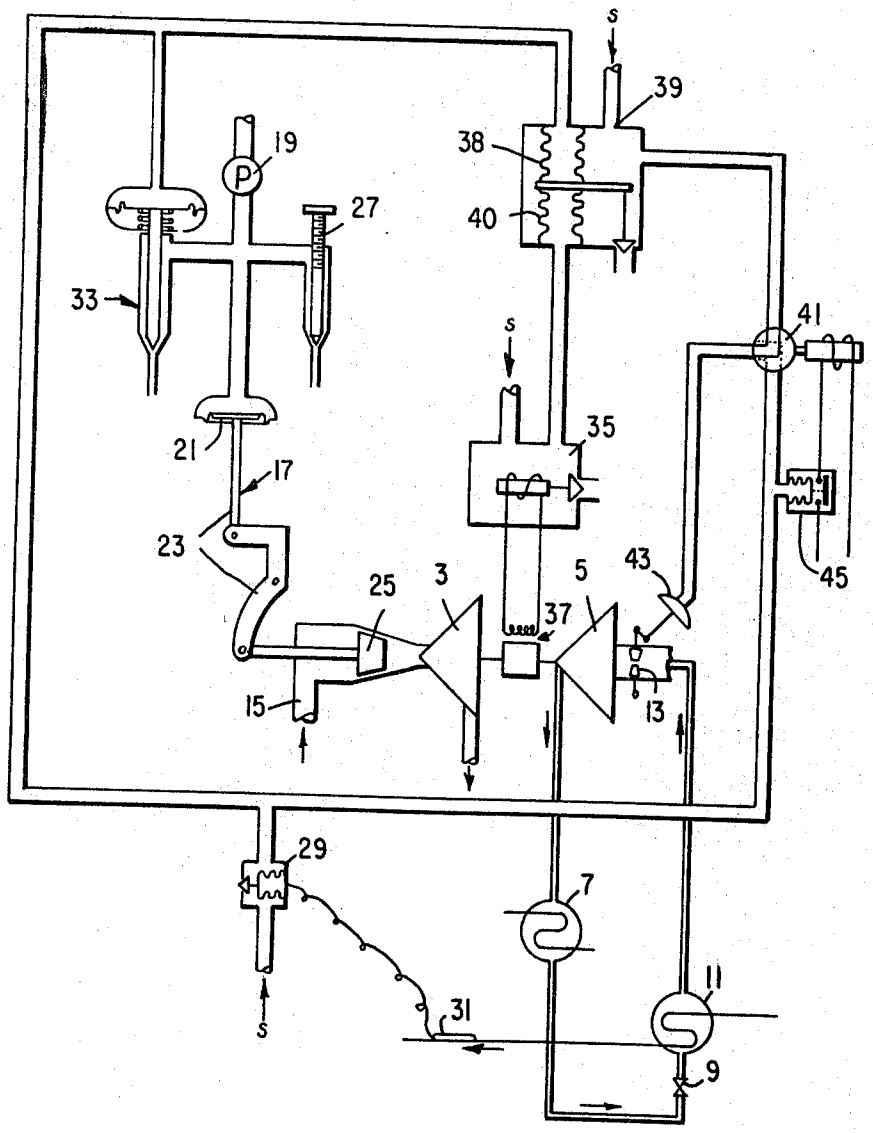
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COMPRESSOR CONTROL

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COMPRESSOR CONTROL

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ABSTRACT OF THE DISCLOSURE

A control system for regulating centrifugal compressor capacity by varying compressor speed to effect a first range of reduction in capacity and thereafter maintaining compressor speed constant and varying compressor guide vane adjustment to effect an additional capacity reduction.

BACKGROUND OF THE INVENTION

In many centrifugal gas compressor installations, such as refrigeration systems where the compressor is employed to pump refrigerant in the gaseous state from low side pressure to high side pressure, a variable load on the compressor is encountered. In order to maintain compressor efficiency and prevent compressor surge, it has been the practice to vary compressor capacity. This is accomplished by varying the position of inlet guide vanes and/or diffuser vanes or by varying compressor speed. At high compressor outputs, the most efficient way of varying capacity is to vary compressor speed. However, if compressor speed is dropped below a certain point, compressor surge may occur. To avoid this problem movable guide vanes are utilized to regulate compressor capacity, resulting in a compressor having a wide stable operating range, at the expense of compressor efficiency.

Another problem encountered in compressor operation is the danger of overloading the driver under extreme operating conditions. For example, in a refrigeration system employing a centrifugal compressor the load on the compressor at start-up can exceed the design operational load to an extent which could damage the driver.

SUMMARY OF THE INVENTION

This invention relates to a compressor control system to vary compressor output according to the load thereon by utilizing a load controller to provide a signal proportional to the load which is effective to alter the set point of a constant speed governor over a range of high loads and which is effective at a preselected medium loading to maintain compressor speed constant while activating a compressor guide vane controller so as to vary compressor capacity by the variation of inlet guide vanes over a range of low compressor loads.

