

R. H. RICE.
 REGULATING DEVICE FOR MIXED. PRESSURE TURBO COMPRESSORS.
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1,154,594.

Patented Sept. 21, 1915.

Fig. 1.

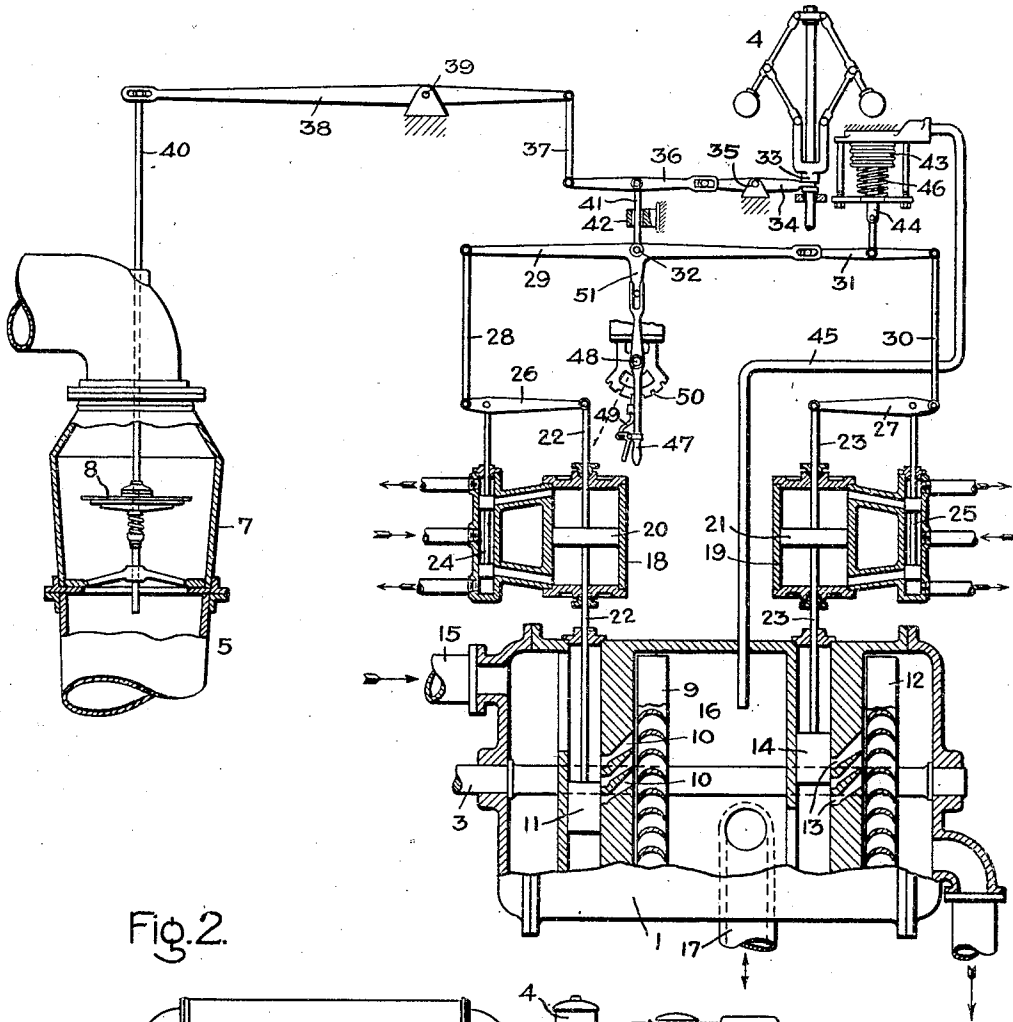
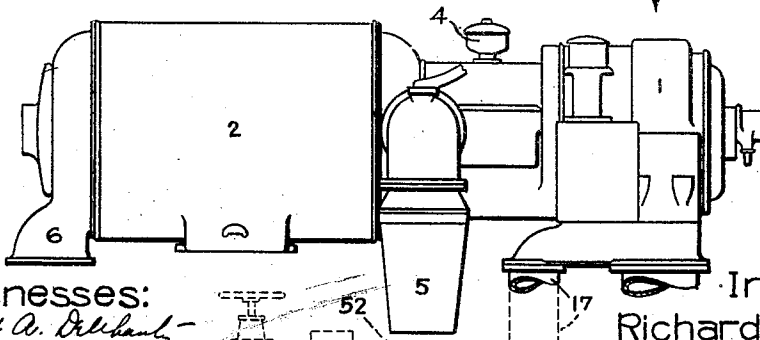


Fig. 2.



