# United States Patent

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[54] **ROTARY COMPRESSOR CONTROL SYSTEM**
**22 Claims, 7 Drawing Figs.**

[52] U.S. Cl. .......... **417/12,** 417/17, 417/26, 418/100, 417/279
[51] Int. Cl. .......... **F04b 49/00**
[50] Field of Search .......... 230/6, 17, 207, 208; 417/17, 27, 28; 418/100

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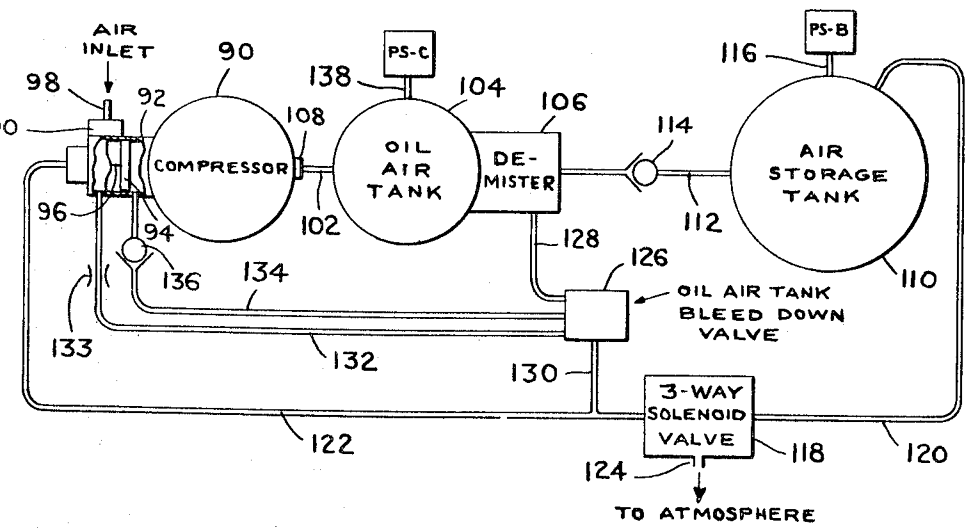
**ABSTRACT:** New and improved rotary compressor control means are provided and include means to prevent restarting of the compressor motor against a high-pressure load in the compressor discharge system, and means to maintain a flow of air through the compressor during unloaded operation of the latter. In addition, means are provided to substantially attenuate the operational noise level of the compressor, and the discomforting effects thereof upon operating personnel.



