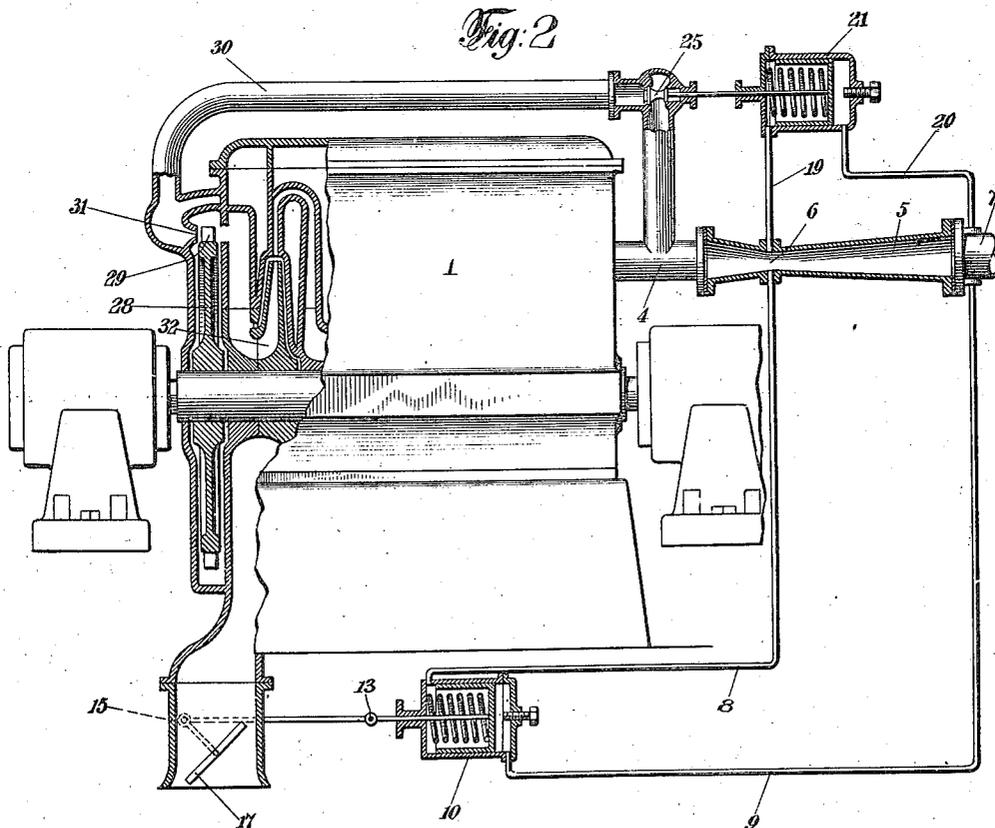
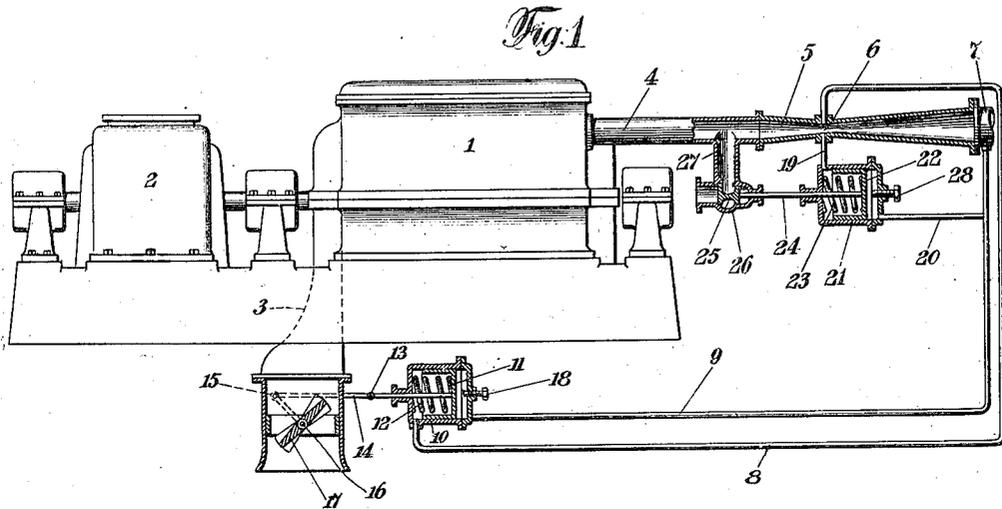


