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A. BAUMANN ET AL

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COMPRESSOR APPARATUS

Filed Feb. 19, 1926

Fig. 1.

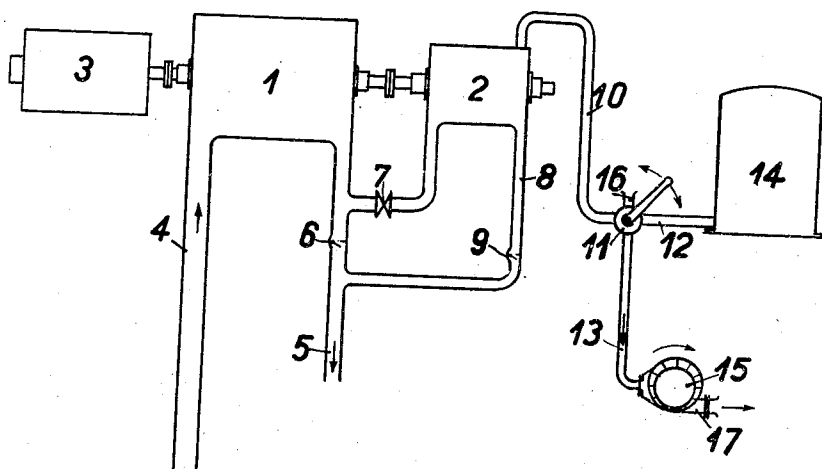


Fig. 2.

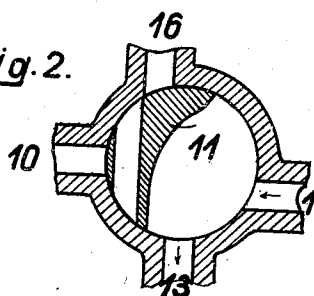


Fig. 3.

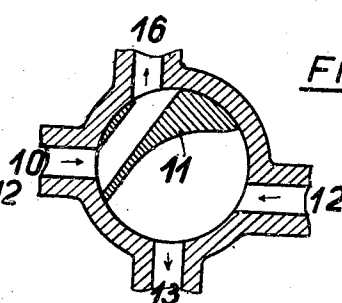


Fig. 4.

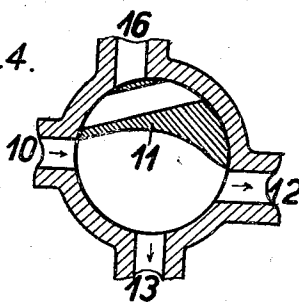
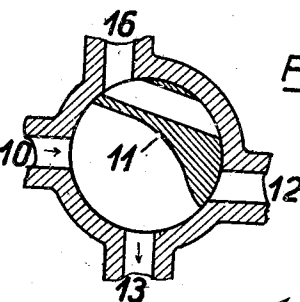


Fig. 5.



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COMPRESSOR APPARATUS

Application filed February 19, 1926, Serial No. 89,272, and in Germany April 6, 1925.

This invention relates to compressing apparatus in which rotary compressors are employed for compressing a fluid medium. Its general purpose is the provision of an apparatus for effecting economy in the operation of rotary compressors which are used intermittently.

Another object is the provision of apparatus whereby the resistance to the compressor may be reduced when it is running light, yet the compressor maintained in such condition of operation that its effectiveness may be availed of immediately when desired.

A further object is the provision of means whereby the apparatus may be controlled with facility and certainty.

Other and further objects will be pointed out hereinafter, indicated in the appended claims, or obvious to one skilled in the art upon an understanding of the present disclosure.

In the drawing forming a part of this specification we show one arrangement of means embodying the invention, but this is presented for purpose of illustration only, as it is intended that the invention, as defined in the claims, may be embodied in different and varying forms. In the drawing

Fig. 1 is a diagrammatic representation of the improved apparatus and

Figs. 2 to 5 inclusive are diagrammatic representations of various positions of the control valve.

There are many kinds of service, for example, in the operation of Bessemer converters, in which the actual employment of the compressor is required only intermittently, there being, between the blast periods, intervals during which the compressor runs light. In such circumstances the no-load losses of the compressor contribute considerably to the operating cost. By means of the present invention, the no-load losses of rotary compressors may be reduced to a minimum, either entirely without change of speed, or with only a very small change. Described generally, the invention contemplates apparatus for closing the compressor on the suction and delivery sides during the no-load period and for putting it under vacuum by special means.

