

[54] **SURGE CONTROL FOR A COMPRESSOR**

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[58] Field of Search **137/489, 489.5, 492.5, 137/488; 415/27; 230/114**

[56] References Cited

UNITED STATES PATENTS

3,393,699	7/1968	Feldman	137/489
2,938,537	5/1960	Silver et al.	137/489
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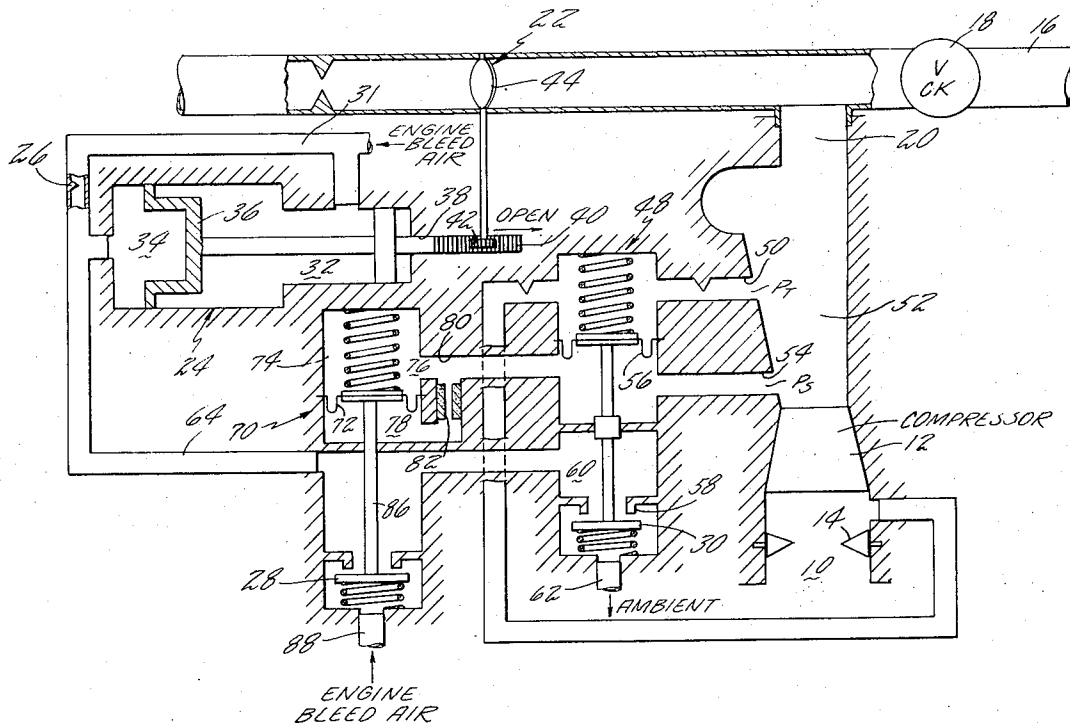
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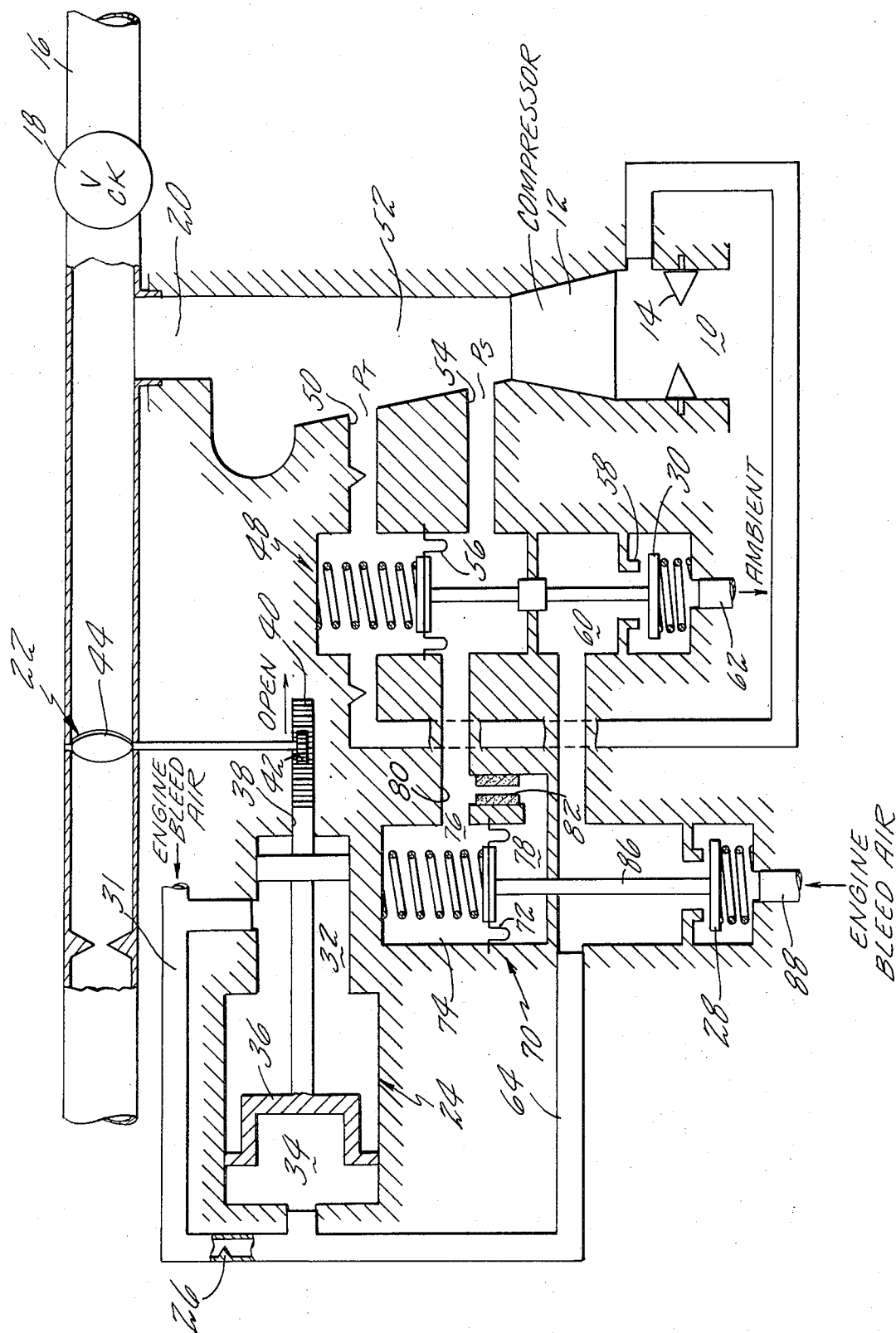
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ABSTRACT

