July 16, 1940. C. E. NICOLET 2,208,428

APPARATUS FOR CONTROLLING COMPRESSOR CAPACITY

Filed June 4, 1938 2 Sheets-Sheet 1

Fig. 1.

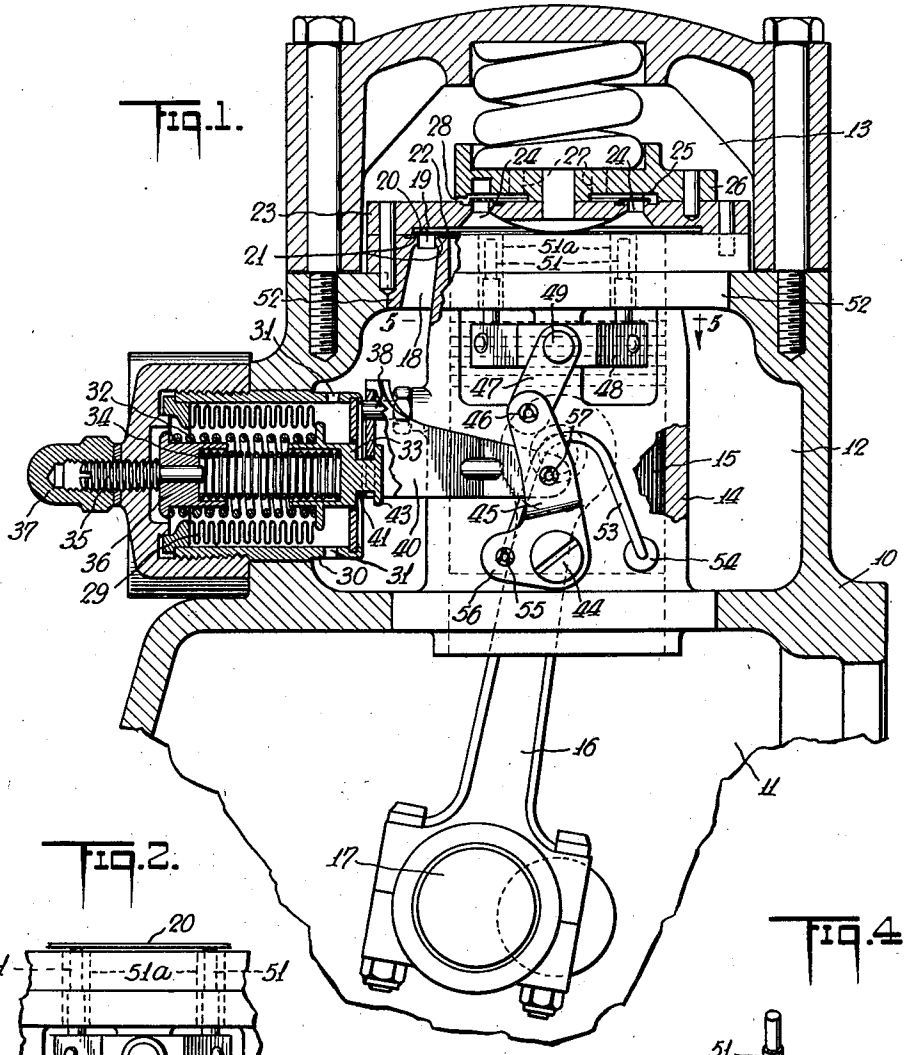


Fig. 2.

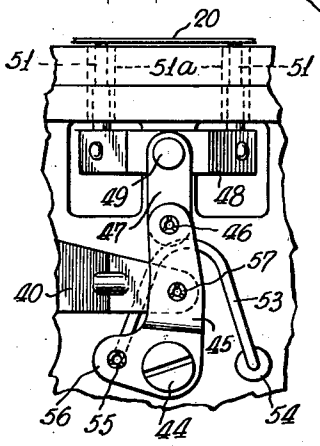


Fig. 3.

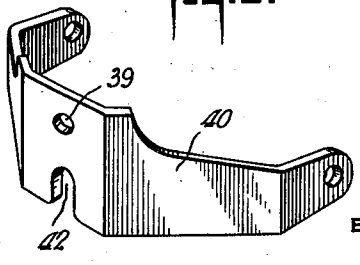
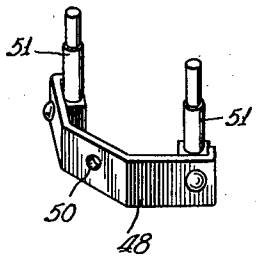


Fig. 4.