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UNITED STATES PATENT OFFICE.

RICHARD H. RICE, OF LYNN, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

REGULATING DEVICE FOR MIXED-PRESSURE TURBO-COMPRESSORS.

1,154,594.

Specification of Letters Patent.

Patented Sept. 21, 1915.

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To all whom it may concern:

Be it known that I, RICHARD H. RICE, a citizen of the United States, residing at Lynn, in the county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Regulating Devices for Mixed-Pressure Turbo-Compressors, of which the following is a specification.

This invention relates to means for regulating the speed of a turbo-compressor set in which the turbine is actuated either by low pressure steam or by high pressure steam or by both, as may be desired, and can be readily changed from one condition to another while running; the regulation of speed being effected mainly by a constant volume governor in the intake of the air compressor, but being subject also to a speed governor under certain conditions. There is also a pressure-responsive device for keeping constant pressure in an intermediate stage or chamber to which low pressure steam is fed and from which steam can be extracted from the turbine for industrial purposes. The constant volume governor is operatively connected to the high pressure valve means and also to the low pressure valve means of the turbine, operating them simultaneously and serving to govern the machine under normal working conditions. In case the speed becomes excessive, the speed governor becomes operative and controls the two sets of valve means, acting as an auxiliary governor for the volume governor. When the turbine is operated as a mixed pressure machine, steam is admitted to an intermediate stage, as well as to the initial stage. When steam is extracted for industrial purposes it is withdrawn from an intermediate stage. For both mixed pressure and extraction operation constant pressure is preferably maintained in said intermediate stage, and this is accomplished by a device responsive to the pressure in the stage, to which steam is admitted or from which it is extracted, and acting upon the low pressure valve means which control the flow of steam from said stage to the next lower.

The valve means which control the flow of

motive fluid to the turbine are usually arranged to open and close a plurality of nozzles. In order to be able to change from operation on high pressure steam to operation on low pressure steam, or to an intermediate condition of mixed pressure operation, I provide a hand device for adjusting the relative positions of the high pressure and low pressure valves so as to vary the ratio of the areas of their respective nozzle openings and thus permit the steam to flow in such a manner as to maintain a constant pressure in the stage to be regulated. This gives a greater range of regulation and by moving the hand lever to its extreme positions the turbine can be changed from purely high pressure to purely low pressure conditions. The intermediate positions of the lever cause the machine to operate under mixed pressure conditions.

In the accompanying drawings, Figure 1 is a diagrammatic view of the regulating device, and Fig. 2 is a side elevation of the turbo-compressor set.

It need hardly be explained that a turbo-compressor set comprises a steam turbine 1 and a centrifugal air compressor 2, the rotating elements of both machines being mounted on a common shaft 3, to which is suitably geared a speed responsive device 4. The compressor has an intake 5 and a delivery pipe 6. The intake has an enlarged frusto-conical portion 7 in which is located a volume governor consisting of a disk 8 floating on the inflowing column of air and shifting its position up and down in the intake in accordance with the varying volume of air passing through said intake. The movements of this disk are relied upon to govern the admission of steam to the turbine and so vary its speed that a constant volume of air will be delivered by the compressor under varying conditions of service. The speed governor 4 is also placed in control of the turbine to prevent abnormal speed under emergency conditions.

The turbine is of the multistage type, the drawing indicating this by showing a high pressure wheel 9 receiving steam from a plurality of nozzles 10 controlled by a valve 11, 100

and a low pressure wheel 12 receiving steam from a plurality of nozzles 13 controlled by a valve 14. The high pressure steam is supplied through a pipe 15, while the low pressure steam may be the exhaust from the wheel 9 entering the chamber 16, or it may be supplied to said chamber from some other source through a pipe 17. It will be understood as a matter of course that the drawing is merely illustrative, and does not pretend to show actual construction.