O. BANNER.  
 REGULATING MEANS FOR CENTRIFUGAL COMPRESSORS.  
 APPLICATION FILED OCT. 25, 1912.

1,154,959.

Patented Sept. 28, 1915.



Witnesses:  
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Inventor  
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# UNITED STATES PATENT OFFICE.

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## REGULATING MEANS FOR CENTRIFUGAL COMPRESSORS.

1,154,959.

Specification of Letters Patent. Patented Sept. 28, 1915.

Application filed October 25, 1912. Serial No. 727,649.

*To all whom it may concern:*

Be it known that I, OTTO BANNER, a subject of the German Emperor, residing at Easton, in the county of Northampton and State of Pennsylvania, have invented a certain new and useful Improvement in Regulating Means for Centrifugal Compressors, of which the following is a specification.

This invention relates to centrifugal compressors and more particularly to regulating means for such compressors.

Although centrifugal compressors can be designed to furnish air at practically constant pressure through quite a large range of volume there is a certain limit, according to the design of the compressor, below which the volume of the air, taken from the compressor, can not be decreased. Below this limit the air does not flow continuously through the compressor but the pressure backs up in certain places and forces its way back through the impellers causing a pulsation or "pumping," as it is called.

The object of the present invention is to provide a compressor and a regulating means for it which will allow the compressor to be operated through a large range of volume below this so called pumping limit.

With this object in view I have devised a regulating means, practical embodiments of which are shown in the accompanying drawings in which:

Figure 1 shows a partly diagrammatic side elevation of a compressor provided with my regulating means. Fig. 2 shows a similar view of a further refinement of the idea.

As shown in Fig. 1 the compressor comprises a centrifugal compressor 1 which may be of any desired construction driven by a motor 2. Air or other gas is taken into the compressor through the inlet pipe 3 and discharged through the exhaust pipe 4. Above the pumping limit the compressor is regulated according to its output by any ordinary speed governing means which is not shown here as it forms no part of the present invention. Below the pumping limit a further regulation is provided which will now be described.

To the exhaust pipe 4 is attached a demand measuring device, here shown as a Venturi tube 5 which, as is well known, maintains a difference of pressure in its throat 6 and its discharge opening 7 which varies in proportion to the amount of fluid

passing through the tube. This varying difference in pressure is applied to the regulating means of the compressor in the following manner:

From the throat 6 and discharge outlet 7, respectively, pipes 8 and 9 lead to opposite ends of a valve operating cylinder 10 in which slides a piston 11 which has a constant pressure toward the back end of the cylinder, into which leads the pipe 9, from a spring 12. This spring 12 is of such a strength that the piston 11 will take a position in the cylinder depending on the excess of pressure in the pipe 9 over that in the pipe 8. Attached to the piston 11 is a rod 13 which is secured by a link 14 to a lever 15. This lever 15 is secured to a shaft 16 on which is mounted a throttle valve or damper 17 placed across the opening of the inlet pipe 3 and adapted to open or close it according to its position, the connections to the piston 11 being such that the throttle valve tends to close as the difference in pressure in the ends of the cylinder 10 and accordingly in the throat and the discharge of the Venturi tube 5 is decreased.