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APPARATUS FOR CONTROLLING COMPRESSOR CAPACITY

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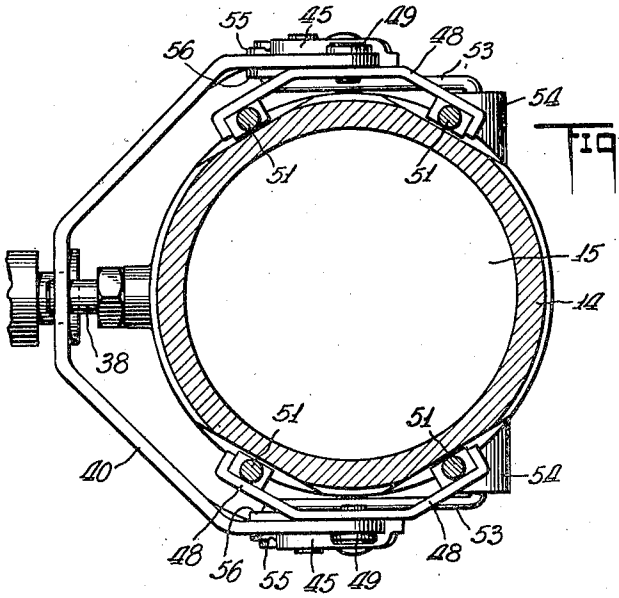


Fig. 5.

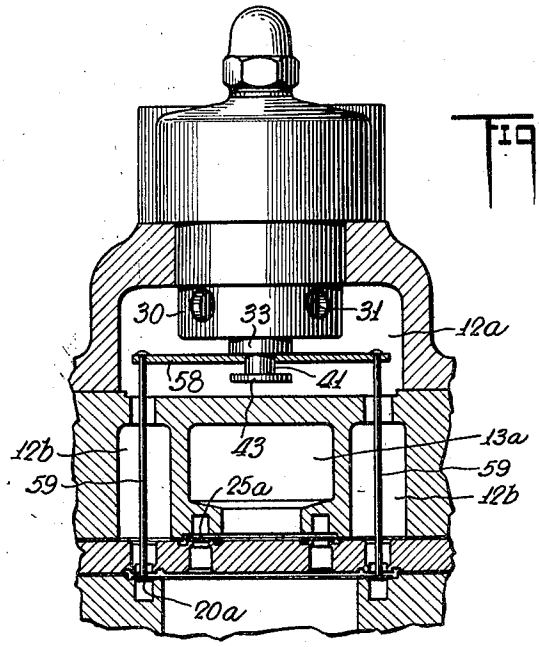


Fig. 6.

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UNITED STATES PATENT OFFICE

2,208,428

APPARATUS FOR CONTROLLING COMPRESSOR CAPACITY

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Application June 4, 1938, Serial No. 211,755

12 Claims. (Cl. 230—30)

This invention relates to fluid compressors, and more particularly to compressors used in conjunction with refrigerating systems.

The general object of the invention is to provide an improved method of and apparatus for controlling the capacity of fluid compressors.

Another object of the invention is to provide for the reduction of the capacity of a fluid compressor in such manner that when the capacity is reduced the power input to the compressor is correspondingly reduced.

It is another object of the invention to provide a system of compressor capacity control which is simple, inexpensive and reliable and which results in efficient operating conditions regardless of whether the compressor is operated at full or partial load.

A feature of the invention resides in maintaining constant communication between the suction line serving the compressor and one or more of the cylinders or compressing elements thereof whenever the pressure in the suction line falls below a predetermined point. The reduction of pressure obtaining in the suction line of a compressor serving a refrigerating system indicates a reduction in the load upon the compressor, and under such conditions all of the required compressing action might be provided, for example, by a lesser number of cylinders than the total number with which the compressors is provided.

A feature of the invention, therefore, resides in constantly maintaining in open position the suction valves serving one or more compressing elements of a compressor apparatus whenever the suction pressure or, in other words, the load on the compressor apparatus, falls below a predetermined point.

