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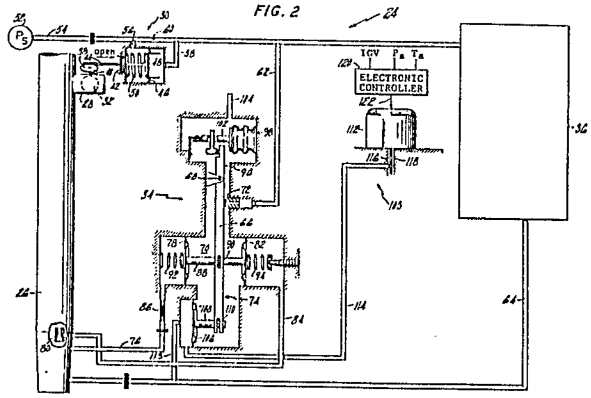
(54) **A surge control for a compressor.**

(57) A surge control (24) is biased by a reset means (105) to provide a control point close to a compressor surge point that varies as a function of pneumatic load, temperature and pressure input to the compressor.

FIG. 2



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Description

A Surge Control For A Compressor

Technical Field

This invention relates to surge controls for compressors.

Background Art

Auxiliary Power Units (APU) generally power the air conditioning and electrical systems within larger aircraft. An air conditioning compressor and electrical generator may be driven by a free turbine of an APU power unt such as a gas turbine engine. It is generally desirable to run the power unit (and therefore, the free turbine) at constant corrected revolutions per minute so that the power unit may be operated at its design point and so that the electrical generator may operate at a constant speed for a constant electrical output.

The air conditioning system does not always require a constant pneumatic load that a constant speed compressor can supply. Typically guide vanes are provided within the compressor air inlet to vary the pneumatic load on the compressor as required by the aircraft. Fuel savings may occur for lesser required air conditioning loads as less energy is required to drive the compressor. Generally, when air requirements are changed, the inlet guide vanes vary the pneumatic load on the compressor which provides the required air flow.

Compressors have different operating as a function of pressure ratio (discharge pressure/let pressure) and corrected discharge weight flow ((weight flow) x (square root of temperature)/(pressure)) versus downstream load. A limited range of operation is provided between the point of compressor surge, where unstable flow occurs, and compressor choke, where maximum corrected airflow can pass. As the operating range of the compressor moves, away from the surge point toward choke, compressor efficiency drops off rather quickly. It is desirable therefore to operate as closely to the surge point as possible without encountering surge.

Some compressors have a constant surge point even if inlet guide vane angles change. Surge controls are known to prevent such compressors from surging by dumping downstream flow to provide a constant corrected flow near the surge point. However, such surge controls are not efficient with compressors that have a surge point that varies as inlet guide vane angle changes. Such controls would dump required compressor outlet flow requiring the APU power unit to work harder to supply required flow wasting fuel thereby.

Disclosure Of The Invention

It is an object of the invention to provide a surge control for a compressor that controls the output of the compressor such that compressor operates efficiently without surge.

A further object of the invention, is to provide a surge valve is provided that controls the air output from a compressor so that an efficient flow is provided for the surge points of the compressor.

According to the invention, a surge controller which provides a constant corrected flow is biased such that for each inlet guide vane angle, the flow is corrected for the surge point associated with each such inlet guide vane angle. The surge controller provides a flow control point for each surge point so that the compressor operates efficiently and avoids surge. More specifically, the surge valve is biased as a function of the inlet guide vane angle (LGV), the ambient pressure, and the ambient temperature.

These and other objects, features and advantages of the present invention will become more apparent in light of the following detailed description of a best mode embodiment thereof, as illustrated in the accompanying drawing.

Brief Description Of The Drawings

Fig. 1 is a schematic diagram of an auxiliary power unit employing a surge control system;

Fig. 2 is a schematic diagram showing an embodiment of the surge control system of Fig. 1;

Fig. 3 is a schematic diagram showing a further embodiment of the surge control system of Fig. 1; and

Fig. 4 is a plot of the pressure ratio versus corrected air flow characteristics of a compressor utilizing the concepts of the invention.

