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Post et al.

[11] **3,788,776**

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[54] **COMPRESSOR UNLOADING CONTROL**

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[52] **U.S. Cl.** **417/295**

[51] **Int. Cl.** **F04b 49/02**

[58] **Field of Search** 417/295, 26, 27, 28, 29

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Assistant Examiner—Richard Sher
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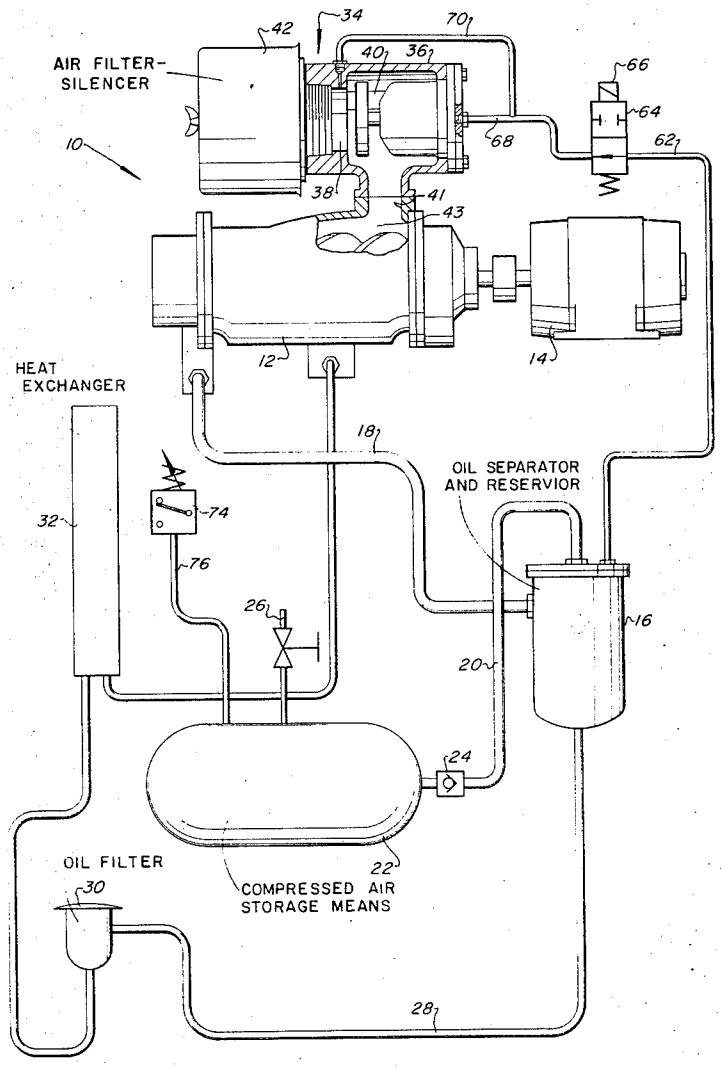
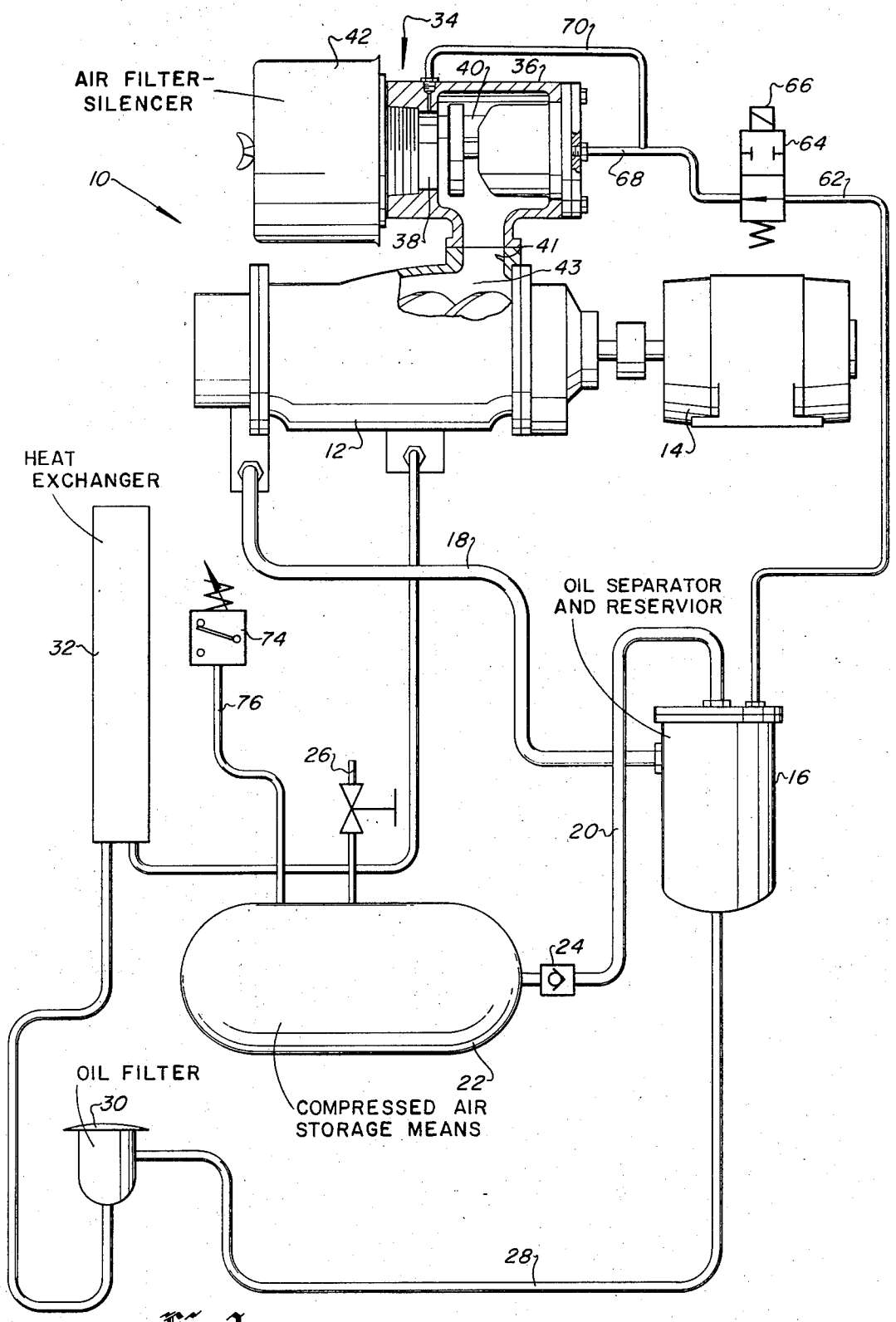
[57] **ABSTRACT**

