O. BANNER.

REGULATING MEANS FOR CENTRIFUGAL COMPRESSORS.

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1,154,959.

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Fig. 1

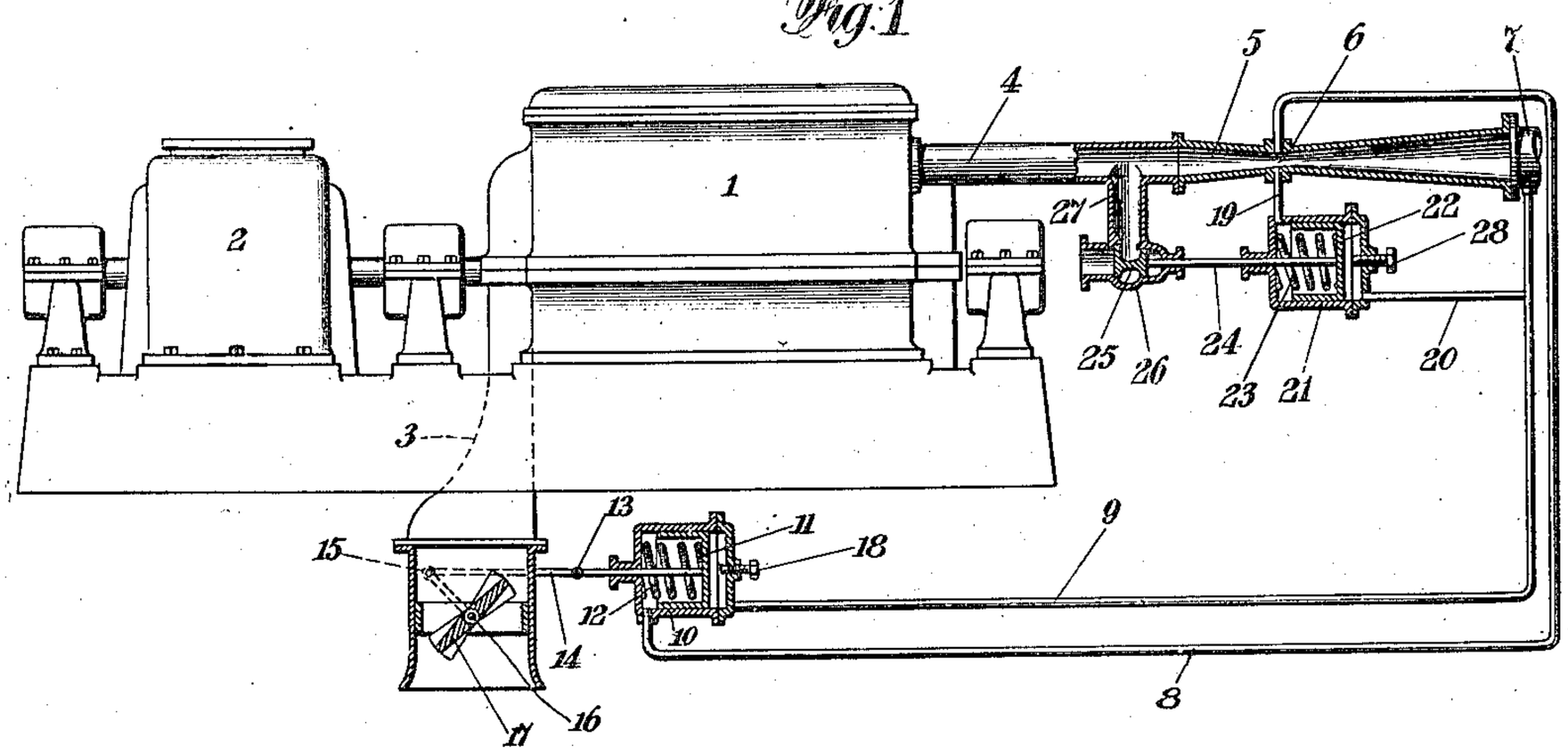
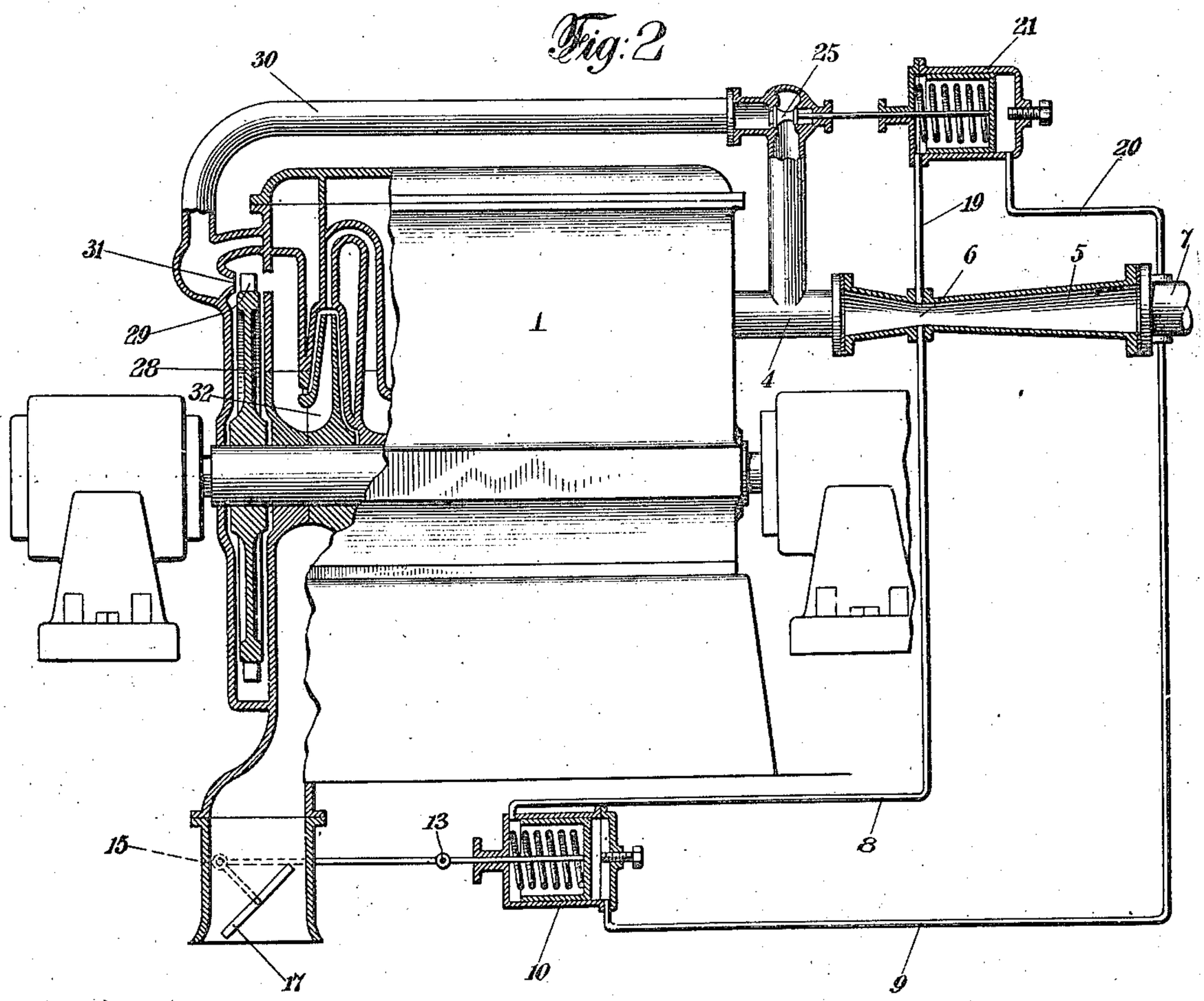


