the cylinder, the annular delivery port being formed between the lower end of this tubular member and the upper end of the lower portion of the inner cylinder wall, sealing rings disposed in recesses respectively in the lower end of the tubular member and the upper end of the lower portion of the inner cylinder wall so as to constitute the upper and lower edges of the annular delivery port, these rings engaging the exterior of the sleeve and each comprising an annular trough-like member the interior of which is open to the delivery pressure and having such relatively thin walls that this pressure tends to force the inner circumferential wall of the ring into contact with the sleeve, an annular perforated distance piece disposed in the outlet port be-

tween the rings and serving to maintain them in their recesses, and at least one sealing ring carried by the cylinder and engaging the sleeve at a point below the inlet ports for the purpose set forth.

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

HARRY RALPH RICARDO.