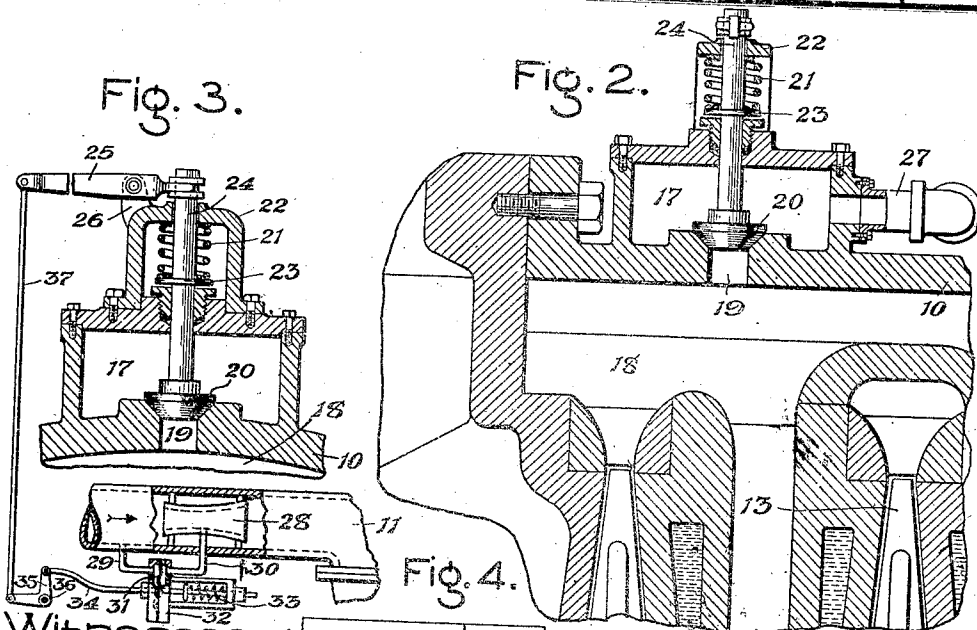
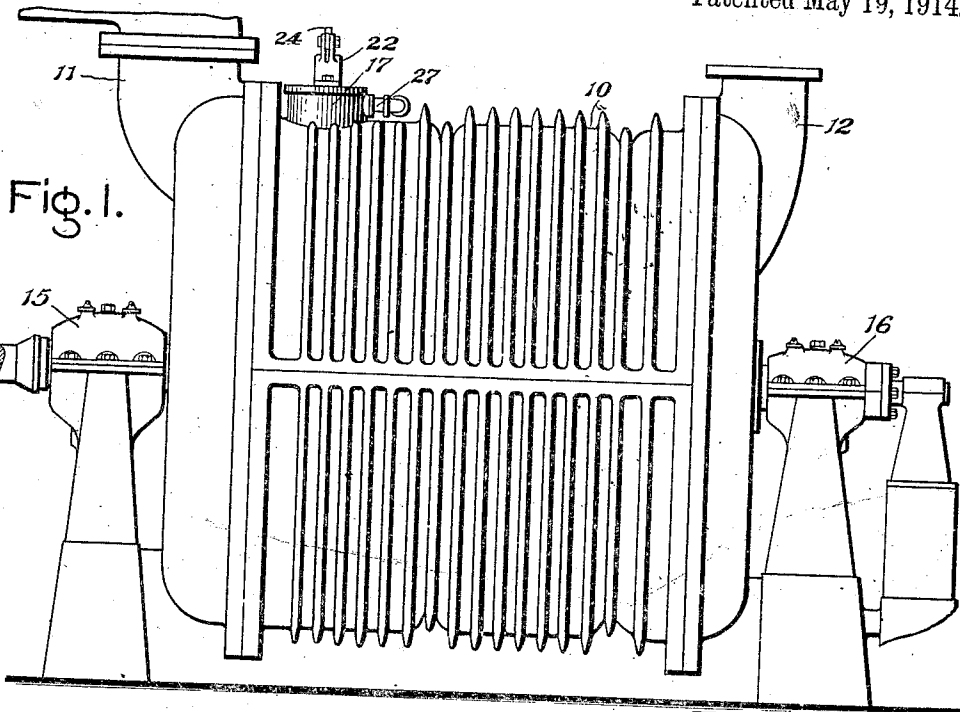