Another feature of the invention resides in providing an automatically operative pressure-responsive control element, subjected to the suction pressure, for fixedly maintaining the suction valve mechanism serving one or more compressor elements in open position whenever the suction pressure falls below a predetermined point, while permitting said suction valve mechanism to operate in normal manner whenever the suction pressure exceeds said point.

Those compressor elements whose suction valve mechanisms are maintained open are, in effect, cut out of active compressing service, for the gas displaced by such elements is merely pumped back to the suction line and, by reason of the fact that no substantial increase in pressure is provided for by operation of the compressing elements under such conditions, no fluid is discharged from the compressing elements into the normal high pressure discharge line of the compressor. The compressor elements which are thus cut out of active compression service require a power input sufficient only to overcome friction losses. Accordingly, the power consumption of the entire apparatus varies very nearly in proportion to the number of cylinders functioning in the normal manner. Thus, for example, if one cylinder of a two-cylinder compressor is cut out of service (that is, if fluid from one cylinder is re-supplied from the cylinder back to the suction line upon what would normally be the compression stroke), the power necessary to drive the compressor would approximate one-half of the power required when both of the cylinders are operating in the normal manner.

Other objects, features and advantages of the invention will be more apparent from the following description to be read in connection with the accompanying drawings in which:

Fig. 1 represents a fragmentary view partly in section of a compressor apparatus embodying one form of the invention;

Fig. 2 is a fragmentary elevational view illustrating a portion of the valve control mechanism of Fig. 1 in operative position;

Fig. 3 is a view in perspective of a yoke employed for operating the valve-lifting assemblies;

Fig. 4 is a view in perspective of one of the valve-lifting assemblies;

Fig. 5 is a view taken on the line 5—5 of Fig. 1; and

Fig. 6 is a view, partly in section, and similar to Fig. 1, illustrating a modified form of the invention.

Referring now to the drawings, numeral 10 designates generally a compressor having a crankcase 11, and a suction manifold 12, adapted to receive fluid to be compressed through any suitable opening (not shown) from, for example, the evaporator of a refrigerating system of which the compressor 10 comprises a part. Numeral 13 designates a discharge manifold into which compressed fluid is discharged from the cylinders of the compressor. While only one cylinder 14, provided with a piston 15, is shown, it is to be understood that any number of cylinders may be utilized without departing from the scope of the invention, and that generally the invention is utilized in connection with compressor apparatus comprising two or more compressing elements. Each piston 15 is actuated by a connecting rod 16 suitably connected to a crank shaft 17 driven in any desired manner.

In a manner well understood in the art, each cylinder 14 is connected with suction manifold 12 through one or more passages 18 communicating with annular chamber 19. Flow of fluid from chamber 19 into the cylinders is controlled by annular disc valve 20 adapted, when closed, to be seated upon valve seats 21 formed at the upper extremities of the chamber 19. In a manner well understood, a recess 22 is formed in the valve guide member 23 to provide for communication between chamber 19 and the cylinder interior, and to guide the valve 20 in its reciprocating motion. Guide member 23 is provided with a plurality of discharge outlets 24, the flow through which outlets is controlled by annular disc valve 25, which is adapted to reciprocatingly move within valve guide member 26. Passages 27 and 28 provide for flow of compressed gas from the valve 25 to the discharge manifold 13.

It will be noted that the suction valve 20 is concentric with and is of greater diameter than the cylinder 14.

Formed within the casing of the compressor 10 and subject to the suction pressure obtaining in suction manifold 12 is an expansible bellows 29 contained within a casing 30 which is preferably apertured, as indicated at 31, to provide communication between the interior of the casing 30 and the suction manifold 12. Within the expansible bellows 29, the interior of which is sealed from the suction chamber 12, there is positioned a spring 32 which tends to elongate the bellows and thus to force the element 33, carried at the right and free end of the bellows 29, toward the right, as seen in Fig. 1. If desired, the interior of the bellows may be provided with an auxiliary spring 34. The springs 32 and 34 may be adjusted by turning screw 35 which bears against collar 36, against which the springs 32 and 34 are positioned. If desired, a cap 37 may be provided for covering the end of screw 35. The springs 32 and 34, and the bellows 29 within which they are contained, are so designed that when the pressure in manifold 12 is at or exceeds a predetermined point, the bellows 29 will be in relatively compressed condition; but when the pressure in the chamber 12 drops below this predetermined point, the combined pressures of the springs will serve to elongate the bellows, thus to move member 33 to the right.