Best Mode For Carrying Out The Invention

Referring to Fig. 1, an APU is schematically shown as comprising a free turbine type of powerplant generally illustrated by numeral 10. The APU has a gas generating or power producing section 12 (compressor, burner and turbine) a free turbine 14, an electric generator 16 and a load compressor 18. The load compressor serves to supply pressurized air to an aircraft air conditioning system (not shown) which in turn controls the pressure and temperature in the aircraft cabin and compartments (not shown). Variable inlet guide vanes 20, which are moveable by an actuator 22, vary the swirl of the air at the inlet of the compressor in order to vary the pneumatic load on the load compressor 18. A surge control system 24 attaches to the compressor outlet 26. The system controls surge by bleeding air through a conduit 28.

Referring to Fig. 2, the details of the surge control system 24 are schematically shown. The surge control system encompasses several major components. A half-area actuator 30 regulates the flow of air dumped through the conduit 28 by positioning a damper 32 therein. The position of the half-area actuator is controlled by a pressure surge valve 34 which reacts to changes in flow within the compressor outlet 26 so that the compressor 18 does not go to surge. A rate sensor 36 also helps position the half-area actuator in the event that there is a sudden decrease in the flow demand on the compressor. Such a device is described in U. S. Patent No. 3,804,112, to Harner and assigned to the common assignee herein such U. S. Patent being incorporated by reference.

The half-area actuator consists of: a pinion 38 which attaches via rod 40 to the damper 32; a piston 42 which attaches to the pinion via a rack 44; a diaphragm 46 which is connected to the piston 42 by a rod 48; and, a spring 50 which biases the diaphragm to the right. The left hand side of the piston is vented to ambient. The volume between the piston and the diaphragm is connected to a supply pressure source 52 via lines 54 and 56. The right hand side of the diaphragm is also connected to supply pressure via lines 54 and 58. A flow restrictor 60 is placed within the line 54 between line 56 and line 58 to allow the damper to react to pressure changes in line 54 and line 62 as will be discussed infra. As will be readily appreciated, when the fluid pressure force of the piston overcomes the fluid pressure force and the diaphragm and the force on the spring, the piston and diaphragm will move to the right pivoting the damper via the rack and pinion to open flow through the conduit. Likewise, when the fluid pressure force and the diaphragm overcomes the fluid pressure force on the piston, the piston and the diaphragm will move to the left pivoting the damper to close flow through the conduit 28.

The rate sensor 36 reacts to large changes in compressor outlet pressure via line 64 to dump supply pressure from behind the diaphragm 46 via line 54 so that large increases in pressure (and drops in corrected flow) within the compressor outlet may be vented through the surge conduit 28 as disclosed in Harner.

The surge valve 34 controls the amount of flow through the conduit for given compressor surge points as will be discussed infra.

The surge valve 34 has a closure beam 66 which is mounted at a fulcrum 68 within a chamber 70. The closure beam controls the pressure behind the half-area actuator through line 62 by moving towards and away from a vent.

The fluid pressure force of the air within the compressor outlet 26 is brought to bear on a bottom portion 74 of the beam 66 by a line 76 which feeds the fluid pressure force to a first diaphragm 78. A flow sensor (venturi) 80 provides an opposing fluid pressure force upon the closure beam to a second diaphragm 82 via line 84. Line 76 has a flow restrictor 86 to provide lead-lag dynamic compensation as is well known in the art. The first and second diaphragms 78, 82 are each attached to the balance beam by a rod 88 and a pin 90. The first and second diaphragms are each biased by spring 92 and spring 94 respectively. The top portion 96 of the closure beam is biased by an evacuated bellows 98 which attaches to the beam by means of an adjustable set screw 100 and rod 102. The chamber is vented to ambient via line 64. As is well known in the art, at lower altitudes the closure beam is biased by the evacuated bellows away from the vent, and at higher altitudes towards the vent.

