

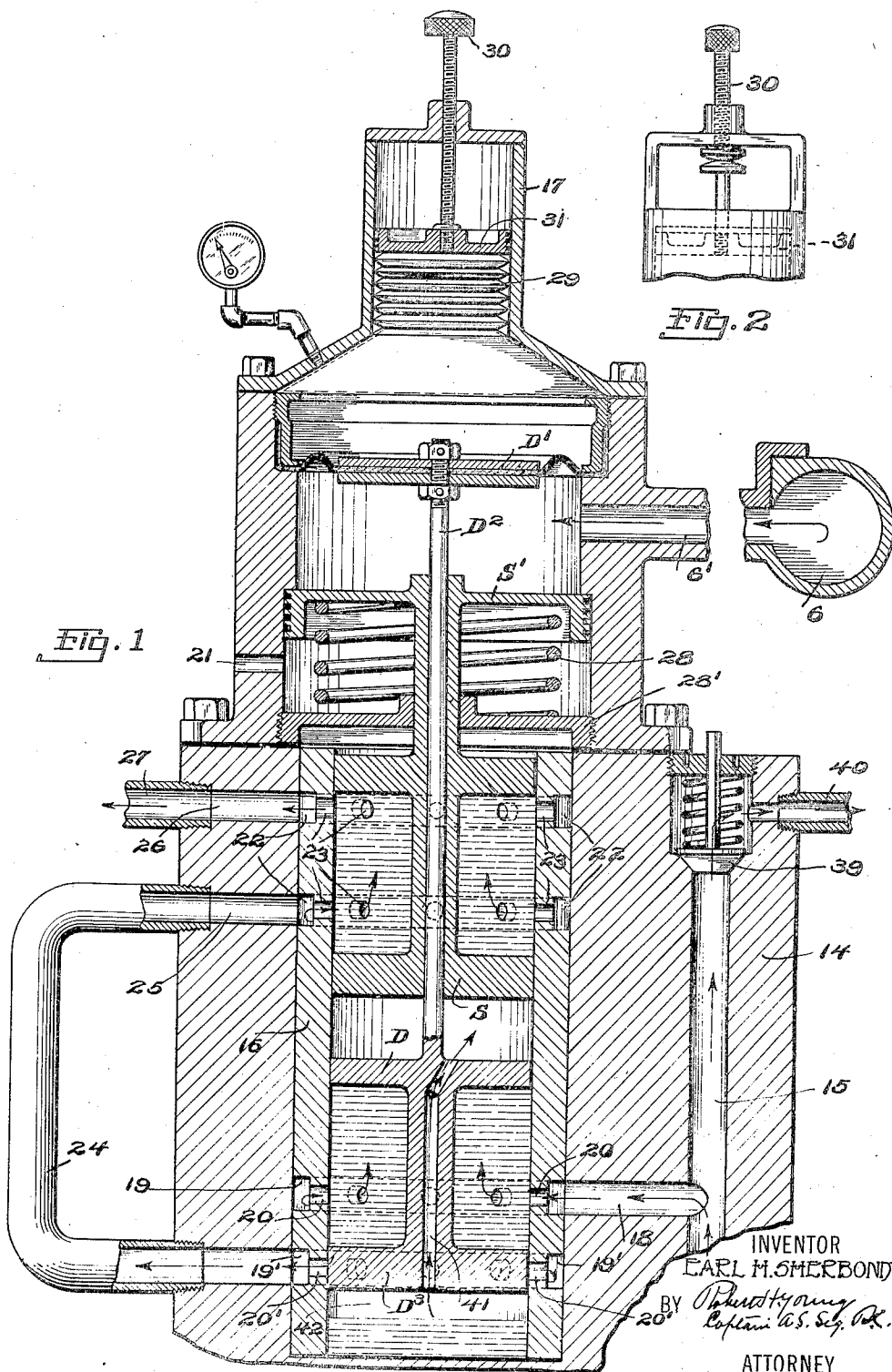
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E. H. SHERBONDY.
AUTOMATIC CONTROL FOR TURBO COMPRESSORS.

APPLICATION FILED MAR. 26, 1918.

Patented July 13, 1920.