An unloading control arrangement for a liquid injected air compressor of the type which includes a pneumatically operated inlet throttling valve, a liquid separator-reservoir tank, and compressed air storage means. A pressure responsive switch connected to the compressed air storage means is operative, at a predetermined pressure condition, to actuate a single power operated valve which vents the separator-reservoir tank and causes the inlet throttling valve to reduce inlet air flow to the compressor. A vent line connected to the power operated valve includes a flow restrictor of suitable size to provide for a low residual pressure in the reservoir tank to insure adequate liquid circulation during compressor unloaded operation.

7 Claims, 2 Drawing Figures




AIR FILTER-
SILENCER
10
42
34
70
40
36
66
64
68
62
38
41
43
12
14
HEAT
EXCHANGER
18
OIL SEPARATOR
AND RESERVIOR
32
74
76
26
16
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24
22
OIL FILTER
30
COMPRESSED AIR
STORAGE MEANS
28

Fig 1

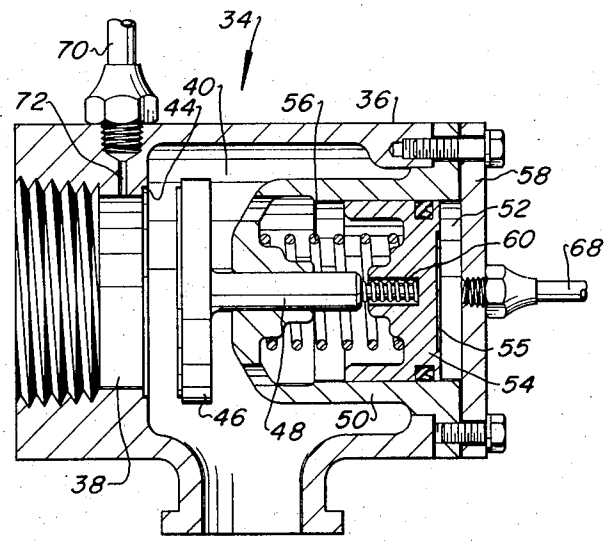

Fig 2

COMPRESSOR UNLOADING CONTROL

BACKGROUND OF THE INVENTION

In the art of controls for gas compressors it is usually desirable to unload or idle the compressor while running by throttling the compressor inlet air flow and reducing the gas pressure downstream of the compressor to reduce power demand. It is also usually necessary in most liquid injected gas compressor systems to provide a flow of liquid through the compressor during unloaded operation to lubricate and cool the compressor. Moreover, certain liquid injected compressors such as rotary helical screw and sliding vane types require the circulation of small quantities of inlet gas through the compressor during unloaded operation to promote quiet operation and to scavenge the liquid injected into the compressor.

Various arrangements of compressor controls are known in the prior art for providing the above mentioned type of unloaded or idling operation of gas compressor units including liquid injected compressors. U.S. Pats. Nos. 2,997,227 to G.E. Ternent; 3,542,497 to H. Chapuis; and 3,582,233 to C. Bloom disclose compressor unloading systems wherein the air pressure downstream of the compressor is relieved in various ways while substantial throttling of the compressor inlet is used to reduce compressor throughput. For the most part prior art compressor unloading controls for providing the herein discussed mode of operation tend to be somewhat complex wherein a plurality of separate valve devices and numerous conduits are required to make up the control system. The complexity of the control system, of course, increases the cost and reduces the inherent reliability of the compressor unit.

SUMMARY OF THE INVENTION

The present invention provides an unloader control system for a liquid injected compressor which substantially throttles inlet gas flow and relieves the gas pressure in the discharge system downstream of the compressor while providing a suitable reduced compressor throughput and pressure in the liquid reservoir to provide adequate liquid circulation and quiet vibration free operation.

The compressor unloader control system of the present invention includes a single power operated valve operable at a predetermined pressure in a compressed gas storage means to relieve the gas pressure in a separator-reservoir tank downstream of the compressor and provide pressure gas to at least partially close a pressure fluid actuated inlet throttling valve.

With the compressor unloader control of the present invention a steady state running condition of reduced compressor gas throughput together with sufficient liquid circulation to insure adequate lubrication is realized with a structurally uncomplicated and reliable arrangement requiring a minimum number of component devices. Accordingly, the compressor unloader control system of the present invention provides a reliable and economical arrangement which functions to control compressor operation in a way similar to more complex control systems.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 illustrates schematically a liquid injected compressor including the unloader control system of the present invention.

FIG. 2 is a detail section view of the inlet throttling valve of the control system shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1 of the drawing, a liquid injected air compressor unit is shown schematically and generally designated by the numeral **10.** The compressor unit **10** includes a positive displacement rotary compressor **12** which may be of the helical screw or sliding vane type, both well known. The compressor **12** is suited for the direct injection of a liquid into the compressor working chamber for mixing with the air being compressed. The liquid used is usually a suitable oil and serves as a lubricant for the compressor bearings and other parts subject to wear as well as a coolant for absorbing the heat of compression and a sealant for reducing the rotor clearances in the working chamber. The compressor **12** is connected to an electric motor **14,** although other types of prime movers may be used.

The compressor unit **10** is also characterized by discharge means including an air-oil separator and reservoir tank **16** and a discharge line **18** which is connected to the compressor **12** for conducting to the tank **16** the oil-air mixture discharged from the compressor. The tank **16** includes suitable means, not shown, for separating oil from the oil-air mixture whereby substantially oil free air may be conducted through a conduit **20** to a compressed air storage means **22.** A check valve **24,** interposed in the conduit **20,** is operable to prevent the backflow of pressure air from the storage means **22** to the oil reservoir tank **16.** The compressed air storage means **22** includes an outlet conduit **26** for work purposes of the compressed air stored therein. An oil return conduit **28** is connected to the tank **16** for conducting oil through a filter **30** and a heat exchanger **32** and finally to the compressor **12** for continuous reinjection.