In this way, assuming for example, that the pressure is reduced to one tenth of its original value, the no-load losses will be only 3% instead of 30%. The plan of reducing the no-load losses by closing the suction branch and opening the delivery to atmosphere, so that a sub-atmospheric pressure is produced in the casing, is a well-known one. Nevertheless, this sub-atmospheric pressure progressively decreases from the delivery to the suction side of the compressor, so that, assuming a pressure ratio of 3, the average pressure would amount to approximately

$$\frac{1.0 + 0.33}{2} = 0.65 \text{ at. abs.}$$

On the other hand, if a vacuum pump be used to maintain a vacuum of 90% = 0.1 at. abs. in the compressor, then given the same pressure ratio, which it is known is independent of the suction pressure for rotary compressors, the suction pressure will be 0.033 at. abs. and the average pressure

$$\frac{0.1 + 0.033}{2} = 0.065 \text{ at. abs.}$$

The no-load losses will therefore amount to only $0.033 \times 30\% = 1\%$ roughly. This reduction of the no-load losses is practicable with rotary compressors in particular owing to the fact that these losses are chiefly due to windage, which varies as the absolute pressure of the enclosed medium.

When the working conditions change at short intervals, as for example in connection with the blast supply for Bessemer converters, the vacuum must be created as rapidly as possible so that the possible gain may be utilized throughout the whole period of reduced load. In such cases the production of the vacuum may be accelerated by connecting the compressor, after its pressure has been reduced as much as possible by discharging to atmosphere, to a vacuum chamber. The further exhaustion of the compressor and chamber is carried out by means of a vacuum pump. In order that the time taken for the further exhaustion of the compressor may not be prolonged by the presence of the vacuum chamber, the latter may be isolated after perform-

ing its function so that the pump has only the contents of the compressor to remove. During the periods of normal working for the compressor, the vacuum pump is connected
 5 to the chamber so that the latter is again brought up to the full vacuum. This accumulator arrangement possesses the advantage of reducing the time required for exhaustion and a further advantage in that the pump
 10 can be run continuously, which, particularly when changing-over must be performed very frequently, is of great value. The power required by the vacuum pump itself is small. For example, suppose it is required to re-
 15 duce the pressure from 0.5 to 0.1 at. abs.; as the pump is discharging to atmosphere it will have to overcome a pressure ratio which varies between

$$20 \quad \frac{1.0}{0.5} = 2 \text{ and } \frac{1.0}{0.1} = 10.$$

The isothermal work of compression per 10 cubic metres of air received per minute will
 25 be:

$$L = \frac{p_1 \times V_1 \times \ln \frac{p_2}{p_1}}{60 \times 75} = 7.7 \text{ to } 5.1 \text{ H. P.,}$$

30 or assuming an isothermal efficiency of 50%, about 15 to 10 H. P. It should not be difficult with the given final vacuum of 90% = 0.1 at. abs. to keep the leakage losses at glands and valves, of a 1000 H. P. compressor for ex-
 35 ample, within the value of 10 cu. metres per minute assumed above, so that the power required by the vacuum pump would amount to between only 1.5% and 1% of that of the main compressor. Assuming the bearing
 40 friction to remain constant at 1%, the total no-load losses in the above case would be 2.5% to 2%. With such a vacuum, a state of equilibrium is reached in which the leakage volume and the capacity of the pump balance
 45 out. By means of a specially designed four-way valve, also a subject of the present invention, the various changes described above may be performed by the operation of
 50 a single handle, thus throwing no special demands on the operator and preventing mistakes in operation.

Fig. 1 shows an example of an application of the invention, in which 1 may be the low-pressure stage and 2 the high-pressure stage
 55 of a compressor, both stages being driven from the motor 3. The high-pressure stage 2 is required only occasionally and during such time is isolated from the pressure system 5 by a valve 7 and non-return valve 9,
 60 for example. Under normal working conditions the medium to be compressed enters the suction branch 4, passes through the low-pressure stage 1, the valve 7, the high-pressure stage 2, the pipe 8 and thence through
 65 the non-return valve 9 into the pressure pipe

5, the non-return valve 6 closing automatically. By closing the valve 7 the high-pressure stage 2 is cut out, the medium passing from the low-pressure stage direct to the pressure
 70 pipe 5 through the non-return valve 6. The non-return valve 9 then closes automatically so that the high pressure stage runs light. The four-way valve 11 is now turned from its
 75 initial position shown in Fig. 2, so that the isolated high-pressure cylinder 2 is put into communication with the atmosphere by way of the pipe 10 and opening 16, as in the position
 80 shown in Fig. 3. The cylinder thus reduces its internal pressure by discharging to atmosphere, the vacuum pump 15 meanwhile
 85 being in communication with vacuum chamber 14 through pipes 13 and 12. On turning the valve 11 still further so that communication at 16 with the atmosphere is interrupted and the pipe 10 is connected to the
 90 vacuum chamber 14 through pipe 12, and also placed in communication with the suction pipe 13 of the vacuum pump, as in Fig. 4, the pressure in the high-pressure compressor is still further reduced by equalization with
 95 that of the vacuum chamber, and the no-load losses of the high pressure compressor correspondingly reduced. On turning the four-way valve 11 still further to the position
 100 shown in Fig. 5, the vacuum chamber is isolated and pipe 10 remains in communication with the suction pipe 13 of the vacuum pump, which latter raises the vacuum in the high
 105 pressure cylinder to the highest possible value. Owing to the fact that this cylinder was previously connected to the vacuum chamber, this is performed in a very short time. If the high pressure cylinder is to
 110 be started up again, the four-way valve 11 is turned back in the opposite direction, which operation first puts the vacuum chamber 14 in communication with the pump and the high
 115 pressure cylinder, with the result that the vacuum in the latter drops somewhat due to the equalization of pressure with that in the vacuum chamber. A further movement of the four-way valve opens the compressor to
 120 atmosphere and the pressure again rises. Finally the opening 16 is closed (Fig. 2) and the compressor returns to normal working conditions after opening the valve 7. If the
 125 medium being compressed must not be permitted to escape into the atmosphere, the discharge openings 16 and 17 may be joined to the suction pipe 4 of the low pressure compressor 1.