3 SHEETS—SHEET 1.



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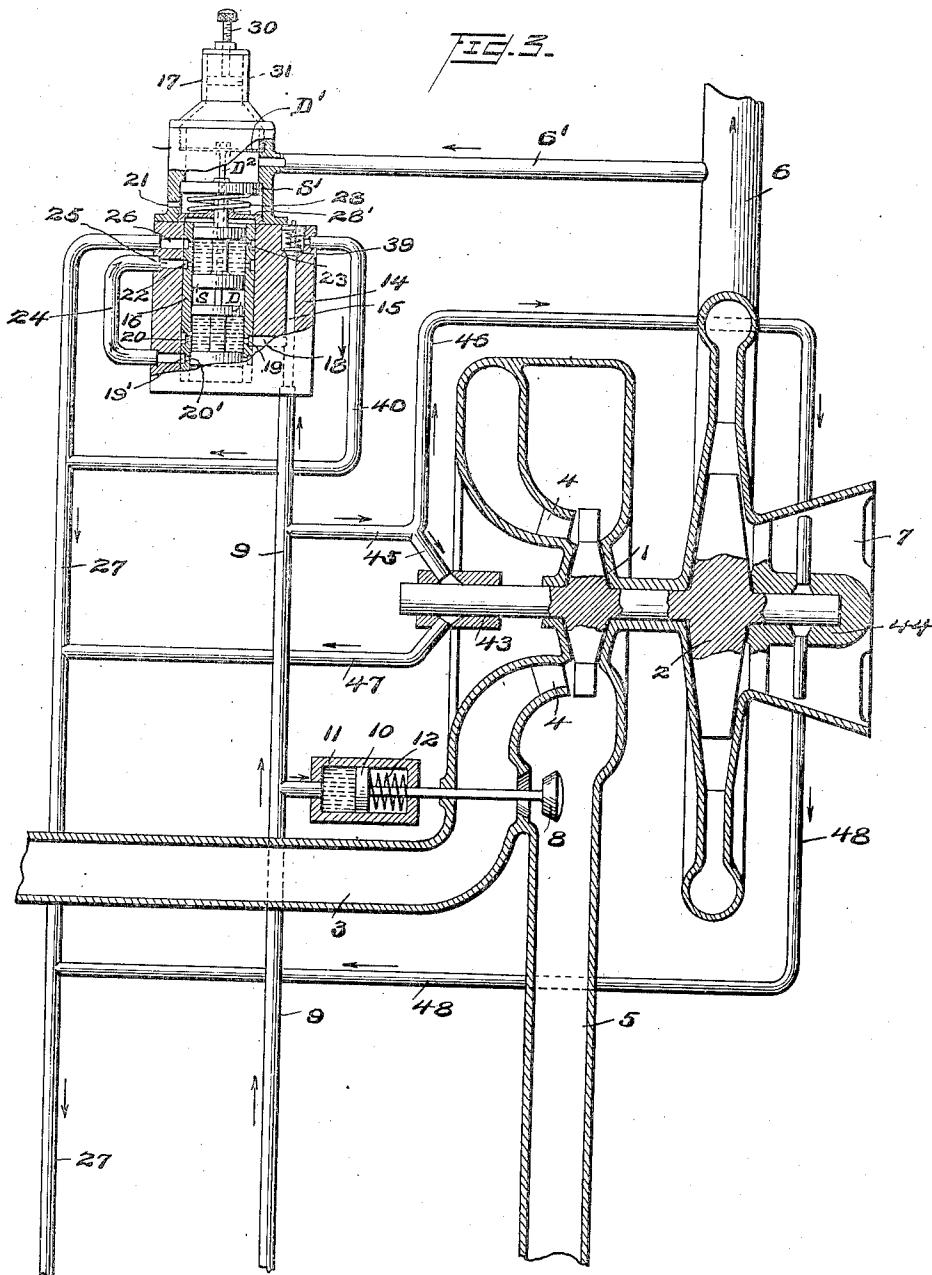