Fig. 2



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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 throttle valve 17 to some extent. This will decrease the amount of air taken into the compressor 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 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 will be maintained in its forward position and the valve 25 kept closed until the throttle valve 17 has been closed to the desired extent by the piston 11. At this point the spring 23 will overcome the difference in pressure in the two ends of the cylinder and will open the valve 25 an amount proportionate to the decrease of the demand allowing any excess of air over the demand to be exhausted to the atmosphere. It will therefore be seen that the regulation of such compressor takes place in three stages. Above the pumping limit the ordinary speed regulation is employed. When the pumping limit is reached an additional regulation is added in the form of a device for automatically throttling the intake thus decreasing the amount of air taken into the compressor and preventing pumping. When the practical limit of this throttling regulation is 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 my copending application, Serial No. 727,650, filed October 25th, 1912, which decreases the power used in the third stage of regulation. In this form the compressor is provided at its forward end with a turbine wheel 28 provided with blades 29, which is directly mounted on the shaft of the compressor. Instead of the air being allowed to escape to the atmosphere when valve 25 is open it is passed through a pipe 30 and directed 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 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 proportionate to the air allowed to escape from the discharge line and pass through the turbine wheel.

It is to be understood that the present showing and description discloses only certain specified modifications of my invention and other forms and modifications are included in the spirit and scope of the invention as expressed in the claims.

What I claim is:

1. In combination with a centrifugal compressor, having an intake and a discharge line, a demand measuring device in said discharge line and means operated from said demand measuring device, for serially choking the intake of the compressor and exhausting the discharge line of the compressor as the demand decreases.

2. In combination with a centrifugal compressor 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, a valve for exhausting said discharge line, and 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 than said intake choking device.

3. 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 a motor operated from said demand measuring 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 to open said discharge valve at a demand lower than that at which said intake closing motor operates.

4. 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, motors for operating said valves comprising cylinders and pistons therein, and connections from the said tube to one end of each of said cylinders and from the discharge of said tube to the other 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.

5. In combination with a centrifugal compressor having an intake and a discharge line, a demand measuring device in said discharge line, means operated from said demand 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 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 compressor 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, 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 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.

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 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 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 conveying 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, 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 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 my hand.

OTTO BANNER.

Witnesses:
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