The vacuum pump may be of the reciprocating, rotary, or ejector type. It may be so
 125 arranged that the pump is automatically shut down when the vacuum in the chamber reaches a maximum, and started up again when the vacuum falls. In this way the pump will not be running unnecessarily.

The device may be employed not only for the arrangement of compressors shown in 130

Fig. 1, but is suitable for any other arrangement desired. For example, the low pressure stage of a multi-stage compressor or one of two compressors in parallel may be intermittently withdrawn from service and evacuated with a corresponding arrangement.

What we claim is:

1. Compressing apparatus comprising the combination with a rotary compressor, of a vacuum chamber, means for closing the compressor against influx of air, and means for putting the compressor into communication with the vacuum chamber.

2. Compressor apparatus comprising the combination with a rotary compressor, of a chamber for communication therewith, means for closing the compressor against influx of air, means for exhausting the chamber, and means for cutting the chamber into and out of communication with the compressor.

3. Compression apparatus comprising the combination with a rotary compressor, of a vacuum chamber, means for closing the compressor against influx of air, and means for consecutively turning the compressor exhaust to atmosphere and connecting the compressor to the vacuum chamber.

4. Compression apparatus comprising in combination, a rotary compressor, a vacuum chamber and a vacuum pump, all arranged for communication, and means for placing the pump inlet into communication with the compressor and chamber selectively.

5. Compressing apparatus, comprising, in combination, a rotary compressor, a vacuum chamber, a vacuum pump, and means for placing each thereof into communication with either of the others selectively.

6. Compressing apparatus comprising, in combination, a rotary compressor, a vacuum chamber, a vacuum pump, means for closing the compressor against air influx, and means for rendering the chamber and pump effective on the compressor.

7. Compressing apparatus comprising, in combination, a rotary compressor, means for closing same against influx of air, a vacuum chamber, a vacuum pump, and means for putting the compressor into communication with said other devices or atmosphere, selectively.

8. Compressor apparatus comprising, in combination, a rotary compressor, a vacuum chamber, a vacuum pump, a selectively operable valve for establishing communication between any one of the same and any one of the others, and means for closing the normal inlet and outlet of the compressor.

9. The combination with compressor apparatus and fluid-evacuating means therefor, of a fluid chamber; valve means having a given operating position providing for communication between said fluid-evacuating means and said chamber to the exclusion of said apparatus, another operating position providing for communication between said

apparatus and said chamber, and still another operating position providing for communication between said apparatus and said fluid-evacuating means to the exclusion of said chamber; and means for actuating said valve means to place the same in said various operating positions thereof.

10. The combination with compressor apparatus and fluid-evacuating means therefor, of a fluid chamber, a valve casing having an outlet opening; valve means disposed in said casing and having various operating positions and being operable when in said positions to provide for various predetermined conditions of communication and non-communication respectively between said apparatus, said fluid-evacuating means, said chamber and said outlet; and means for effecting movement of said valve means into said operating positions thereof.

11. The combination with compressor apparatus and fluid-evacuating means therefor, of a fluid chamber, and single means providing for various predetermined conditions of communication and non-communication between said apparatus and said fluid-evacuating means and said chamber.

12. The combination with compressor apparatus and fluid-evacuating means therefor, of a fluid chamber, a valve casing having an outlet opening; a valve disposed in said casing and having a first position providing for communication between said means and said chamber to the exclusion of said apparatus, a second position providing for communication between said apparatus and said outlet and independent communication between said means and said chamber, a third position providing for communication between said apparatus and said means and said chamber, and a fourth position providing for communication between said apparatus and said means to the exclusion of said chamber; and means for actuating said valve to place the same in said positions thereof.

In testimony whereof we have hereunto subscribed our names at Zurich, Switzerland, on the 20th day of January, A. D. 1926.

ADOLF BAUMANN.

ADOLF MEYER.