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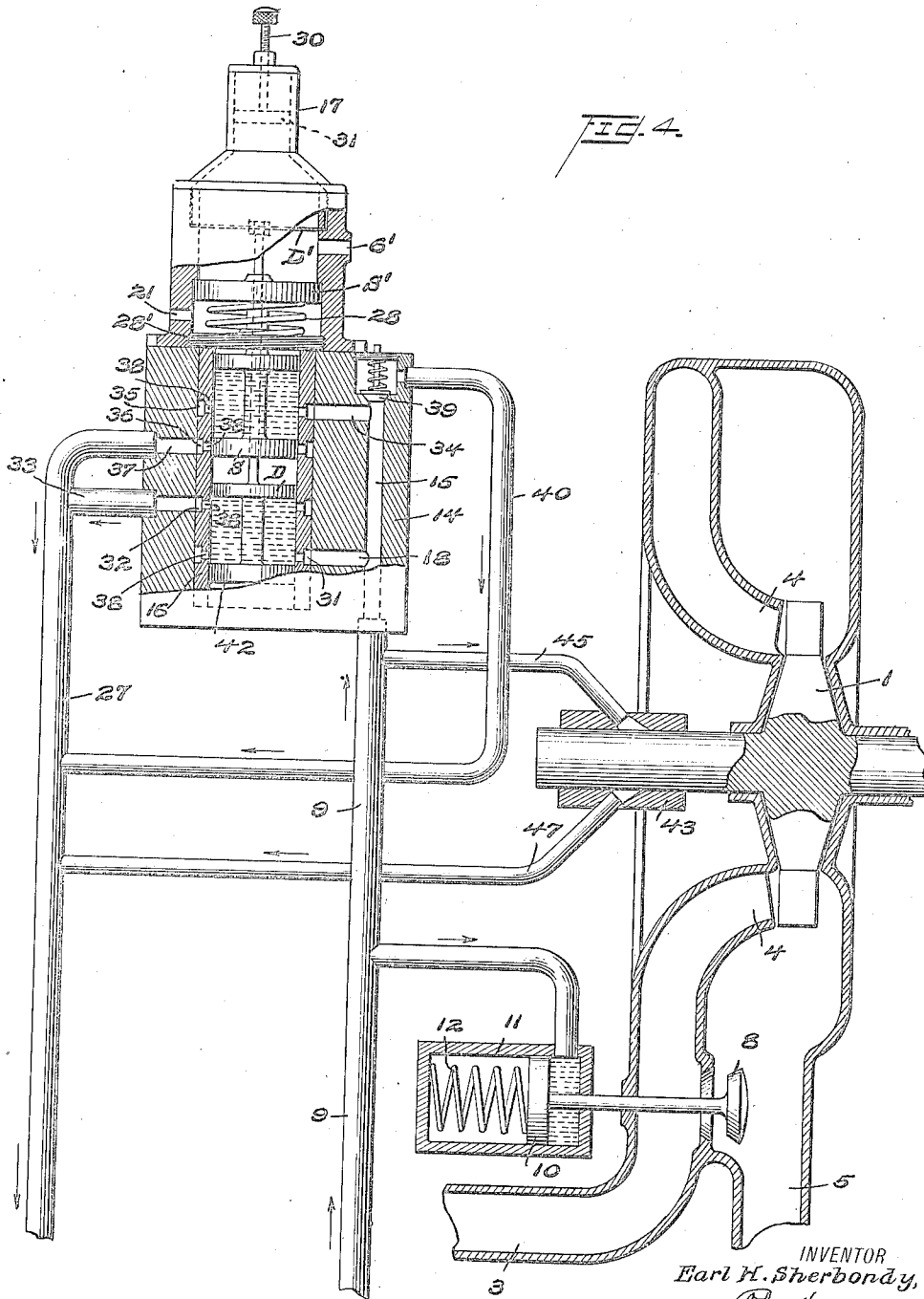
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3 SHEETS—SHEET 3.