M. I. NUSIM.
 PREVENTING PULSATIONS IN CENTRIFUGAL COMPRESSORS.
 APPLICATION FILED SEPT. 11, 1913.

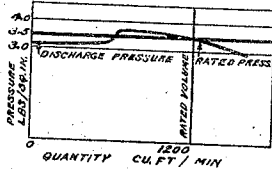
1,097,259.

Patented May 19, 1914.



Witnesses:

Marcus L. Byng.
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 by *Alfred Davis*
 Att'y.

UNITED STATES PATENT OFFICE.

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PREVENTING PULSATIONS IN CENTRIFUGAL COMPRESSORS.

1,097,259.

Specification of Letters Patent.

Patented May 19, 1914.

Application filed September 11, 1913. Serial No. 789,259.

To all whom it may concern:

Be it known that I, MELACH I. NUSIM, a citizen of the United States, residing at Lynn, county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Preventing Pulsations in Centrifugal Compressors, of which the following is a specification.

This invention relates to centrifugal air compressors of that type in which a rapidly rotating impeller throws the air through curved or tangential passages in a stationary diffusing ring surrounding said impeller. The action of these passages is to convert the velocity of the air into pressure, and when properly designed such machines may as in the present case operate on what is known as a rising characteristic. This means that the pressure does not remain constant for all volumes of air flowing through the intake, but varies with the volume delivered. In order to secure an efficient and stable operation, the pressure should be above a predetermined value, or so-called "rated pressure". If it drops below this, the diffusing ring causes the air column to fluctuate or pulsate. The pressure curve, plotted with varying volumetric output as abscissas, shows that it starts at a point slightly below the desired rated pressure and rises slowly as the volume increases until at about half load it becomes slightly in excess of said rated pressure, when it suddenly jumps up to a higher pressure. After this it maintains a fairly even pressure with increasing volume for some time, and then gradually drops to almost the rated pressure at full load. This sudden jump in pressure is called the critical or breakdown point, and is the source of great trouble when the compressor is trying to carry a light load, the pressure fluctuating violently and noisily and setting up dangerous vibrations and shocks in the machine, and preventing the delivery of a steady blast of air, which is what is desired from an air compressor.

My invention aims to overcome these very objectionable surgings or pulsations and insure a quiet, smooth operation of the compressor at all loads. I accomplish this by adjusting a multistage compressor to draw in a volume in excess of the breakdown load and then providing means for blowing off such portion of the air as is not needed at that point in the casing of the machine

where the least possible waste of air and energy can occur. By experiment I find that this is best effected by placing the blow-off valve at a point which permits the pressure to reach a certain value to establish equilibrium with a minimum waste of air. As the air passes from one stage to the next it increases in pressure, and it is obvious that if the valve were placed at the discharge a great waste would occur, and it is the object of my invention to locate the valve in such a position as to release air from the casing at the lowest possible pressure, whereby the stability of the compressor is regained with the least possible waste of air, and a saving in power necessary for driving is effected. Thus the preferable position of the valve in relation to the stages is about one-third the length of the casing away from the intake. In a three or four stage machine, the valve would be in the first stage; in a nine stage machine, at the third or fourth stage. The blow-off valve can be operated either by hand or automatically; in the latter case it is controlled by a device which is responsive preferably to the air pressure in the intake pipe of the compressor.

In the accompanying drawing which illustrates one embodiment of the invention, Figure 1 is a front elevation of a multistage centrifugal compressor with the valve in position. Fig. 2 is a fragmentary section of the compressor showing a blow-off valve. Fig. 3 is a cross-section of the same showing in addition an automatic regulator. Fig. 4 illustrates a curve which gives the pressure characteristics.