A rate sensor and control cooperating with a surge control senses the static pressure of the compressor diffuser and serves to assure that the compressor stays out of the surge condition in the event that there is a sudden decrease in the flow demand on the compressor. This device is characterized as having high gain and rapid response relative to the normal surge control whose response and gain characteristics are dictated by system stability and accuracy requirements.

6 Claims, 1 Drawing Figure





SURGE CONTROL FOR A COMPRESSOR

BACKGROUND OF THE INVENTION

This invention relates to surge controls for compressors and particularly to means for increasing the rate of response for actuating the surge valve whenever there is a sudden decrease in flow demand on the compressor.

This invention has utility in aircraft air conditioning systems and is currently incorporated in an APU of the type disclosed in U.S. Pat. No. 3,678,285 granted to J. J. Griffith on July 18, 1972 and assigned to the same assignee. The invention is designed to solve the problem of keeping the compressor out of surge when it evidences a rapid reduction in airflow such as when the main aircraft engine pressure increases causing a check valve downstream of the compressor to close, thus, closing off the discharge from the compressor and dropping airflow so as to cause the compressor to go toward the surge condition.

The normal surge control associated with this heretofore mentioned aircraft air conditioning system could not respond quickly enough to actuate the surge valve which is designed to open so as to maintain sufficient airflow through the compressor to prevent it from entering the surge region.

I have found that I can obviate this problem by providing a rate sensor which senses the rate of increase of the static pressure in the diffuser duct leading from the compressor and actuating the surge valve at a rate that is faster than the normal surge control to hold the compressor out of surge. I have found that the static pressure at the diffuser is particularly efficacious since it will increase when the system flow is decreased due to two factors: (1) the Mach number past the static tap is decreasing therefore the static pressure will increase towards the compressor discharge total pressure and (2) compressor discharge total pressure increases as system flow is decreased toward the surge line. These two effects combine to produce substantial rate of increase of compressor discharge static pressure whenever system airflow is reduced rapidly.