Referring to FIGS. **1** and **2,** the compressor unit **10** is further characterized by an inlet throttling valve generally designated by numeral **34.** The inlet throttling valve **34** includes a housing **36** having an opening **38** into an interior **40** which is in communication with the compressor inlet means **41** opening into a working chamber **43.** A suitable air filter-silencer **42** is fitted in the opening **38.** The housing **36** also includes a portion forming a valve seat **44** which may be engaged by a valve closure member **46** to close off the compressor inlet. The closure member **46** includes a stem **48** which is supported in a housing portion **50.** The housing portion **50** includes a chamber **52** in which is disposed actuating means comprising a piston **54** engageable with the stem **48** for moving the closure member **46** toward the seat **44** to throttle the flow of inlet air into the compressor **12.** The valve **34** also includes a coil spring **56** in the housing portion **50** for biasing the piston toward a cover member **58.** A coil spring **60** is disposed between the stem **48** and piston **54** for biasing the closure member **46** against the seat **44** with light force to prevent the backflow of oil out of the compressor **12** under certain conditions on shutdown.

The inlet throttling valve **34** comprises part of an unloader control system for the compressor unit **10** which also includes a conduit **62** leading from the tank **16** to a power operated valve **64.** The valve **64** is represented schematically in the drawing as a two-position normally

open valve having a solenoid actuator **66**; that is the valve is open to permit the relief of pressure in the tank **16** when not energized and is closed when energized. The valve **64** is commercially available in a number of conduit sizes. The valve **64** is also connected to the chamber **52** by a conduit **68** and to the inlet opening **38** by a conduit **70**. The conduit **70** opens into the inlet opening **38** through restricted passage means **72** formed in the valve housing **36**.

The unloader control system for the compressor unit **10** also includes a pressure responsive electric switch **74** in communication with the air storage means **22** by way of a conduit **76**. The switch **74** may be of a well known type which is adjustable to open a set of circuit contacts on increasing pressure at a first predetermined pressure and close said set of contacts to complete an electrical circuit at a second predetermined pressure less than the first pressure. The switch **74** is suitably connected to the solenoid valve **64** and to a source of electric energy, not shown, to energize the valve to be in the closed position when the air pressure in the storage means **22** decreases to a value below the second predetermined pressure and to remain closed until the air pressure increases to the first predetermined pressure.

The unloader control system herein described operates to control the compressed air output of the compressor **12** and to reduce the compressor power demand during periods of nonuse of compressed air from the storage means **22**. Assuming that the compressor unit **10** is running and the pressure in air storage means **22** is less than the pressure required to open the switch **74**, the valve **64** will be in the closed position and the inlet throttling valve piston **54** will be biased toward the cover member **58** permitting the closure member **46** to be open to allow air to enter the compressor inlet. Normal use of the compressor unit **10** will result in a sufficient pressure in the tank **16** to force the oil separated therein to continuously recirculate through filter **30** and heat exchanger **32** and back to the compressor **12**. A reduction or cessation of use of compressed air for work purposes will cause a pressure increase in storage means **22**. When the pressure increases to the first predetermined pressure the switch **74** will be actuated to open the circuit to valve **64** to deenergize the solenoid **66** causing the valve to open. The opening of valve **64** will substantially vent pressure air in the tank **16** through conduit **70** into the inlet opening **38**. The check valve **24** will prevent back flow of compressed air from storage means **22** to the tank **16**. Venting the tank **16** into the inlet opening **38** will not create objectionable noise due to the noise muffling ability of the air inlet filter-silencer **42**. The restricted passage **72** will limit the rate of bleeddown or venting of the tank **16** and, accordingly, pressure air in the conduit **68** will be conducted to the chamber **52** to cause the piston **54** to move the closure member **46** toward the seat **44** to throttle the flow of inlet air to the compressor.