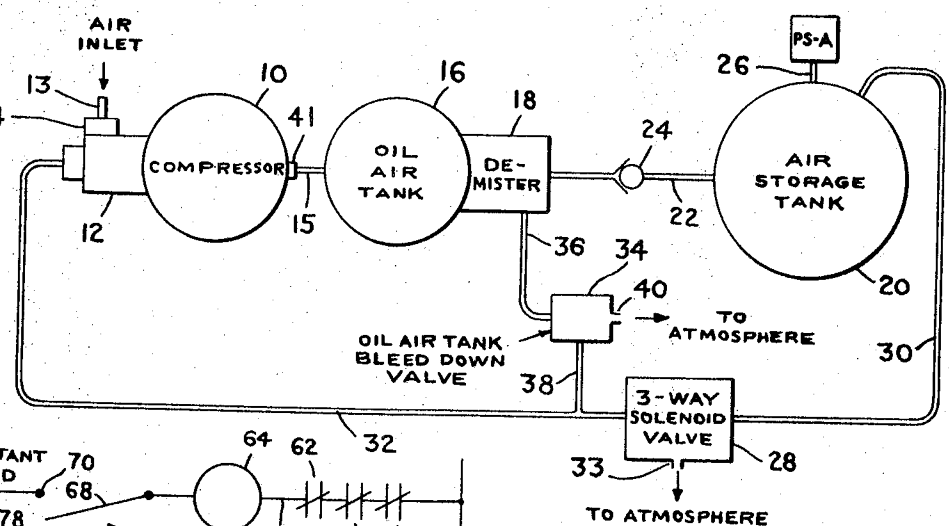



FIG. 1

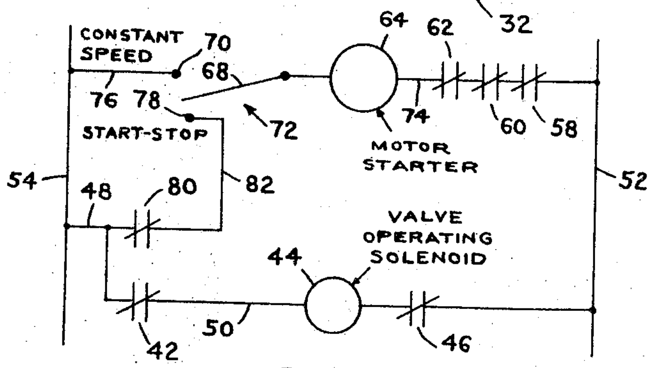



FIG. 2

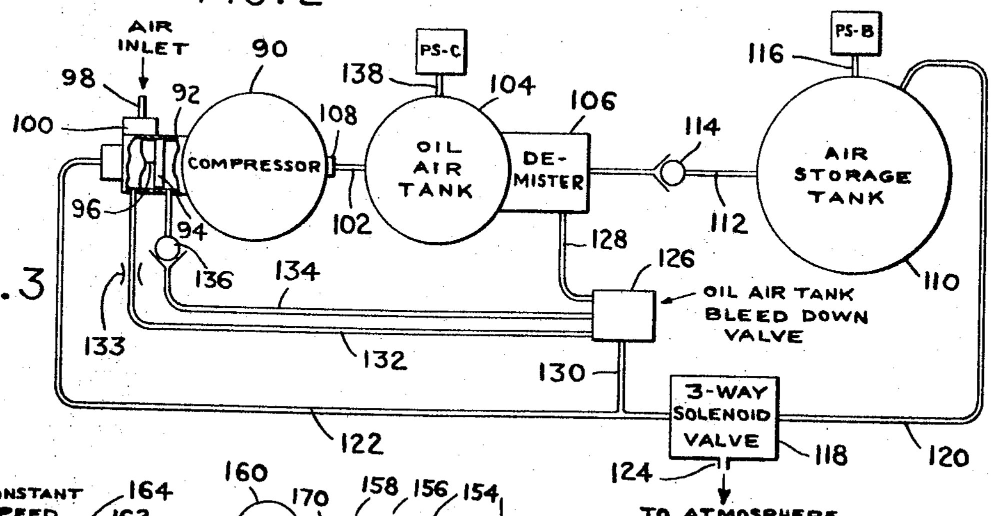



FIG. 3

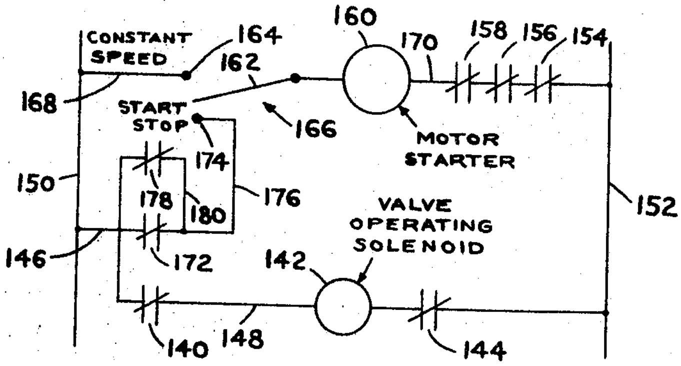



FIG. 4

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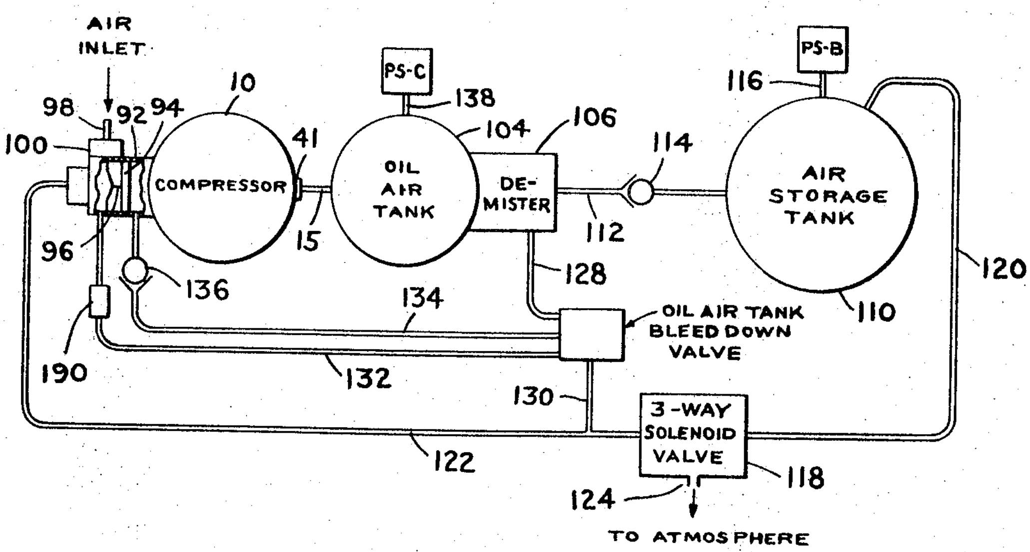


FIG. 5

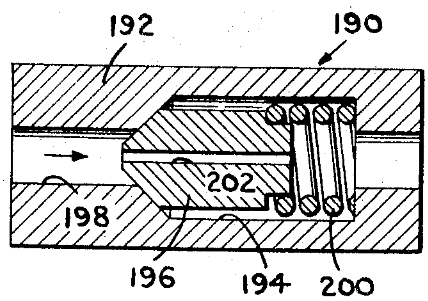


FIG. 6

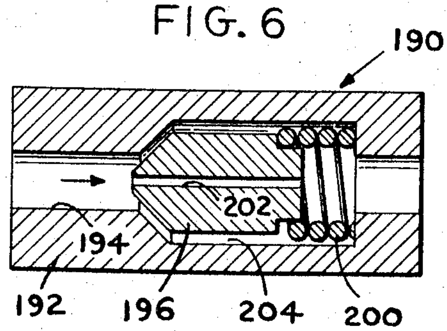


FIG. 7

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# ROTARY COMPRESSOR CONTROL SYSTEM

## BACKGROUND OF THE INVENTION

This invention relates to a new and improved control system for rotary compressors and, more particularly, to a rotary compressor control system for controlling, in interrelated manner, the loading and unloading thereof and the starting and stopping of the compressor.

Although a wide variety of rotary compressor control systems are known for controlling the loading and unloading of the compressor, and the starting and stopping thereof, it may be understood that, in general, there are certain not insignificant disadvantages inherent in the design and/or manner of operation thereof. More specifically, in many of the prior art rotary compressor control systems, it may be understood that the compressor is subjected to excessively frequent compressor motor starts with resultant damage to the latter and/or decrease in the operational life thereof.

Too, in many instances, the compressor is required to frequently restart against a high-pressure load in the compressor discharge system with resultant possibility of damage to the blades of the rotary compressor, and undesirable high initial torque demand and attendant and similarly undesirable high initial electrical power demand on the electrical system which powers the compressor. In addition, many of the prior art rotary compressor control systems substantially discontinue the flow of air through the compressor during unloaded operation thereof with resultant undesirable effect upon the compressor lubrication system and the operation of compressor safety devices in the nature, for example, of discharge air temperature sensing means.

Another problem which arises in part from this substantial discontinuance of airflow during unloaded operation, and in part from the direct bleeddown of high-pressure compressor system components to atmosphere, is the very significant problem of high operational noise level and the aggravation and general discomfort caused thereby on operating personnel.

Further, although a variety of solutions in the nature, for example of electrical timer means have been proposed in the prior art for solving the problem of excessive compressor motor starts and/or the problem of requiring compressor restarting against a high-pressure load, it may be understood that, in general, such solutions have proven inordinately expensive and/or insufficiently reliable for long term operation under demanding operational conditions.

## OBJECTS OF THE INVENTION

It is, accordingly, an object of this invention to provide a new and improved rotary compressor control system which prevents excessive compressor motor starts.

Another object of this invention is the provision of a rotary compressor control system as above which prevent compressor restarts against high-pressure loads in the compressor discharge system.

Another object of this invention is the provision of a rotary compressor control system as above which functions to provide for some flow of air through the compressor during unloaded operation to insure adequate compressor lubrication and effective operation of compressor safety devices.