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UNITED STATES PATENT OFFICE.

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AUTOMATIC CONTROL FOR TURBO-COMPRESSORS.

1,346,563.

Specification of Letters Patent.

Patented July 13, 1920.

Application filed March 26, 1918. Serial No. 224,894.

To all whom it may concern:

Be it known that I, EARL H. SHERBONDY, a citizen of the United States, and resident of Cleveland, in the county of Cuyahoga and State of Ohio, have invented certain new and useful Automatic Control for Turbo-Compressors, of which the following is a specification.

This invention relates to means for controlling the delivery pressure from a centrifugally operated air compressor by controlling the speed of said air compressor.

The centrifugal air compressor, commonly known as a turbo-compressor, is operated by the waste gases from an airplane engine and is adapted to supply air at substantially atmospheric pressure to the airplane engine, regardless of the height at which the airplane may be. The general arrangement of this system is shown in my copending case, Serial Number 224,356, filed Mar. 23, 1918. More specifically, the invention comprises an automatic means for controlling the delivery pressure of the air compressor.

The invention also comprises a fluid system under pressure, variations in the pressure in said system operating means to change the speed and consequently, the delivery pressure of the air compressor.

In the drawings, illustrating two embodiments of my invention, Figure 1 is a sectional view of the controlling valve unit; Fig. 2 is a detail; Fig. 3 shows the controlling unit connected up with the turbo-compressor; and Fig. 4 shows a slight modification.

Referring now to the drawings, in which similar reference characters indicate similar parts, 1 indicates the turbine and 2 the blower wheel of the turbo-compressor. The turbine is operated by waste gases from the airplane engine led thereto through the pipe 3 and nozzles 4. After having passed through the buckets of the turbine, the gases escape to the atmosphere through the pipe 5.

The air compressed by the blower wheel 2, passes into the delivery pipe 6 and is led to the carbureter, as shown more particularly in my co-pending case Serial No. 224,356.

Air is drawn into the blower wheel 2 through the mouth 7, which preferably faces in the direction of travel of the airplane.

As the airplane rises, it is obvious that more and more air must be pumped by the compressor to make up for the increasing

rarefaction with the increase of height. This progressive increase of speed may be accomplished by causing more and more of the exhaust gases to pass through the buckets of the turbine, to speed it up, as the airplane rises higher and higher.

To this end, there is provided a by-pass valve 8, so arranged between the exhaust pipes 3 and 5, that when open, a by-pass for the gases is provided which permits the gases to pass directly to the atmosphere without going through the turbine. At sea level, this valve 8 is practically wide open and very little exhaust gases pass to the turbine.

This invention provides means for gradually closing this valve to cause the turbine to speed up as the airplane rises.

A fluid system under pressure, is used to actuate the valve, the pressure line of said system being indicated at 9. This pipe 9, may be kept supplied with oil under substantially constant pressure by any convenient means, such as shown in my said copending case Serial No. 224,356. The valve stem of the valve 8, is provided with a piston 10 working in a cylinder 11, which cylinder is connected, as shown in Fig. 3, to the pressure pipe 9. On the other side of piston 10, is a spring 12. It should be noted that spring 12 is so arranged, that it tends to counterbalance the outward pressure of the exhaust exerted on the valve 8. The valve is thus balanced and is responsive to the oil pressure in the pipe 9.

It should be noted, that when the oil pressure is on, the valve 8 will be open, the gases will be by-passed and the turbine will run very slowly and very little air will be pumped. That is to say, a high oil pressure corresponds to a low turbine speed and to a low compressor pressure.

The means for controlling this oil pressure, will now be described. Referring to Fig. 1, which shows the valve control unit, a casing 14 is provided, carrying a passage 15, which is connected to the pressure pipe 9.

The casing 14 is provided with an opening in which is located the vertically disposed cylinder 16. Working in the cylinder, are two balanced valves, which are used to control the oil pressure in a manner now to be described. The valve for gradually speeding up the turbine as the airplane rises, will first be described. This valve designated D, is of a well known balanced type and is con-

trolled by a diaphragm D' through the valve stem D².

The diaphragm D' is actuated according to the relationship existing between the delivery pressure from the air compressor, acting on the under side thereof through the pipe 6' connected to the delivery pipe 6 and a standard pressure, acting on the upper side thereof.

This standard pressure is provided by an airtight casing 17, arranged above the diaphragm D' to confine a certain volume of air just above the diaphragm. It is evident that when this volume of air confined within the casing 17, which hereafter I shall call a standard pressure, exceeds the delivery pressure from the compressor, the valve D will be moved downwardly and vice versa if the relationship between the two pressures should be reversed.