A reset system 105 utilizes a third diaphragm 106 which biases (or resets) the bottom portion 74 of the closure beam via rod 108 and pin 110. The third diaphragm has the fluid pressure force of the air within the compressor outlet impinging thereon via line 113. The fluid pressure force of the regulated pressure upon the third diaphragm 106 is controlled by a torque motor 112 which regulates the amount of air escaping from behind the third diaphragm via line 114 and vent 116 by positioning a flapper 118 towards and away from the vent 116. The torque motor sets the bias (or reset) force as a function of inlet guide vane angle, ambient pressure, and ambient temperature. As is well known in the art, for a given inlet guide vane angle, a given pressure and a given temperature, the compressor will have a particular surge point. An electronic controller 120 senses the guide vane angle from the actuator 22 via an electric line (not shown). The ambient pressure and temperature are sensed via external sensors (not shown). The electronic controller 120 upon receiving such information, refers to an internal look-up table to determine the given surge point. Once the given surge point is determined, the controller sends a signal to the torque motor via line 122 to position the flapper thereby biasing the closure beam to a control point near the surge point via the third diaphragm. Compressor outlet corrected flow is controlled by the surge control system thereby such that the compressor operates at the control point as close as to the surge point as possible without going into surge.

Referring to Fig. 3, a further embodiment of the invention is shown. As may be perceived from the above explanation, the broadest concept of Applicants' invention is to properly bias the closure beam to account for different surge points of the compressor. As is shown in Fig. 2 the beam is biased by a regulated pressure source whose fluid pressure force on the beam is controlled by a torque motor. Fig. 3 shows an hydraulic system 124 which biases the second diaphragm 82 to provide the proper bias on the closure beam for each surge point. A regulated supply of hydraulic fluid from source 126 is brought to bear upon piston 128 via line 130 and line 132. The line 132 has a flow restrictor 134 so that the piston may be positioned as the fluid pressure force of the hydraulic fluid is modulated. The fluid pressure force of the hydraulic fluid upon the piston 128 is controlled by a torque motor 130 similar to the torque motor 112 shown in Fig. 2. The torque motor receives a positioning signal from a controller 132 which has referred to the look-up table. The torque motor 130 controls a flapper 134 which regulates the pressure on the right side of the piston via line 135. The flapper ports the hydraulic fluid to a drain 136 thereby positioning the piston to position as a function of the position of the flapper. Movement of the piston 128 effects movement of a second piston 138 via rod 140 which positions the spring via rod 142 to bias the second diaphragm.

The effect is similar to the embodiment in Fig. 2 in that the surge control provides the proper control points close to the surge point so that surge may be avoided while the compressor acts efficiently.

A linear variable transducer 144 is attached to the piston 128 to provide a feedback to the controller 132 as to the bias on the second diaphragm. This is important so that the beam can be accurately biased for given conditions.

Referring to Fig. 4, the advantages of the invention may be clearly seen. For a surge control that does not bias or reset its closure beam for each inlet guide vane angle, the air flow remains at relatively constant corrected flow (o-reset control line) for different pressure ratios while avoiding surge. This is desirable if the surge point remains relatively constant for each inlet guide vane angle. However, if the surge point shifts for each inlet guide vane angle, a constant corrected flow may not be desirable. If the air conditioning system does not need such a constant flow, the excess flow is dumped. The APU powerplant is working harder than it needs to be. With bias or reset control points (reset schedule) the compressor works closer to the required air flow for each inlet guide vane angle. The APU powerplant may work less hard and theoretically save the difference between the reset schedule and reset control line in fuel consumption. Note that the control points of the reset schedule are spaced from the compressor surge line to provide a margin of safety.

While the present invention has been illustrated and described with respect to a particularly preferred embodiment thereof, it will be appreciated by those skilled in the art that various modifications to the system may be made without departing from present invention. Thus, it will be understood that the following claims cover the embodiment described herein and all such equivalence thereof is fall within the scope of this invention. Having thus described the invention, what is claimed is:

Claims

1. Apparatus for controlling the surge of compressor having air input thereto and air output therefrom, said compressor having means for varying the pneumatic load input thereto, the apparatus characterized by:
surge means for providing a constant corrected flow from said compressor so that surge is avoided, and
means for biasing said surge means such that said surge means efficiently prevents surge for each surge point of the compressor as said means for varying the pneumatic load vary said pneumatic load.

2. Apparatus of claim 1 further characterized by:
feedback means for monitoring a bias by said means for biasing so that said means for biasing may be operated properly.

3. Apparatus for controlling surge characterized by:
a compressor having a surge point that varies depending on a pneumatic load input to said compressor,
surge means for providing a constant corrected flow from said compressor, and
means for biasing said surge means such that said surge means efficiently prevents surge for said surge point as said pneumatic load input to said compressor changes.