The closure member **46** will move to throttle inlet air to the compressor **12** until a balanced or steady state condition of reduced compressor air throughput is reached. This balanced operating condition is desirably one wherein the pressure in the tank **16** is on the order of 5–16 percent of the normal working pressure of the compressor unit. Under this operating condition a sufficient pressure differential will exist between the tank **16** and the compressor working chamber to assure adequate oil flow to the compressor. The back pressure which the compressor must work against together with the reduced compressor inlet flow will result in suitably low power consumption while the compressor is unloaded and the small amount of air admitted to the compressor will provide quiet operation and scavenging of the oil being injected for lubrication and cooling purposes. When the pressure in storage means **22** drops to the second predetermined pressure the switch **74** will close to energize the solenoid **66** closing the valve **64**. Pressure air in the chamber **52** will be vented to the inlet opening **38** and the valve closure member **46** will open in response to the vacuum developed in the inlet of the compressor **12** to admit full inlet air flow to the compressor to restore normal loaded operation.

The reduced pressure and flow conditions at which the compressor unit operates while unloaded may be controlled by selection of the size of the restricted passage means **72** as well as by determining the area of the piston pressure surface **55** and the force-deflection characteristic of the spring **56**. The restricted passage means **72** may be formed as an orifice at any location in the conduit **70** downstream of the junction with conduit **68**, and the restriction to flow may be provided by proper selection of the internal diameter and length of the conduit **70** itself rather than the orifice formed by the passage means **72**.

As may be appreciated from the foregoing disclosure a structurally simple and reliable unloader control system is provided by the present invention which is operable to provide for reduced unloaded power consumption of a liquid injected gas compressor while maintaining suitable liquid circulation and quiet running of the compressor. Although the control system of the present invention is disclosed in detail in combination with a liquid injected gas compressor unit it is contemplated that certain so-called dry type compressor units may also use the disclosed arrangement. Moreover, the unloader control system of the present invention provides for the same functions as certain prior art control systems but with a minimum of attendant devices. The electric pressure switch **74** and solenoid operated valve **64** may be replaced by equivalent fluid operated devices such as a pilot pressure valve responsive to pressure in the storage means and connected to a two-position pilot pressure fluid actuated valve.

What is claimed is:

1. In combination:

a gas compressor including gas inlet and discharge means;

gas storage means connected to said discharge means for receiving and storing compressed gas;

a check valve between said discharge means and said storage means for substantially preventing backflow of gas from said storage means to said discharge means;

a compressor inlet throttling valve connected to said inlet means and including a closure member and pressure fluid actuating means for moving said closure member to throttle inlet gas flow to said compressor; and an unloader control system characterized by:

a conduit interconnecting said discharge means and said actuating means;

power operated valve means interposed in said conduit between said discharge means and said actuating means;

pressure responsive means in communication with said storage means for operating said valve means to open in response to a predetermined pressure in said storage means; and,

vent means connected to said conduit between said valve means and said actuating means for controlled venting of said discharge means to a gas pressure in said discharge means which is less than the gas pressure in said storage means in response to opening of said valve means.

2. The invention set forth in claim **1** wherein:

said vent means includes conduit means connected to said conduit between said valve means and said actuating means and including means for controlling the venting of said discharge means in response to the opening of said valve means.

3. The invention set forth in claim **2** wherein:

said inlet throttling valve includes a housing including an inlet opening, a chamber, and piston means disposed in said chamber and movable in response to the admission of pressure fluid to said chamber to move said closure member to throttle inlet gas flow to said compressor, and said conduit opens into said chamber for admitting gas from said discharge means to exert a pressure force on said piston means.

4. The invention set forth in claim **3** together with:

biasing means for biasing said piston means to move against the pressure force exerted on said piston means by said gas in said chamber.

5. The invention set forth in claim **3** wherein:

said means for controlling the venting of said discharge means comprises restricted passage means of a predetermined size which will control the venting of said discharge means to provide a reduced pressure in said conduit and said chamber for moving said closure member to a position which will provide for a reduced inlet gas flow to said compressor.

6. The invention set forth in claim **5** wherein:

said restricted passage means opens into said inlet opening in said housing.

7. The invention set forth in claim **1** wherein:

said compressor is liquid injected, said discharge means includes a gas-liquid separator tank and said vent means is operable to vent said tank to a reduced presssure less than said predetermined pressure in response to the opening of said valve means.

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