Referring now to the valve D, the interior of said valve between the two disks thereof is directly connected with the oil pressure pipe 15 through the passage 18, which passage registers with an annular groove 19 cut into the cylinder 16. A series of holes 20, communicating with the groove 19, admit oil to the interior of the valve as shown.

Another groove 19' and holes 20' are provided, similar to the groove 19 and holes 20, just described. The holes 20', when the airplane is at sea level, are closed by the lower disk D² of the valve D. It may be said at this point, that the valves shown in Figs. 1, 3 and 4 are positioned as they would be when the airplane is at sea level.

The operation of the valve D will now be described. At sea level, the holes 20' are closed and consequently the oil pressure in the passage 15 and pipe 9 is high. This means that the valve 8 is wide open, the gases are by-passed and the turbine runs very slowly. Now as the airplane goes up, the air pressure in the pipe 6 tends to decrease, because it is in direct communication with the atmospheric air through the opening 7. The pressure below the diaphragm accordingly tends to fall below the standard pressure, the valve, D is moved downwardly to "bleed" the oil line, the oil pressure is decreased, the spring 12 will be allowed to close the valve 8 and the speed of the turbine and, therefore, the pressure within the pipe 6 will be increased.

It is evident that as the airplane rises, the speed of the turbo-compressor will progressively increase. This, however, cannot go on indefinitely, because the turbine and blower wheel could not withstand the centrifugal forces. There is accordingly, provided an automatic speed limiting means, which acts to prevent the turbine speed exceeding a certain predetermined amount. It is evident that there is some definite height at which the turbine attains its maximum safe speed,

which height may be called a "critical height." This "critical height" may be, say, 20,000 ft., but, of course, the turbo-compressor may be designed for any desired "critical height." In place of the speed limiting valve S, an ordinary centrifugal speed governor could be used, such as shown in my said co-pending case Serial No. 224,356.

There is accordingly provided, a speed limit valve S, controlled by piston S', which piston is so located as to be subject to the delivery pressure of the compressor on its upper side. The lower side of said piston S' is subject to the external atmospheric pressure by means of the passage 21, leading to the atmosphere.

The cylinder 16 is provided with two annular grooves 22, which in turn, communicate with the interior of the cylinder between the two disks of the valve S by the holes 23.

The oil leaving the valve D, passes into the pipe 24 through the passage 25, into grooves 22, to the space between the valve disks and thence out again through the passage 26 to the oil waste pipe 27.

It should be noted that the two valves are connected in series and that any oil leaving the valve D must pass through the valve S to the waste pipe. It is evident that as shown in Fig. 1, the valve S is normally inactive. This oil passage leads from pipe 24 to waste pipe 27, the valve D this time, acting as the controlling valve for the oil pressure. The valve D gradually "bleeds" the oil line until the "critical height" is reached, at which point, the valve S comes into play to stop this "bleeding," which stops any further increase in speed of the turbo-compressor.

The valve S is then set to come into action at a definite height, say, 20,000 ft. The air pressure at 20,000 ft. is substantially 7.2 lbs. The air pressure at sea level is substantially 14.7 lbs. The difference is 7.5 lbs. Now it is evident that if the spring 28 is provided to load the under side of the piston S', the strength of said spring being equal to the said 7.5 lbs. difference between the atmospheric pressure at sea level and the atmospheric pressure at 20,000 ft., that the valve S' will remain stationary, as shown in Fig. 1, until this height of 20,000 ft. is reached and that it will be unseated and moved downwardly as soon as the airplane rises beyond 20,000 ft. As the valve thus moves down, the upper disk of the valve S' will close the upper series of holes 23 to cause the oil pressure to back up in pipe 24, pipe 15 and pipe 9, to by-pass the gases and prevent any further increase in the speed of the turbo-compressor.

It may be noted at this point, that valve D, at 20,000 ft., is, of course, wide open. That is to say, is down to its lowermost position.

Any suitable means for adjusting the standard pressure in the casing 17 may be provided. One suitable means consisting of a bellows 29, which may be compressed or extended by the handle 30 and piston 31, is shown.