According to this invention the rate sensor operates so as to open a large poppet which ports high pressure into the surge valve actuator causing it to open rapidly to keep the compressor out of surge. Thus, whenever the rate of increase of compressor discharge pressure exceeds a given value the poppet will be caused to open an amount which allows the surge valve to open at a rate which is significantly faster than would be possible with only the normal surge control. For normal operation of the surge system the rate of increase of compressor discharge static pressure is not high enough to cause the large poppet to open and hence will not adversely affect the surge control. Thus, the normal surge control which is stable and accurate during normal operation but unable to respond fast enough under certain conditions is not compromised since the rate controller serves to keep the compressor out of surge during these certain conditions. Therefore, where the heretofore air conditioning system with a single surge control was unable to keep the compressor out of surge for rapid airflow decreases, the incorporation of the present invention has obviated this problem so that the compressor in response to rapid airflow decreases is maintained out of surge.

While rate sensors for surge controls are not new in the art as is exemplified by the U.S. Pat. No. 2,969,805 granted to D. U. Hunter on Jan. 31, 1961, what is deemed novel by this invention is the incorporation of a rate sensor working in conjunction with a normal surge control such that the normal surge control can be designed to have a lower rate of response and hence a relatively low gain so as to be stable and accurate not only for the purpose of simplicity of apparatus but also to enhance its sensitivity the rate sensor is made responsive to the static pressure in the diffuser duct leading from the compressor. As distinct from the prior art the rate sensor does not require the use of check and poppet valves in the sensor itself as is shown in the heretofore mentioned prior art.

SUMMARY OF THE INVENTION

A primary object of this invention is to provide an improved surge control for a compressor.

A still further object of this invention is to provide a rate sensor cooperating with a surge controller for actuating the surge valve in the event of a rapid flow decrease at the exit end of the compressor.

A still further object of this invention is to provide a rate sensor for a surge control sensing the static pressure in the diffuser at the exit of the compressor for opening a poppet for porting high pressure into the surge valve actuator for opening the surge valve rapidly.

Other features and advantages will be apparent from the specification and claims and from the accompanying drawing which illustrates an embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWING

The sole FIGURE is a view partly in schematic and partly in section illustrating the details of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the sole FIGURE of the drawing, air which may be ram air supplied by the ram scoops of the aircraft (not shown) is admitted into the duct 10 where it is directed to the compressor 12 through the inlet guide vanes 14 where it is compressed and delivered to the air conditioning package to supply the aircraft cabin and/or compartments via duct 16, check valve 18 and exit diffuser 20. Not shown, but generally a part of this system, are cross ducts which are in communication with the engine bleed air and in the event that the pressure from the engine becomes at a sufficiently high level check valve 18 is closed to prevent backflow to the compressor. When either this occurs or when the demand from the air conditioning package is at such a low level that requires a low airflow from the compressor below the value where surge will ensue a surge valve generally illustrated by numeral 22 which is normally in the closed position is positioned to open by surge actuator 24.

Actuator 24 which may be of the half area type is controlled by virtue of bleeding high pressure servo air through the restrictor 26 which is in series flow connection with poppet valve 30. Poppet valve 28 is in parallel with orifice 26 and can also supply high pressure air to open the actuator. For this purpose high pressure bleed air from the main engine of the aircraft is admitted.

ted to line 31 and a portion being directed into cavity 32 and a portion flows past restrictor 26 into chamber 34, and out of valve 30 to ambient under normal conditions. Since the effective area of piston 36 exposed to chamber 32 is substantially half the area of the piston exposed into chamber 34 approximately half the amount of pressure in chamber 34 as is in chamber 32 is necessary in order to equalize the forces on the piston. A slight force in either direction will cause piston 36 and its extending rod 38 to move. Rectilinear movement of piston 36, accordingly, will move ratchet 40 and hence pinion gear 42 for rotating butterfly valve 44 of surge control valve 22.