The cylinder 14 is provided with a pin 38 which extends through an aperture 39 formed in a yoke 40 which extends halfway about the cylinder 14, the yoke being slidable upon pin 38. A stud 41 extending from the member 33 is fitted within aperture 42 of yoke 40 and is provided with a collar 43 adapted to engage the yoke.

Pivoted at the side of cylinder 14, as at 44, is an arm 45 which is pivotally connected by pin or the like 46 to a second arm 47. Thus arms 45 and 47 comprise a toggle joint. Arm 47 pivotally engages a member 48, approximately arcuate in shape, as by a pin or the like, 49, adapted to extend within the aperture 50 formed in the member 48. Member 48 carries a pair of upwardly extending pins 51 which extend through suitable apertures 51*a* formed in the member 52 in which inlet passages 18 are formed. Preferably, a member 48 with its pins 51 is provided at each side of the cylinder 14. It will be apparent, of course, that more than two such members 48 may be used, if desired, and that any number of pins corresponding to pins 51 may be used without departing from the scope of the invention. It is preferred to employ at least four pins 51 circumferentially spaced, since this assures level lifting of the valve 20.

Upon a decrease in the pressure obtaining in suction manifold 12 below a predetermined point, the bellows 29 will expand and the member 33 will abut the yoke 40 and move it to the right. This in turn will cause clockwise rotation of the arm 45 about the pin 44 and the counterclockwise rotation of the arm 47. Such rotation of the arms 45 and 47 constitutes a toggle-joint action which serves to raise the members 48 and the pins 51 mounted thereon, so that the suction valve 20 is raised by the pins 51, as shown in Fig. 2. So long as the valve 20 remains in raised position, compression within the cylinder 14 served thereby cannot be accomplished, since upon what would normally be the compression stroke, the gas which has been intaken within the cylinder is merely discharged back into the suction manifold 12.

Whenever the suction pressure in manifold 12 rises sufficiently to recompress the bellows 29, the arms 45 and 47 will return to the position indicated in Fig. 1 thus to lower the members 48 and to effect release of the valve 20 from the control of pins 51, and normal operation of the valve 20 will thereafter continue.

To provide for snap action of the lift pins 51, there is preferably provided an arched spring 53 pivotally connected to the side of the cylinder 14, as at 54. The other end of the spring 53 is pivotally connected at 55 to a crank arm extension 56 of arm 45. As will be apparent from inspection of Figs. 1 and 2, whenever the pins 51 are in the position of maximum lift, the pivot point 57 at which the yoke 40 is connected to arm 45 is off-center and to the right of a line connecting the centers of pins 44, 46 and 49. When the bellows 29 is compressed as the pressure in suction manifold 12 increases, the member 33 and hence the pivot point 57 are moved relatively slowly to the left and then, under the influence of spring 53, pivot point 57 is snapped rapidly to the left, the snap action being permitted by the travel of yoke 40 to the left along the stud 41 of member 33. The snap action thus provided quickly and effectively lowers the pins 51 and thus restores the valve 20 to normal operating condition. The spring 53 also facilitates the lifting of the valve 20 in a corresponding manner.

In Fig. 6 is illustrated a modification of the invention in which gas to be compressed is supplied from suction manifold 12*a* to suction passages 12*b* and thence to the cylinders, the compressed gas being delivered to discharge manifold 13*a* under the control of valve 25*a*. The bellows-operated stud 41 carries a yoke 58 from which depend a plurality of pins 59 extending through the suction passages 12*b* and adapted, when the yoke 58 is in maximum downward position, to hold the suction valve 20*a* in downward or open position. When the pressure in suction manifold 12*a* increases, the bellows is compressed and the yoke 58 is lifted by the collar 43, thus freeing the valve 20*a* to operate in normal manner.

If desired, different numbers of cylinders of a compressor may be arranged to cut out at different suction pressures by suitable adjustment of the individual bellows control devices associated therewith. Further, if so desired, a single bellows device, such as illustrated in Fig. 1, may be utilized to control the suction valves of two or more cylinders merely by sufficiently increasing the length of the yoke 40.