With such an arrangement, it is evident that by increasing the standard pressure, the turbo-compressor will be caused to operate fairly strongly even at sea level in order to super-charge the engine in case an unusual speed or an unusual amount of power is desired.

A flexible joint is shown in Fig. 2, to allow for lateral movements of the handle 30.

The control just described, is one in which a high oil pressure corresponds to a low compressor pressure. The modification in Fig. 4, will now be described, in which a low oil pressure corresponds to a low compressor pressure. This difference is the result of the modified control in which the oil pressure tends to hold the valve seated and spring pressure tends to open it. In other words, "bleeding" the oil line, will by-pass the gases to decrease the compressor pressure. A series of four grooves is provided, in the modification shown in Fig. 4, but arranged somewhat differently from the arrangement shown in Fig. 1. Oil is led between the disks of the valve D through the groove 31 and leaves through the groove 32 and pipe 33, passing into the waste line 27.

As shown, the parts are positioned as they would be at sea level, oil passing freely through the pipe 15 to the pipe 33 thereby "bleeding" the oil line and by-passing the gases. As the airplane goes up, the valve D is moved downwardly, the upper disk of the valve D closes the groove 32, gradually builds up the pressure in the pressure line 9, which closes the valve 8 to speed up the turbine and so pump more air. The valve D goes on building up the pressure in the oil pipe 9 until the "critical height" of, say, 20,000 feet is reached. At this point, the speed limit valve S comes into operation to prevent any further building up of this pressure.

The space between the disks of the valve S, communicates with the pipe 15 through the passage 34 and groove 35. The groove 36, communicating with passage 37, is provided for the escape of the oil to the waste pipe 27. Normally, the groove 36 is closed by the lower disk of the valve S. Each of these grooves 31, 32, 35 and 36, communicate with the interior of the cylinder 16 through the holes 38. It is evident that at 20,000 ft., the supposed "critical height," the valve D will be closed and the oil pressure in pipe 9 will be at a maximum.

As soon as the airplane goes beyond this height, the valve S will open to bleed the oil pipe 9 to prevent any increase in the

quantity of air supplied to the engine. The pressure pipe 15 may be provided with a safety valve 39, the oil escaping therefrom through the pipe 40, being led to the waste pipe 27.

The valve D is arranged to act as a dash-pot to dampen its own movement. In the body of the valve D is a hole 41, bored through it so that any suitable fluid contained in the space 42 below the valve, will be pumped up through the hole 41, to the upper part of the valve, thereby preventing unduly rapid movements of the valve.

It should be noted that the valve stem D², is made small enough to pass through the valve S and piston S', this arrangement contributing to a compact structure.

The strength of the spring 28 may be adjusted by means of a screw-threaded element 28'.

The bearings for the turbo-compressor shown at 43 and 44, are provided with forced feed lubrication through the pipes 45 and 46, connected to the pressure pipe 9; the oil after leaving the bearings, escaping through the pipes 47 and 48 into the waste pipe 27.

A single oil pressure system, it is apparent, serves two purposes. First—that of serving as an important part of the automatic control for the turbo-compressor and second—that of providing a forced feed lubrication for the turbo-compressor bearings.

While I have illustrated certain embodiments of my invention, it should be understood that the invention may be carried out in other ways and that the disclosure be considered in an illustrative and not in a limiting sense.

I claim:

1. In combination with an air compressor, means responsive to a standard pressure and the compressor pressure to control the compressor pressure and means responsive to the atmospheric pressure and the compressor pressure to control the compressor pressure.

2. In combination with an air compressor, means responsive to a standard pressure and the compressor pressure to control the speed of the compressor and means responsive to the atmospheric pressure and the compressor pressure to control the speed of the compressor.

3. In combination with an air compressor, means to control the pressure of the air compressed by said compressor, means responsive to a standard pressure and the compressor pressure to actuate said pressure controlling means and means responsive to the atmospheric pressure and the compressor pressure to also actuate said pressure controlling means.

4. In combination with an air compressor, means to control the speed of said compressor.

sor, means responsive to a standard pressure and to the delivery pressure of the said compressor to actuate said speed controlling means and means responsive to atmospheric pressure and the delivery pressure of said compressor to also actuate said speed controlling means.