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FIG. 1

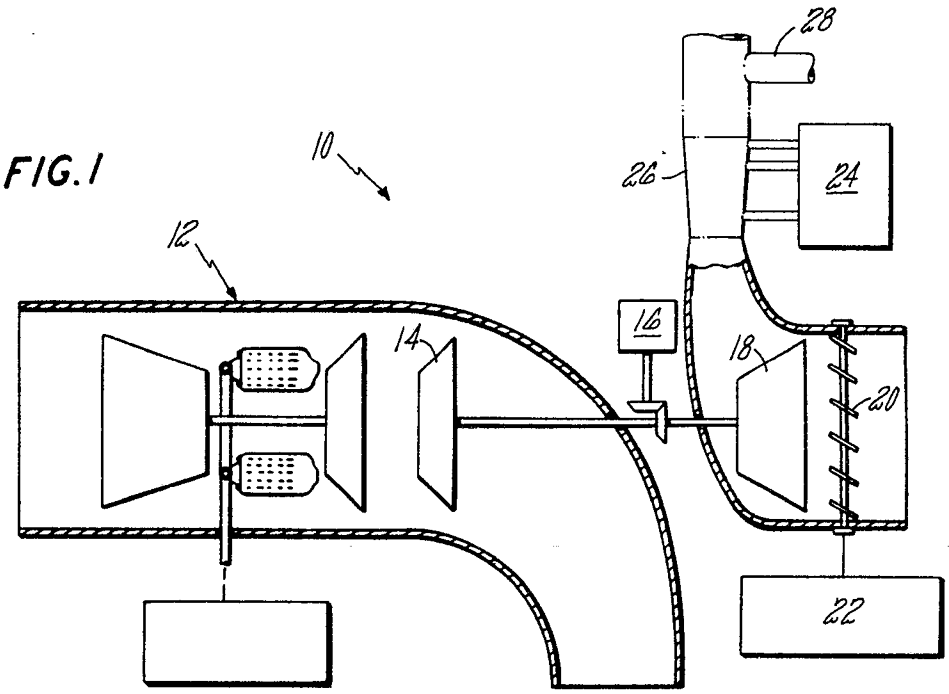
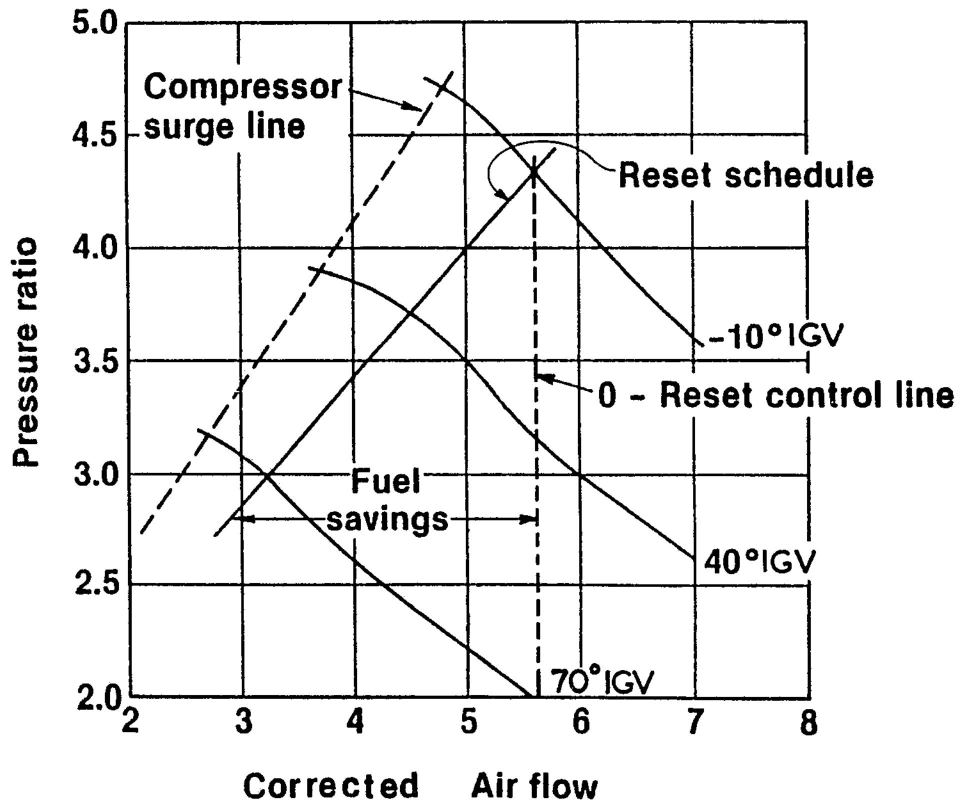