The valves 11 and 14 are preferably actuated by hydraulic motors, comprising cylinders 18, 19 containing pistons 20, 21 connected to the valve stems 22, 23. Fluid pressure is admitted to the cylinders by pilot valves 24, 25 which are connected to levers 26, 27, which are pivoted at one end to extensions of the valve stems 22, 23. The other end of the lever 26 is connected by a link 28 with one end of a floating lever 29, while the corresponding end of the lever 27 is connected by a link 30 with one end of a lever 31 whose other end is articulated to the adjacent end of the floating lever 29.

An intermediate point 32 on the floating lever is connected both to the speed responsive device and to the volume governor, in such a manner that an increase either in the speed of the machine or in the volume of the air entering the compressor will cause a lowering of the floating lever. The system of levers for this purpose shown in the drawing is merely illustrative and may be replaced by other equivalent mechanism. As shown, the sliding collar 33 of the speed governor is connected by a short lever 34 fulcrumed at 35 to one end of an arm 36 whose other end is connected by a link 37 to a lever 38 fulcrumed at 39 and pivoted at its other end to the stem 40 on which the floating disk 8 is mounted. The arm 36 is pivoted to a short plunger 41 sliding in a stationary guide 42 and pivoted to the floating lever 29 at the point 32.

A pressure responsive device is connected to the lever 31 and actuates it in correspondence with variations in the steam pressure in a stage or chamber of the turbine. The preferable construction is indicated in the drawing, comprising a so-called siphon diaphragm 43 attached to a rod 44 which is pivotally connected to the lever 31. A pipe 45 conveys fluid pressure from the stage or chamber 16 to the diaphragm, so that upon an increase of pressure in said chamber the spring 46 will be compressed and the lever 31 will be forced downwardly.

The means for positively tilting the floating lever 29 comprises a hand lever 47 fulcrumed at 48 and having a latch 49 cooperating with a notched quadrant 50. The upper end of the hand lever is jointed to an arm 51 on the floating lever 29 in such a way as not to interfere with the free up and down

movements of the floating lever, but at the same time enable the attendant to tilt the floating lever one way or the other by manipulating the hand lever.

The construction and arrangement of the mechanism having thus been described, it remains to point out how these parts function. Let us consider first what happens upon an increase in the volume of air entering the compressor. This occurs when the resistance offered to the column of air is decreased, as for instance when the fuel in a gas producer has been consumed sufficiently to allow the air to pass through it more freely. Any increase in the volume of air lifts the floating disk 8 and its stem 40 and thereby depresses the opposite end of the lever 38, carrying with it the arm 36. As this arm fulcrums on the end of the lever 34, which is held stationary by the speed governor, the plunger 41 will be depressed, dropping the floating lever 29 bodily. This movement forces down one end of the lever 26, which fulcrums at the upper end of the valve stem 22. The downward movement of the pilot valve 24 admits hydraulic or other fluid pressure under the piston 20, causing it to move upwardly and lift the high pressure valve 11, thereby closing some of the nozzles 10 and slowing down the machinery to lessen the volume of air. Simultaneously with this closing of the high pressure valve 11, the low pressure valve 14 is closed also, in the following manner: The bodily downward movement of the lever 29 carries down the adjacent end of the lever 31 which fulcrums on the rod 44 and thereby lifts the link 30, the lever 27 and the pilot valve 25, admitting fluid pressure on top of the piston 21 and forcing down the low pressure valve 14, thereby shutting off some of the nozzles 13 or decreasing the outlet area.

The above-described movement of the pistons 20, 21 gives the levers 26, 27 a movement in the opposite direction to that which they had previously received, so that the pilot valves will be restored to mid-position covering both ports leading to their cylinders and retaining the valves 11 and 14 in the positions to which they have shifted.

Assuming now an abnormal increase of speed of the machine, due to a drop in load or other causes, the speed governor acts in the following manner to throttle the steam and restore the speed to normal: The outward movement of the fly-balls of the governor lifts the collar 33 and that end of the lever 34, depressing the opposite end of said lever and with it the arm 36, which fulcrums on the link 37 and pushes down the plunger 41; thereby causing a drop of floating lever 29 and a partial closing of the valves 11 and 14 in the manner above described.