5. In combination with an air compressor, means responsive to the atmospheric pressure and to the compressor pressure to control the compressor pressure, said means becoming operative when the compressor pressure exceeds the atmospheric pressure by a certain amount, and means responsive to a standard pressure and to the compressor pressure to additionally control the compressor pressure.

6. In combination with an air compressor, means responsive to the atmospheric pressure and to the compressor pressure to control the speed of the compressor, said means becoming operative when the compressor pressure exceeds the atmospheric pressure by a certain amount, and means responsive to a standard pressure and to the compressor pressure to additionally control the speed of the compressor.

7. In combination with an air compressor, means to control the compressor pressure, comprising a fluid system under pressure, means responsive to a standard pressure and to the compressor pressure to vary the pressure in said fluid system and means responsive to the atmospheric pressure and to the compressor pressure to vary the compressor pressure.

8. In combination with an air compressor, means to control the compressor pressure, comprising a fluid system under pressure, means responsive to a standard pressure and the compressor pressure to vary the compressor pressure and means responsive to the atmospheric pressure and to the compressor pressure to vary the pressure in said fluid system.

9. In combination with an air compressor, means to control the compressor pressure, comprising a fluid system under pressure, means responsive to a standard pressure and the compressor pressure to vary the pressure in said fluid system and means responsive to the atmospheric pressure and the compressor pressure to also vary the pressure in said fluid system.

10. In combination with an air compressor, means to control the compressor speed, comprising a fluid system under pressure, means responsive to a standard pressure and the compressor pressure to vary the pressure in said fluid system and means responsive to the atmospheric pressure and the compressor pressure to also vary the pressure in said fluid system.

11. In combination with an air compressor, means to control the pressure of

said compressor, comprising a fluid system under pressure, a valve interpolated in said fluid system to vary the pressure therein, means responsive to a standard pressure and the compressor pressure to actuate said valve and means responsive to the atmospheric pressure and the compressor pressure to vary the compressor pressure.

12. In combination with an air compressor, means to control the pressure of said compressor, comprising a fluid system under pressure, a valve interpolated in said fluid system to vary the pressure therein, means responsive to the atmospheric pressure and to the compressor pressure to actuate said valve and means responsive to a standard pressure and the compressor pressure to vary the compressor pressure.

13. In combination with an air compressor, means to control the pressure of said compressor, comprising a fluid system under pressure, a valve interpolated in said fluid system to vary the pressure therein, means responsive to a standard pressure and to the compressor pressure to control said valve, a second valve interpolated in said fluid system to vary the pressure therein and means responsive to the atmospheric pressure and to the compressor pressure to actuate said second valve.

14. The combination as claimed in claim 13, in combination with a valve cylinder in which both valves operate.

15. The combination as claimed in claim 13, in combination with a valve cylinder in which both valves operate, the valve stem of one valve working within the valve stem of the other valve.

16. The combination as claimed in claim 13, in combination with a valve cylinder in which both valves operate, the lower valve also acting as a dash pot to dampen its own movement.

17. The combination claimed in claim 1, in combination with means to adjust said standard pressure.

18. The combination claimed in claim 2, in combination with means to adjust said standard pressure.

19. The combination claimed in claim 3, in combination with means to adjust said standard pressure.

20. The combination claimed in claim 4, in combination with means to adjust said standard pressure.

21. In combination with an air compressor, means responsive to a standard pressure and the delivery pressure of said compressor to control the speed of the compressor and means responsive to the atmospheric pressure and the delivery pressure of said compressor adapted to come into action at a predetermined time to prevent any additional speed increase of the compressor.

22. In combination with an air com-

pressor, means to control the delivery pressure of said compressor, comprising a fluid system under pressure, means responsive to a standard pressure and the delivery pressure of said compressor, interpolated in said fluid system, adapted to progressively change the pressure in said fluid system according as the delivery pressure of said compressor varies, and a second means re-

sponsive to the atmospheric pressure and the delivery pressure of said compressor, interpolated in said fluid system, adapted to come into action at a certain time to supersede said first-mentioned means. 10

Signed at Newark in the county of Essex and State of New Jersey this 21st day of March A. D. 1918. 15

EARL H. SHERBONDY.