Another object of this invention is the provision of a rotary compressor control system as above which substantially reduces the operational noise level of the compressor and the aggravating effects thereof upon operating personnel.

A further object of this invention is the provision of a rotary compressor control system as above which requires the use of only readily available components of proven dependability in the fabrication thereof to thus provide for long periods of satisfactory, maintenance-free control system operation under demanding operational conditions.

A still further object of this invention is the provision of a rotary compressor control system which provides all of the significant advantages stipulated above at relatively low cost.

## SUMMARY OF THE INVENTION

As currently preferred the new and improved rotary compressor control system of the invention is for application to a rotary compressor having a compressor suction control for loading and unloading the compressor, an oil air tank connected to the compressor discharge for compressor lubrication purposes, an air storage tank connected to the discharge of the oil air tank, and pressure responsive control means operatively associated with the air storage tank and the energization circuit for the compressor motor and effective to respectively operate the compressor suction control to load and unload said compressor, and to start and stop said compressor motor, in response to the pressure in the air storage tank. For such use, the control system of the invention comprises a restricted conduit which is effective, upon compressor-unloading operation of the pressure responsive control means, to bleeddown the oil air tank through the compressor suction control at a predetermined rate, and an air injection conduit which is concomitantly operable to inject air into the compressor inlet to maintain a flow of air through the compressor during unloaded operation thereof. Further included in the system of the invention are pressure responsive means which are operatively associated with the oil air tank and are operable to prevent stopping of the compressor by the pressure responsive control means until the pressure in the oil air tank has been bled down to a predetermined level. In an alternate form, the system of the invention comprises a variable restriction in the oil air tank bleeddown conduit, and said variable restriction is effective to bleeddown the oil air tank at a variable rate in accordance with the pressure in the latter.

## DESCRIPTION OF THE DRAWINGS

The above and other objects and advantages of this invention are believed made clear by the following detailed description thereof taken in conjunction with the accompanying drawings wherein:

FIG. **1** is a schematic flow diagram of a representative, rotary compressor control system constructed and operative in accordance with the teachings of the prior art;

FIG. **2** is a circuit diagram of the control circuit for use with the control system of FIG. **1**;

FIG. **3** is a schematic flow diagram of a first form of a rotary compressor control system constructed and operative in accordance with the teachings of this invention;

FIG. **4** is a circuit diagram of the control circuit for use with the control system of FIG. **3**;

FIG. **5** is a schematic flow diagram of a second form of a rotary compressor control system constructed and operative in accordance with the teachings of this invention;

FIG. **6** is a longitudinal cross-sectional view taken through the controlled restriction bleeddown valve of the system of FIG. **5** in a first position thereof; and

FIG. **7** is a longitudinal cross-sectional view taken through the controlled restriction bleeddown valve of FIG. **5** in a second position thereof.

## DESCRIPTION OF THE PRIOR ART

Referring initially to the representative, prior art rotary compressor control system of FIG. **1**, the same may be seen to include a rotary compressor **10** comprising conventional compressor suction control means **12** which are, of course, effective to load and unload the former. The suction control means **12** include a compressor air inlet conduit **13** connected thereto, and suitable air filter means **14** are connected as shown in the said air inlet conduit for obvious purpose.

A discharge conduit **15** connects the discharge of the rotary compressor **10** to an oil air tank **16**, and demister means **18** are operatively associated with the latter in conventional manner.

An air storage tank is indicated at **20**, and a conduit **22**, including a check valve **24** connected therein as shown, connects the demister **18** to the said air storage tank.

A double contact, normally closed pressure switch is indicated at PS–A and may be seen to be operatively connected to the air storage tank **20** by conduit **26** so as to be responsive to the pressure in the former. A three-way solenoid valve is indicated at **28** and is connected as shown, by conduits **30** and **32**, respectively, to the air storage tank **20** and the compressor suction control means **12**. The three-way solenoid valve **28** includes a vent port as indicated at **33** which is effective to vent the same to atmosphere.

An oil air tank bleeddown valve is indicated at **34** and is connected as shown to the demister **18** by a conduit **36**, and to the conduit **32** by a conduit **38**. The said bleeddown valve includes a bleed port **40** which is effective to bleed the valve to atmosphere.