A set screw 18 adjustably limits the rearward movement of the piston 11 and consequently the final position of the throttle valve 17. From the throat and discharge opening of the Venturi tube pipes 19 and 20 lead also to the front and rear ends of a second cylinder 21, provided with piston 22 and a spring 23 which is weaker than the spring 12. To the piston 22 is secured a rod 24 which operates a valve 25 set in a valve chest 26 in a pipe 27 which opens to the atmosphere from the discharge pipe 4 of the compressor. This valve is arranged to open upon rearward movement of the piston 22 due to a decreased difference in the pressure in the throat and discharge opening of the Venturi tube. An adjustable set screw 28 also limits the movement of the piston 22 and the valve 25.

In operation, the difference in pressure in the throat and discharge of the Venturi tube and the strength of the spring 12 are so adjusted that the piston 11 will be maintained in its extreme forward position and the throttle valve 17 remain in a fully open position as long as the amount delivered by the compressor through the Venturi tube is above the pumping limit of the compressor. As the demand on the compressor falls below

this limit and the difference in pressure in  
 the Venturi tube is decreased the piston 11  
 will be moved rearwardly closing the throt-  
 tle valve 17 to some extent. This will de-  
 5 crease the amount of air taken into the com-  
 pressor and hence prevent pumping. This  
 throttling of the intake however will not  
 prevent pumping below a certain limit so  
 that the throttle valve is allowed to close  
 10 only a certain amount, which is determined  
 by the position of the set screw 18. Here the  
 valve 25 takes up the regulation. The spring  
 23 is of such a strength that the piston 22  
 15 will be maintained in its forward position  
 and the valve 25 kept closed until the throt-  
 tle valve 17 has been closed to the desired ex-  
 tent by the piston 11. At this point the  
 spring 23 will overcome the difference in  
 20 pressure in the two ends of the cylinder and  
 will open the valve 25 an amount propor-  
 tionate to the decrease of the demand allow-  
 ing any excess of air over the demand to be  
 exhausted to the atmosphere. It will there-  
 25 fore be seen that the regulation of such com-  
 pressor takes place in three stages. Above  
 the pumping limit the ordinary speed regu-  
 lation is employed. When the pumping  
 limit is reached an additional regulation is  
 30 added in the form of a device for automati-  
 cally throttling the intake thus decreasing  
 the amount of air taken into the compressor  
 and preventing pumping. When the practi-  
 cal limit of this throttling regulation is  
 35 reached the compressor will run at constant  
 speed and with constant gross delivery, but a  
 portion of the air delivered to the discharge  
 line is exhausted to the atmosphere.

In Fig. 2 a further refinement is added  
 along the lines of the mechanism disclosed in  
 40 my copending application, Serial No.  
 727,650, filed October 25th, 1912, which de-  
 creases the power used in the third stage of  
 regulation. In this form the compressor is  
 provided at its forward end with a turbine  
 45 wheel 28 provided with blades 29, which is  
 directly mounted on the shaft of the com-  
 pressor. Instead of the air being allowed to  
 escape to the atmosphere when valve 25 is  
 open it is passed through a pipe 30 and di-  
 50 rected by one or more nozzles 31 on the  
 blades of the turbine wheel. From there the  
 air passes directly into the first impeller 32  
 of the compressor and again travels through  
 the compressor. In this way the compressed  
 55 air in the discharge line, which is allowed to  
 escape in the first form, is made to perform  
 useful work in actuating the turbine wheel  
 28 thus diminishing the load on the motor  
 driving the compressor an amount propor-  
 60 tionate to the air allowed to escape from the  
 discharge line and pass through the turbine  
 wheel.

It is to be understood that the present  
 65 showing and description discloses only cer-  
 tain specified modifications of my invention

and other forms and modifications are in-  
 cluded in the spirit and scope of the inven-  
 tion as expressed in the claims.