The surge control 48 senses total pressure downstream of compressor 12 in diffuser section 52 via line 50 and static pressure in the diffuser section 52 of the compressor via line 54. It being noted that the static pressure is sensed at the throat or reduced area section and total pressure or its approximation is sensed at the larger area section. The difference of pressure drop across diaphragm 56 is indicative of the air weight flow in the diffuser 52, and hence through the compressor.

From the foregoing it is apparent that under normal conditions valve 30 is away from seat 58 whenever the weight flow is above the predetermined value. Whenever the weight flow drops below the predetermined value i.e. the value where surge ensues, diaphragm 56, responding to the drop between static and total pressure in diffuser 52, positions the diaphragm in an upward direction closing line 64 from ambient via line 62 so that the pressure in chamber 34 will buildup toward the value of the pressure in line 31 to position actuator 24 to the right to open the surge valve 44.

It is apparent from the foregoing that closing poppet 30 causes engine bleed in line 31 to decrease the pressure drop across restrictor 26 thus increasing the pressure in chamber 34, positioning piston 36 to the right for rotating butterfly valve 44 in the open position. Obviously, opening the surge valve increases air weight flow above the value where surge ensues. It being understood that surge is a well known phenomena, undesirable or intolerable operating condition and need not be theorized for an understanding of this invention.

Also for the sake of convenience and simplicity the particular details of the surge controller is not deemed essential to an understanding of this invention and is omitted herefrom. It being only important to understand that a suitable sensor serves to measure parameters indicative of surge. In this instance diaphragm 56 senses the differences between total and static pressure of diffuser 52 to open surge valve 22 to hold compressor discharge weight flow above a predetermined value and it is also being appreciated that the rotational speed of the compressor is held at a constant.

In accordance with this invention the rate sensor generally indicated by reference numeral 70 senses static pressure at the throat of diffuser 52. Diaphragm 72 is disposed in cavity 74 dividing it into a pair of subchambers 76 and 78. Static pressure in line 80 is admitted directly into chamber 76 and via restrictor 82 before egressing to chamber 78. Since diaphragm is sensitive to the difference between static pressure directly and

the bleed through orifice 82 it will only move when the rate is above a predetermined value. This value is selected to assure proper cooperation between the surge control and rate sensor.

Assuming a closure of check valve 18, a rapid increase in compressor discharge pressure will occur, an even larger rapid increase in diffuser static pressure will also occur creating a large pressure drop across diaphragm 72. This actuates poppet valve 28 via rod 86 suitably interconnecting diaphragm 72 and poppet 28 to position it open and connecting line 88 with line 64 for admitting engine bleed air into chamber 34 to surge actuator 24 to open surge valve 44. The springs serve to center the diaphragm and poppet, adjust the loads and change the rate controls sensitivity.

What has been described is a rate controller that is characterized as economical and simple to construct having a minimum of moving parts, having a high gain that cooperates with a surge controller that has a low gain, and both maintaining the compressor out of surge.

It should be understood that the invention is not limited to the particular embodiments shown and described herein, but that various changes and modifications may be made without departing from the spirit or scope of this novel concept as defined by the following claims.

I claim:

1. Means for preventing a compressor discharging into a diffuser from operating under surge conditions, including in combination, a surge control operating under one set of conditions and a rate controller operating under another set of conditions, said surge control having a lower gain than the rate controller, said rate controller being responsive to the static pressure at the reduced area section of the diffuser operating independently and/or concomitantly with said surge control, means responsive to both said surge control and said rate controller for maintaining the airflow through said compressor above a predetermined value.

2. Means as claimed in claim 1 including a surge valve, an actuator controlled by said surge control and said rate controller for controlling said surge valve.

3. Means as claimed in claim 2 wherein said actuator includes a half-area servo piston.

4. Means as claimed in claim 3 wherein said actuator has both sides of said half area servo piston exposed to a servo pressure, and means controlled by said surge control and said rate controller for bleeding servo pressure from or adding servo pressure to one side of said half area servo piston.

5. Means as claimed in claim 1 wherein said rate controller positions said actuator at a rate that is faster than the rate of said actuator when positioned by said surge control.

6. Means as claimed in claim 1 wherein said rate controller includes a cavity, a diaphragm extending across said cavity defining a pair of subchambers, means including passages for admitting pressure into both subchambers, and a flow restrictor in said passages restricting flow into only one of said subchambers.

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