While the invention has been described with particular reference to a compressor of the reciprocating type, it will be apparent that the invention is not so limited but may be utilized in connection with various types of compressor apparatus. Further, while as above described it is contemplated that the cylinder 14 constitutes one compressing element of a compressor embodying a plurality of compressing elements, it is to be understood that, if desired, the invention may be utilized in connection with compressor apparatus having but a single compressing element, or for cutting out of service all of the compressing elements of a multi-compressing element apparatus. Thus interruption of compression action may be effected without stopping and starting of the compressor driving means.

Since many changes may be made in the invention without departing from its scope, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative only and not in a limiting sense, applicant limiting himself only as indicated in the appended claims.

I claim:

1. In a fluid compressor apparatus including a first compressing element, a second compressing element connected in parallel fluid flow arrangement with said first element, driving means for said elements, fluid supply means and a suction valve for controlling the communication between said fluid supply means and said first compressing element, the combination of a pressure-responsive element subjected to the pressure of said fluid supply means, and means under the control of said pressure-responsive element for maintaining said valve in opened position responsive to decrease in the fluid pressure in said supply means below a predetermined point.

2. In a fluid compressor apparatus including a first compressing element, a second compressing element connected in parallel fluid flow arrangement with said first element, driving means for said elements, fluid supply means and a suction valve for controlling the communication between said fluid supply means and said first compressing element, the combination of a pressure-responsive element subjected to the pressure of said fluid supply means and adapted to expand upon reduction of said pressure below a predetermined point, and means responsive to the expansion of said element for maintaining said valve in opened position, whereby constant communication between said fluid supply means and said first compressing element is maintained whenever the fluid pressure in said supply means falls below a predetermined point.

3. In a fluid compressor apparatus including a compressing element, driving means therefor, fluid supply means and a suction valve for controlling the communication between said fluid supply means and said compressing element, the combination of an expansible and contractable element subjected to the fluid pressure obtaining in said supply means and adapted to expand upon reduction of said pressure below a predetermined point, means adapted constantly to maintain said valve in opened position, and means for rendering operative said last-mentioned means responsive to the expansion of said expansible element and for rendering inoperative said last-mentioned means responsive to the contraction of said element.

4. In a fluid compressor apparatus including a compressing element, driving means therefor, fluid supply means and a suction valve for controlling the communication between said fluid supply means and said compressing element, the combination of an expansible element subjected to the fluid pressure obtaining in said supply means and adapted to expand upon reduction of said pressure below a predetermined point, means adapted constantly to maintain said valve in opened position, means for rendering operative said last-mentioned means responsive to the expansion of said expansible element and for rendering inoperative said last-mentioned means responsive to the contraction of said element, and adjustment means for controlling the expansion of said expansible element, whereby to regulate the pressure at which said expansible element will expand.

5. In a fluid compressor apparatus including a compressing element, driving means therefor, fluid supply means and a suction valve for controlling the communication between said fluid supply means and said compressing element, the combination of an expansible bellows subjected to the fluid pressure obtaining in said supply means and adapted to expand upon reduction of said pressure below a predetermined point, one end of said bellows being fixedly mounted while the other end of said bellows is free to move, means adapted to maintain said valve in opened position, and means responsive to movement of the free end of said bellows upon expansion of said bellows for rendering operative said last-mentioned means, said last-mentioned means being arranged to become inoperative upon contraction of said bellows.

6. In a fluid compressor apparatus including a compressing element, driving means therefor, fluid supply means and a suction valve for controlling the communication between said fluid supply means and said compressing element, the combination of an expansible bellows subjected to the fluid pressure obtaining in said supply means and adapted to expand upon reduction of said pressure below a predetermined point, one end of said bellows being fixedly mounted while the other end of said bellows is free to move, means adapted to maintain said valve in opened position, means responsive to movement of the free end of said bellows responsive to expansion of said bellows for rendering operative said last-mentioned means, said last-mentioned means being arranged to become inoperative upon contraction of said bellows, spring means within said bellows tending to expand said bellows, and means for adjusting the force exerted by said spring means, so that by adjustment of said spring means said bellows may be caused to expand at different predetermined fluid pressures in said fluid supply means.