BRIEF DESCRIPTION OF THE DRAWING

The figure is a schematic diagram of a control system for a turbine driven centrifugal refrigeration system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing, there is illustrated a steam turbine **3** driving a centrifugal refrigerant compressor **5**, which supplies refrigerant to condenser **7**, expansion valve **9** and water chiller **11**. From water chiller **11**, the refrigerant is returned to the compressor inlet which has adjustable guide vanes **13** therein. The turbine is supplied with motive fluid through line **15** which is regulated by governor valve **17** to control turbine speed. The governor valve **17** is comprised of a positive displacement pump **19** operably associated with the turbine shaft so as to

provide fluid under pressure, proportional to turbine speed, to a diaphragm **21**, which, through linkages **23**, controls the positioning of the valve disc **25** to regulate the motive fluid supplied to the turbine so as to maintain a constant speed thereof. The initial setting of valve **17** is obtained by the adjustment of a needle valve **27** which bleeds a portion of the pumped fluid from the governor valve circuit so as to limit the pressure obtainable therein.

The control system is provided with a temperature controller **29** which is responsive to the temperature of the chilled water leaving chiller **11** as evidenced by chilled water sensor **31** to vary control air pressure from a suitable source (not shown) so as to provide control air pressure between 3 p.s.i. and 15 p.s.i. to the control system. Under high load conditions evidenced by a control pressure range between 15 p.s.i. and 9 p.s.i., the capacity of the compressor is varied by changing the speed of the turbine. This is accomplished by a secondary bleed valve **33** which is responsive to control pressure transmitted thereto to change the governor valve set point as evidenced by bleed valve **27** by bleeding governor valve pressure therefrom. Secondary bleed valve **33** is sized so as to be wide open at 9 p.s.i. at which point the pressure in the governor valve circuit is such as to provide a bottom limit to compressor speed. When the system capacity is being varied by changing turbine speed and thus the pumping rate of the compressor, it is also subjected to an overload control comprised of an electro-pneumatic transducer **35** responsive to turbine speed as evidenced by an electrical signal produced by a signal generator **37** on the turbine drive shaft which transmits a pneumatic signal to a differential controller **39** including upper and lower bellows elements **38** and **40**. As may be noted in the drawing lower bellows **40** communicates with the output of the transducer **35**. System control pressure from the temperature controller **29** is provided to the upper bellows element **38** of the differential controller **39**. As long as the two signals provided to the differential controller are equal, a constant 9 p.s.i. signal is transmitted through a three-way solenoid valve **41** to guide vane regulator **43** which is sufficient to maintain the vanes wide open. If the signal from the transducer **35** drops below that from temperature controller **29**, it indicates that the turbine is overloaded. Differential controller **39** senses the difference in the signals being applied to the bellows elements and automatically throttles the signal to the guide vane regulator **43** by transmitting a reduced pressure signal to the regulator, partially closing the vanes, unloading the compressor and permitting the turbine to return to the desired speed. During high load operation, control pressure from temperature controller **29** is also utilized to hold switch **45** open so as to maintain solenoid operated three-way valve **41** in a position to communicate differential controller **39** with guide vane regulator **43**.

Once the signal from temperature controller **29** drops below 9 p.s.i., it is ineffective to further vary the governor set point. As such, below that point, the governor will act to maintain turbine speed constant at the level dictated by a 9 p.s.i. signal. A control pressure below 9 p.s.i. will allow switch **45** to close, activating three-way solenoid valve **41** so as to communicate control pressure directly to guide vane regulator **43**. The low range system capacity, therefore, is varied solely by the positioning of the guide vanes **13** under the influence of control pressure from temperature controller **29** below the 9 p.s.i. level.

As can be seen from the above, applicants' compressor control provides for economical operation of a wide range of compressor loads and includes a provision to prevent driver overload at extreme high load conditions such as start-up.

While we have described a preferred embodiment of the invention, it is to be understood the invention is not limited thereto.

We claim:

1. A control system for a gas compressor having a variable speed driver comprising:

load sensing means operable in response to compressor loading to provide a signal proportional thereto;

means for varying the speed of the compressor in response to the signal from said load sensing means;

speed sensing means operable in response to the speed of the compressor to provide a signal proportional thereto;

means associated with the inlet of the compressor to vary the capacity thereof; and

differential control means operable in response to the difference between the signal from said load sensing means and the signal from said speed sensing means indicative of an overload on the driver to actuate said compressor inlet means to vary compressor capacity to prevent overload thereof.

2. A control system for a gas compressor according to claim 1 wherein the variable speed driver comprises a steam turbine,

said load sensing means including a pneumatic control operable in response to compressor loading to provide a variable pressure air signal,

said means for varying compressor speed including a steam governor valve, operable in response to air pressure from said pneumatic control to vary the quantity of steam supplied to the turbine,

said speed sensing means including a signal generator, operably associated with the compressor to provide

an electric current proportional to compressor speed, said speed sensing means further including an electro-pneumatic transducer for providing a variable pressure air signal in response to the variations in electric current from said signal generator.

3. A control system for a gas compressor according to claim 1 wherein said means for varying the speed of the compressor is nonresponsive to a range of signals from said load sensing means indicative of low compressor loading, the control system further including

means, responsive to a range of signals from said load sensing means indicative of low compressor loading to bypass said speed sensing means and said differential control means to effect control of said compressor inlet means directly by said load sensing means.

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