The pressure in the intermediate chamber 16 of the turbine is under the control of the

pressure regulator 43, which operates the low pressure valve 14 only. Should the pressure in this chamber increase, the syphon diaphragm will move downwardly, overcoming the tension of the spring 46 and pushing down the lever 31. As this fulcrums at the point where it is pivoted to the floating lever 29, the link 30 will depress the lever 27 and the pilot valve 25, thereby admitting fluid pressure under the piston 21 and lifting the low pressure valve 14 to open more of the nozzles 13 and permit a larger flow of steam from the chamber 16 to the lower stage of the turbine, thereby relieving the excess of pressure in said chamber.

The pressure regulator has an important function in supplementing under certain conditions the effects of the volume and speed governors. To make this plain, let it be assumed that the machine is running only on low pressure steam derived from the exhaust of another engine or some similar source. The load is carried solely by the bucket wheel 12. If, now, the supply of low pressure steam is reduced the machine will slow down and the speed governor will act to open up the high pressure valve 11 and admit live steam to the bucket wheel 9 to carry the load. Simultaneously, it tends to open the low pressure valve 14 still wider. But the reduction of pressure in the chamber 16 due to the failure of the low pressure steam causes the pressure regulator to operate in a manner to shut off some of the low pressure nozzles 13 in an attempt to restore the lost pressure. Almost immediately however, the steam exhausting into the chamber 16 from the wheel 9 builds up the pressure, and passing to the wheel 12 causes the latter to resume such portion of the load as the reduced area of the nozzles 13 permits. Upon the slight increase in speed, due to the operation of both wheels, the volume governor acts to reduce the supply of steam, and causes the machine to settle down to a mixed pressure condition of operation.

It will be observed that the pressure regulator operates quite independently of the volume and speed governors, and also that the operation of these two latter devices is not interfered with by the pressure regulator. This feature is of importance when the machine is running as an extraction turbine, because the supply of steam from the chamber 16 for industrial purposes must be maintained at a constant pressure, irrespective of the variations of load on the compressor.

To obtain the highest efficiency of the high pressure and low pressure combination, the hand lever 47 and its cooperating parts enable the pressure ratio between the high pressure and low pressure valves to be varied. By moving the lever to the right in Fig. 1 the floating lever 29 will be tilted up

at the left hand end, causing the normal nozzle opening for the high pressure valve 11 to be greater than that for the low pressure valve 14. If the handle 47 is carried to the extreme right, all the low pressure nozzles will be closed and all the high pressure nozzles opened, and the machine will then operate as a simple high pressure turbine. The pressure of the exhaust entering the chamber 16 will act upon the syphon diaphragm and cause it to open the low pressure valve means sufficiently to permit the steam to pass to the condenser. Any excess pressure will be taken care of by the relief valve 52 in the pipe 17. When running in this manner on high pressure steam alone, the machine can be used for extraction purposes, steam being led off through the pipe 17, and a constant pressure being maintained by the pressure regulator.

If the handle 47 is thrown to the extreme left, the high pressure valve 11 will be closed and the low pressure valve 14 opened, and the machine will run on low pressure steam supplied to the chamber 16 through the pipe 17. In both cases, whether high pressure or low pressure, the volume governor, the speed governor and the pressure regulator maintain complete regulative control of the machine, although when the handle 47 is in either of its extreme positions it absolutely prevents the speed and volume governors from moving the corresponding valve enough to open its ports. Consequently, if the machine is running on low pressure steam only, with the high pressure valve out of service, any serious reduction in the supply of low pressure steam must be met by the engineer, who must shift the handle 47 far enough toward the midposition to let the movement of the high pressure valve by the governor cause it to open some of the high pressure steam nozzles. When the handle 47 occupies an intermediate position, the machine will operate as a mixed pressure unit, subject as before to the regulation of the volume and speed governors and the pressure regulator. The position of the handle 47 determines the pressure ratio between the two valves, by determining the relative amounts of normal nozzle opening. Thus, if the handle occupies the position indicated by the dotted line in Fig. 1, the machine will operate normally on low pressure steam but will call the high pressure steam into service when the load becomes greater than the low pressure steam can carry, the speed governor operating to open the high pressure valve. It will be understood that there is more or less simultaneous play of the valves all the time, due to the action of the two governors, but that the normal regulating movement is not enough to open the high pressure valve when the handle 47 is in the dotted line position.