7. In a fluid compressor apparatus including a compressing element, driving means therefor, fluid supply means and a suction valve for controlling the communication between said fluid supply means and said compressing element, the combination of an expansible bellows subjected to the fluid pressure obtaining in said supply means and adapted to expand upon reduction of said pressure below a predetermined point, one end of said bellows beig fixedly mounted while the other end of said bellows is free to move, means adapted to maintain said valve in opened position upon expansion of said bellows, said means including a toggle joint and valve-controlling means actuated by said toggle joint, and

a yoke actuated by the free end of said bellows and pivotally connected to said toggle joint.

8. In a fluid compressor apparatus including a compressing element, driving means therefor, fluid supply means and a suction valve for controlling the communication between said fluid supply means and said compressing element, the combination of an expansible bellows subjected to the fluid pressure obtaining in said supply means and adapted to expand upon reduction of said pressure below a predetermined point, one end of said bellows being fixedly mounted and the other end of said bellows being free to move, means adapted to maintain said valve in opened position upon expansion of said bellows to a predetermined degree, said means including a pair of toggle joints and valve-controlling elements actuated by said toggle joints, a yoke actuated by the free end of said bellows and pivotally connected to said toggle joints, and spring means for providing snap-action operation of said toggle joints, said yoke being slidably positioned upon an extension of the free end of said bellows.

9. In a fluid compressor apparatus including a compressing element, driving means therefor, fluid supply means and a suction valve for controlling the communication between said fluid supply means and said compressing element, the combination of an expansible bellows subjected to the fluid pressure obtaining in said supply means and adapted to expand upon reduction of said pressure below a predetermined point, one end of said bellows being fixedly mounted and the other end of said bellows being free to move, means adapted to maintain said valve in opened position upon expansion of said bellows to a predetermined degree, and means responsive to movement of the free end of said bellows for rendering operative said last-mentioned means, said last-mentioned means including a yoke actuated in response to expansion of said bellows, and a plurality of pins actuated by said yoke and adapted to engage said valve and to maintain said valve in opened position when said bellows is expanded.

10. In a fluid compressor apparatus including a compressing element, driving means therefor, fluid supply means and a suction valve for controlling communication between said fluid supply means and said compressing element, the combination of an expansible bellows subjected to the fluid pressure obtaining in said supply means and adapted to expand upon reduction of said pressure below a predetermined point, one end of said bellows being fixedly mounted and the other end of said bellows being free to move, a pair of toggle joints arranged on opposite sides of said compressing element, valve-engaging mechanism actuated by said toggle joints and adapted to engage and open said valve responsive to elongation of said toggle joints, and a yoke actuated by the free end of said bellows and adapted to elongate said toggle joints upon expansion of said bellows.

11. In a fluid compressor apparatus including a compressing element, driving means therefor, fluid supply means and a suction valve for controlling communication between said fluid supply means and said compressing element, the combination of an expansible bellows subjected to the fluid pressure obtaining in said supply means and adapted to expand upon reduction of said pressure below a predetermined point, one end of said bellows being fixedly mounted and the other end of said bellows being free to move, a pair of toggle joints arranged on opposite sides of said compressing element, valve-engaging mechanism actuated by said toggle joints and adapted to engage and open said valve responsive to elongation of said toggle joints, and a yoke actuated by the free end of said bellows and adapted to elongate said toggle joints upon expansion of said bellows, said valve-engaging mechanism comprising a pair of secondary yokes each actuated by one of said toggle joints, and a plurality of valve-engaging pins operated by said secondary yokes.

12. In combination, a plurality of compressor elements, feed means for supplying fluid to be compressed to said elements in parallel fluid flow arrangement, means arranged in parallel fluid flow arrangement for receiving compressed fluid from said elements, inlet valve means controlling communication between said feed means and at least one of said compressor elements, and means responsive to decrease of the pressure in said feed means below a predetermined point for maintaining said valve means in continuously opened position, said last-mentioned means including a pressure-responsive element subject to the pressure prevailing in said feed means, and valve actuating means under the control of said control element.

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DISCLAIMER

2,208,428.—*Constant E. Nicolet*, Syracuse, N. Y. APPARATUS FOR CONTROLLING COMPRESSOR CAPACITY. Patent dated July 16, 1940. Disclaimer filed December 11, 1941, by the assignee, *Carrier Corporation*.

Hereby enters this disclaimer to claims 1 and 12 of said patent.

[*Official Gazette January 6, 1942.*]