What I claim is:

1. In combination with a centrifugal com- 70  
 pressor, having an intake and a discharge  
 line, a demand measuring device in said dis-  
 charge line and means operated from said  
 demand measuring device, for serially chok-  
 75 ing the intake of the compressor and ex-  
 hausting the discharge line of the compres-  
 sor as the demand decreases.
2. In combination with a centrifugal com-  
 pressor having an intake and a discharge  
 line, a demand measuring device in said 80  
 discharge line, a valve for choking said in-  
 take, means operated from said measuring  
 device to close said valve as the demand de-  
 creases, a valve for exhausting said dis-  
 85 charge line, and means operated from said  
 measuring device to open said discharge line  
 valve as the demand decreases, said dis-  
 charge line valve operating means operating  
 at a lower demand than said intake choking  
 90 device.
3. In combination with a centrifugal com-  
 pressor having an intake and a discharge  
 line, a demand measuring device in said dis-  
 charge line, an intake choking valve having  
 a motor operated from said demand measur- 95  
 ing device arranged to close said valve as the  
 demand decreases below a predetermined  
 point, and a discharge exhausting valve for  
 said compressor, having a motor arranged  
 100 to open said discharge valve at a demand  
 lower than that at which said intake clos-  
 ing motor operates.
4. In combination with a centrifugal com-  
 pressor having an intake and a discharge 105  
 line, a Venturi tube, a valve for closing the  
 intake of said compressor, a valve for ex-  
 hausting the discharge of said compressor,  
 motors for operating said valves compris-  
 110 ing cylinders and pistons therein, and con-  
 nections from the said tube to one end of  
 each of said cylinders and from the dis-  
 charge of said tube to the other ends of said  
 cylinders, the piston in the intake valve  
 115 motor being arranged to operate at a greater  
 difference in pressure in the ends of its cyl-  
 nder than the piston in the discharge valve  
 motor.
5. In combination with a centrifugal com-  
 pressor having an intake and a discharge  
 line, a demand measuring device in said dis- 120  
 charge line, means operated from said de-  
 mand measuring device, for serially choking  
 the intake of the compressor and exhausting  
 the discharge line of the compressor as the  
 demand decreases, a fluid pressure engine 125  
 operatively connected with said compressor,  
 and means for conveying the exhaust fluid  
 from the discharge line to said engine.
6. In combination with a centrifugal com- 130  
 pressor having an intake and a discharge

line, a demand measuring device in said discharge line, a valve for choking said intake, means operated from said measuring device to close said valve as the demand decreases, 5 a valve for exhausting said discharge line, means operated from said measuring device to open said discharge line valve as the demand decreases, said discharge line valve operating means operating at a lower demand 10 than said intake choking device, a fluid pressure engine operatively connected with said compressor, and means for conveying the exhaust fluid from the discharge line to said engine.

15 7. In combination with a centrifugal compressor having an intake and a discharge line, a demand measuring device in said discharge line, an intake choking valve having an operating motor operated from said demand measuring device arranged to close 20 said valve when the demand decreases below a predetermined point, a discharge exhausting valve for said compressor having an operating motor arranged to open said 25 discharge valve at a demand lower than that at which said intake closing motor operates, a fluid pressure engine operatively connected with said compressor, and means for con-

veying the exhaust fluid from the exhaust line to said engine.

8. In combination with a centrifugal compressor having an intake and a discharge line, a Venturi tube, a valve for closing the intake of said compressor, a valve for exhausting the discharge of said compressor, 35 motors for operating said valves comprising cylinders and pistons therein, fluid connection from the throat of this Venturi tube to one end of each of said cylinders and from the discharge of said tube to the other 40 ends of said cylinders, the piston in the intake valve motor being arranged to operate at a greater difference in pressure in the ends of its cylinder than the piston in the discharge valve motor, a fluid pressure engine operatively connected with said compressor, and means for conveying the exhaust fluid from the discharge line to said engine.

In testimony whereof, I have hereunto set 50 my hand.

OTTO BANNER.

Witnesses:

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F. A. POPE.