FIG. 4



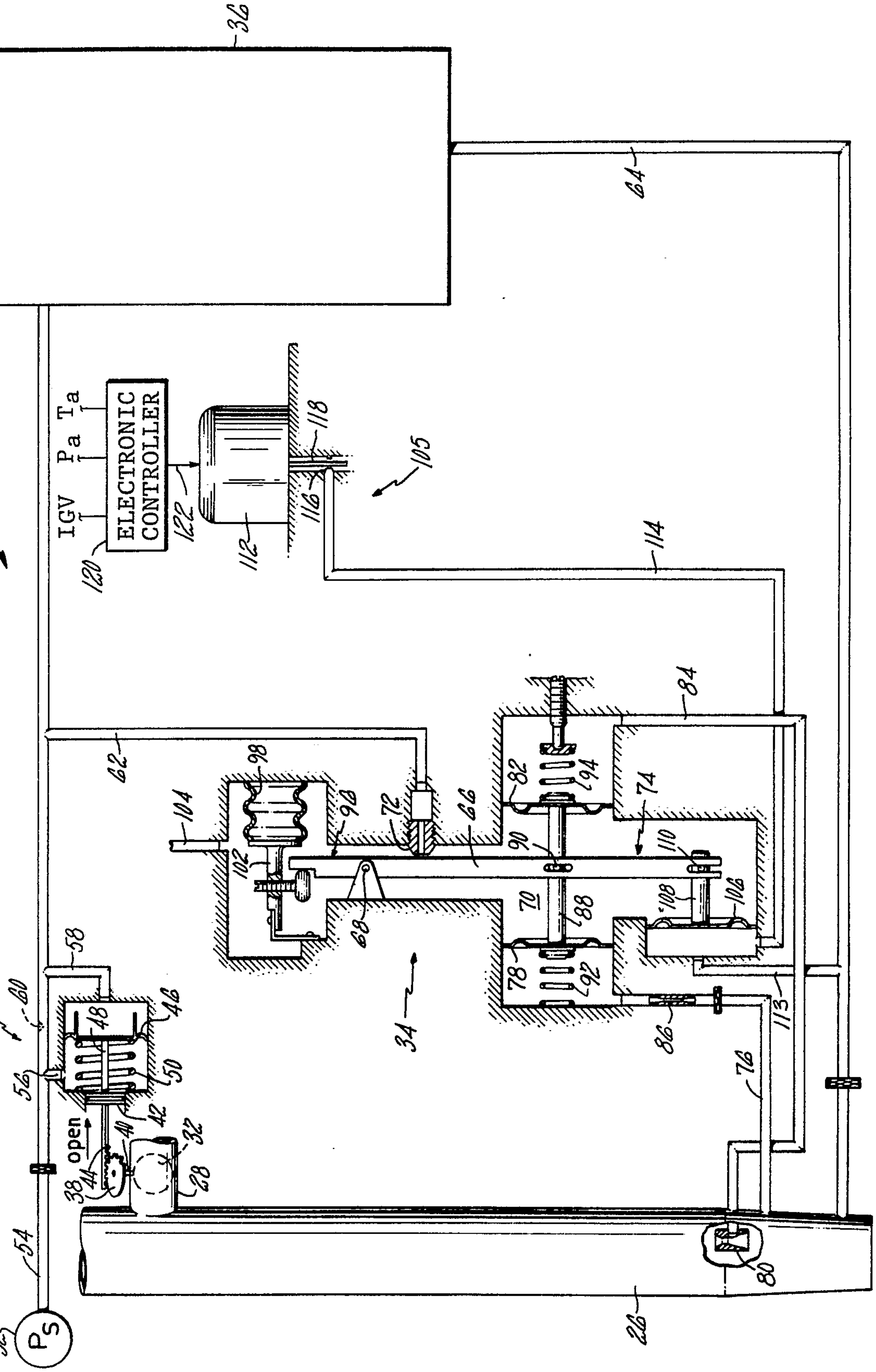


FIG. 2

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