Temperature responsive electrical switch means are indicated at **41** and may be understood to be operatively connected in the compressor discharge, just downstream of the compressor discharge ports, to sense air discharge pressure.

The control circuit for the prior art, rotary compressor control system of FIG. **1** is depicted in FIG. **2** and may be seen to include normally closed contacts **42** of the pressure switch PS–A, the operating solenoid **44** of the three-way solenoid valve **28**, and suitable motor starter interlock means **46**, to break current to the solenoid on shutdown to bleed the unit which are respectively connected as shown in series across the line sources **52** and **54** by leads **48** and **50**.

Further included in this control circuit are the normally closed contacts **58** and **60** of suitable, motor overload responsive safety devices, the normally closed contacts **62** of the temperature responsive switch means **41**, the compressor motor starter means **64**, and the pole **68** and constant speed contact **70** of a two-position selector switch **72**, respectively all of which are connectable in series across the line sources **52** and **54** by leads **74** and **76** and the switch pole **68** when the selector switch **72** is in the constant speed position thereof. The start-stop contact **78** of the two-position selector switch **72**, and the remaining normally close contacts **80** of the pressure switch PS–A are connected as shown in series by lead **82** which is in turn connectable in series with leads **48** and **74** across the said line sources through the switch pole **68** when the selector switch **72** is in the start-stop position thereof.

The three-way solenoid valve **28** is arranged in the flow diagram of FIG. **1** to connect conduits **30** and **32** when the valve-operating solenoid **44** is deenergized and it may be understood that this will be effective to supply a pressure signal from the air storage tank **20** to the suction control means **12** to close the latter and unload the rotary compressor **10**, and to concomitantly supply a pressure signal therefrom to the oil air tank bleeddown valve **34** to connect conduit **36** with the bleeddown valve port **40** to bleeddown the oil air tank **16**.

With the valve-operating solenoid **44** of valve **28** energized, it may be understood that the three-way solenoid valve **28** will be effective to vent conduit **32**, and accordingly conduit **38**, to atmosphere through vent port **33** with the results that the compressor suction control will reopen to reload the compressor, while the oil air tank bleeddown valve **34** terminates the bleeddown of the oil air tank **16** through conduit **36**.

In the operation of the prior art compressor control system of FIGS. **1** and **2** with the selector switch **72** in the start-stop position thereof, pressure switch PS–A will be set to open switch contacts **42** and **80** in response to a predetermined pressure in air storage tank **20**. As this occurs, the motor starter **64** will be deenergized through the opening of switch contacts **80** in lead **82** to stop the compressor **10**. Concomitantly, the opening of switch contacts **42** in lead **50** will effect the deenergization of the valve-operating solenoid **44** whereby the solenoid valve **28** will operate the suction control **12** to unload the compressor **10** while commencing the bleeddown of the oil air tank **16** to atmosphere through bleeddown valve port **40**.

If, on the one hand, the pressure in the air storage tank **20** is suddenly and markedly reduced, as by a sudden large scale demand for compressed air well before oil air tank bleeddown has been completed, it may be understood that the resultant reclosing the contacts **80** and **42** of PS–A will force the compressor **10** to restart against a large pressure load in the said oil air tank to require a very high starting torque with resultant possibility of damage to the compressor motor and/or to the plant electrical system as a result of this sudden high power demand on the latter. In addition, it is believed clear that such restarting of the rotary compressor **10** against a high-pressure load in the compressor discharge system may, of course, result in damage to one or more of the compressor blades. Too, it may readily be understood that with the control system being effective to immediately restart the compressor **10** every time the pressure in air storage tank **20** falls below a predetermined minimum pressure, excessive restarting of the compressor motor with attendant damage thereto and/or decrease in the operational life thereof, will most probably result.

If, on the other hand, the oil air tank **16** is enabled to bleeddown to atmosphere, there being substantially no flow of air through the compressor **10** when the latter operates unloaded, it may be understood that the pressure therein will become insufficient to immediately supply adequate lubrication to the compressor **10** upon subsequent restarting of the latter, thus giving rise to the possibility of damage to the compressor, from inadequate lubrication resulting from repeated restarting under such conditions.