The machine can be used as a mixed pressure turbine, running partly on high pressure and partly on low pressure steam, but not under extraction conditions at the same time. When the turbine is running under mixed or low pressure conditions, the low pressure steam enters through the pipe 17. Under extraction conditions, the high pressure steam is used and the extracted steam is led off through the same pipe 17, to a branch pipe having a suitable valve which is closed when the low pressure steam is used.

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 combination with an air compressor, driven by a mixed pressure turbine, of a device responsive to variations in volume of the air passing through said compressor, high pressure and low pressure valves for said turbine, and means whereby said valves are simultaneously operated by said device.

2. The combination with an air compressor, driven by a mixed pressure turbine, of a device responsive to variations in volume of the air passing through said compressor, high pressure and low pressure valves for said turbine, operative connections between said device and said valves, whereby both valves are operated simultaneously, and a speed responsive device also connected to said valves, and operating them simultaneously.

3. The combination with an air compressor, driven by a mixed pressure turbine, of a volume governor in the intake of said compressor, high pressure and low pressure valves for said turbine, actuating mechanism for operating said valves simultaneously, and connections between said actuating means and said governor.

4. The combination with an air compressor, driven by a mixed pressure turbine, of a speed governor driven by said turbine, a volume governor in the intake of said compressor, high pressure and low pressure valves for said turbine, actuating mechanism for operating said valves simultaneously, and operative connections between said actuating means and both of said governors.

5. The combination with an air compressor, driven by a mixed pressure turbine, of a speed governor driven by said turbine, a volume governor in the intake of said compressor, high pressure and low pressure

valves for said turbines, actuating mechanism for operating said valves simultaneously, operative connections between said actuating means and both of said governors, and means for varying the pressure ratio between said high pressure and low pressure valves.

6. The combination with an air compressor, driven by a mixed pressure turbine, of a speed governor driven by said turbine, a volume governor in the intake of said compressor, high pressure and low pressure valves for said turbine, actuating mechanism for operating said valves simultaneously, operative connections between said actuating means and both of said governors, and means for varying the relative nozzle areas respectively controlled by said valves.

7. The combination with an air compressor, driven by a mixed pressure turbine, of a volume governor in the intake of the compressor, high pressure and low pressure valves for the turbine, actuating mechanism for operating said valves simultaneously, connections between said actuating means and said governor, and a device responsive to intermediate stage pressure having independent control of said low pressure valve.

8. The combination with an air compressor, driven by a mixed pressure turbine, of a speed governor driven by said turbine, a volume governor in the intake of said compressor, high pressure and low pressure valves for said turbine, actuating mechanism for operating said valves simultaneously, operative connections between said actuating means and both of said governors, and a device responsive to intermediate stage pressure having independent control of said low pressure valve.

9. The combination with an air compressor, driven by a mixed pressure turbine, of a volume governor in the intake of said compressor, high pressure and low pressure valves for said turbine, mechanism controlling said valves comprising a floating lever, and connections whereby said lever is moved bodily in response to the varying positions of said governor.

10. The combination with an air compressor, driven by a mixed pressure turbine, of a volume governor in the intake of said compressor, a speed governor driven by said turbine, high pressure and low pressure valves for said turbine, mechanism controlling said valves comprising a floating lever, and connections whereby said lever is moved bodily in response to the varying positions of either governor.

11. The combination with an air compressor, driven by a mixed pressure turbine, of a volume governor in the intake of said compressor, high pressure and low pressure valves for said turbine, mechanism control-

ling said valves comprising a floating lever-connections whereby said lever is moved bodily in response to the varying positions of said governor, and means for tilting said
5 floating lever one way or the other to vary the relative nozzle areas controlled by said valves.

In witness whereof, I have hereunto set my hand this 16th day of July, 1914.

RICHARD H. RICE.

Witnesses:

JOHN J. MCKENNEY,
JOHN A. McMANUS, Jr.