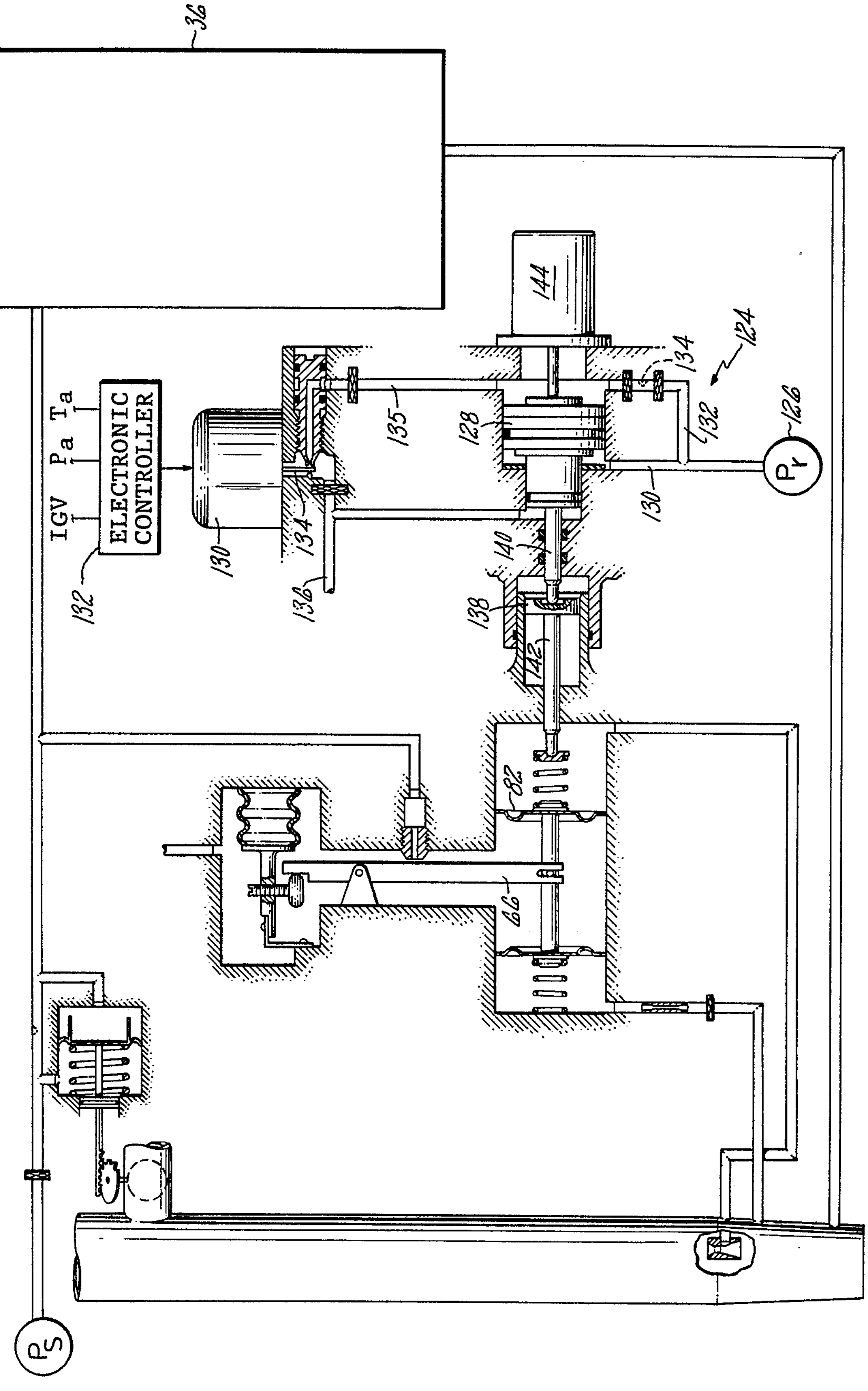
FIG. 3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