Referring to the drawings, 10 indicates a casing for a multistage centrifugal compressor having an intake 11 and a discharge 12. Located in the casing is an impeller 13 secured to the shaft which is mounted in the bearings 15 and 16. A chamber 17 is cast integral with the casing and is connected to the inner chamber 18 of the first stage of the compressor by a passage 19. Controlling this passage is a valve 20 which is normally held on its seat by the spring 21. One end of the spring 21 abuts against the rigid frame 22 and on the other against the washer 23 which is fast on the spindle 24. For opening the valve 20 a lever 25 is provided, fulcrumed on the bracket 26 which is cast with the frame 22. The lever 25 can be

manually operated or connected to an automatic regulator for opening the valve under pulsating condition. When the valve 20 is lifted from its seat air from the casing enters the chamber 17 and is led off through the pipe 27 and can be used for any desired purpose.

Located in the intake pipe 11 is a tube 28 acting like a Venturi tube which causes the air passing through it to increase in velocity and decrease in pressure, thereby causing a difference in pressure from that in the intake. These pressures are led off through the pipes 29 and 30 to the diaphragm 31 located in the casing 32. The high pressure when at or above the rated value acts against the diaphragm 31 and balances the low pressure and the spring 33. Secured to the diaphragm 31 is a spindle 34 the opposite end of which is secured to the bell crank 35 fulcrumed at 36. The rod 37 connects the bell crank 35 and the lever 25. The illustration is diagrammatic and the proportions of the parts are obviously incorrect from a practical standpoint.

When the discharge volume drops so low that the discharge pressure falls to or near to the breakdown point, the difference in pressures on the opposite sides of the diaphragm 31 becomes less due to the lessened rate of flow through the intake. The spring 33 is therefore able to overbalance the higher pressure and forces the spindle 34 to the left lifting the valve 20 to afford an additional discharge of air from the low pressure stage of the machine. Whether accomplished by hand or automatically, the effect of this is to permit a reduction below the breakdown point of the volume of air passing out of the discharge 12 while maintaining a volume entering through the intake 11 which is above the breakdown. The result of this is to stop the pulsations, because actual experience indicates that the breakdown point occurs for a certain minimum flow of air at the inlet of the machine, and if the flow at this point can be kept above said minimum no trouble will occur.

Fig. 4 illustrates a curve which gives the characteristics of a centrifugal compressor having rated volume and pressure and a discharge pressure indicated by the irregular line which cuts the line of rated pressure. As the flow or volume of air is reduced below the rated value, the pressure at first rises slightly, and when the volume is further reduced to one-half or one-third the rated value, there is a sudden drop in pressure which is due to the fact that the internal passages in the diffusing ring are not suited for efficient action at lighter loads.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention together with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. The method of preventing pulsations at light loads in a multi-stage centrifugal air compressor, which consists in running said machine at a rate of flow above the required load, and blowing off the excess of air from a lower stage.

2. A multistage centrifugal air compressor having means for blowing off air from a lower stage.

3. A multistage centrifugal air compressor having a blow-off opening in a lower stage of its casing and a valve controlling said opening.

4. A multistage centrifugal air compressor having a blow-off opening in a lower stage of its casing and a valve controlling said opening, a spring normally holding said valve closed, and means for opening said valve.

5. A multistage centrifugal air compressor having a blow-off opening in a lower stage of its casing and a valve controlling said opening, a spring normally holding said valve closed, and means for opening said valve automatically when the air pressure approaches the breakdown point.

6. A multistage centrifugal air compressor having a blow-off opening in a lower stage of its casing, a valve controlling said opening, a spring normally holding said valve closed, and means for opening said valve automatically when the air pressure approaches the breakdown point, comprising a device responsive to the flow of fluid in the intake of the machine, and operative connections between said device and the blow-off valve.

7. A multistage centrifugal compressor having a blow-off opening associated with an intermediate pressure stage, a valve controlling the opening, and a device responsive to changes in the rate of flow of the fluid passing through the compressor for opening the valve when the load on the compressor has been reduced to or below the breakdown point.

In witness whereof, I have hereunto set my hand this sixth day of September 1913.

MELACH I. NUSIM.

Witnesses:

J. A. McMANUS, Jr.,
FRANK G. HATTE.