In addition, and under either of the above circumstances, it may be understood that the operational noise level of the compressor **10** is markedly increased, and/or the effect thereof upon operating personnel markedly aggravated, by the bleed of the oil air tank directly to atmosphere through bleeddown valve port **40**, and by the change in pitch of the operational noise of the compressor **10** as the latter cycles between loaded and unloaded operation. Too, the substantial lack of airflow through the compressor **10** during unloaded operation thereof will materially decrease the effectiveness of the temperature sensing switch means **41** under such conditions, as should be obvious.

Further, although the setting of the selector switch **72** to the constant speed position thereof will prevent excessive compressor motor restarting against high compressor discharge system pressure loads, it will not compensate for the other significant disadvantages enumerated above, and further, will require increased electrical power since the compressor motor will be operating constantly.

One solution which has been proposed for solving the problems encountered during start-stop operation of a prior art compressor control system as described above is the incorporation therein of electrical timer means to provide for a predetermined time delay between the opening of contacts **80** of PS–A and the stopping of the compressor motor. The use of such timer although generally satisfactory may, however, be readily understood to give rise to other significant disadvantages in the nature of excessive timer costs and the lack of absolute reliability thereof for long periods of operation under demanding operational conditions.

## DETAILED DESCRIPTION OF THE INVENTION

Referring now to the new and improved rotary compressor control system constructed and operative in accordance with the teachings of this invention as depicted in FIG. **3**, the same may be seen to be applied to the control of a rotary compressor **90** which may, for example, take the form of that manufactured and marketed under the model designation "RS Mono Rotor Air Compressor" by applicant's assignee, The Worthington Corporation of Harrison, New Jersey. The rotary compressor **90** comprises compressor suction control means **92**, including a closure disc **94**, which is actuable in conventional manner by a plunger rod **96** to load and unload the said compressor. The suction control means **92** comprise a compressor air inlet conduit **98** connected thereto, and suitable air filter means **100** are connected therein as shown for obvious purpose.

A discharge conduit **102** connects the discharge of the rotary compressor **90** to operatively associated oil air tank and demister means **104** and **106**, respectively, and a temperature sensitive switch as indicated at **108** is disposed as shown at the compressor discharge just downstream of the compressor discharge ports to sense the temperature of the compressed air discharged therefrom.

An air storage tank is indicated at **110**, and a conduit **112**, including a check valve **114** connected therein as indicated, connects the demister **106** to the said air storage tank.

A double contact, normally closed pressure switch is indicated as PS–B and is connected as shown by conduit **116** to the air storage tank **110** so as to be responsive to the pressure in the latter.

A three-way solenoid valve is indicated at **118** and is connected to the air storage tank **110** by conduit **120**, and to the suction control means **92** by conduit **122**. The three-way solenoid valve **118** includes a venting port as indicated at **124** to vent the same to atmosphere.

An oil air tank bleeddown valve is indicated at **126** as is connected to the demister **106** by conduit **128**, and to the conduit **122** by a conduit **130**.

A bleed conduit **132** comprising a restriction as indicated at **133** interposed therein, extends as shown from the oil air tank bleeddown valve **126** into communication with the suction control means **92** at a location in the latter upstream of the closure disc **94**, whereby is believed made clear that the said bleed conduit extends into communication with the atmosphere through the air inlet filter means **100**.

An air injection conduit **134** extends as shown from the oil air tank bleeddown valve **126** into communication with the suction control means **92** but at a location in the latter downstream of the closure disc **96**, whereby is believed made clear that the said air injection conduit extends into communication with the inlet ports of the rotary compressor **90**. A check valve **136** is interposed as shown in the air injection line **134** to prevent flow therethrough in the direction of the said bleeddown valve.

A normally open pressure responsive switch is indicated at PS–C and is connected by conduit **138** to the oil air tank **104** so as to be responsive to the pressure in the latter.

The control circuit for the rotary compressor control system of FIG. **3** is depicted in FIG. **4** and may be seen to include normally closed contacts **140** of the pressure switch PS–B, the valve-operating solenoid **142** of the three-way solenoid valve **118**, and suitable motor starter interlock means **144**, to break current to the solenoid on shutdown to bleed the unit respectively connected as shown in series across the line sources **150** and **152** by leads **146** and **148**. Further included in this control circuit are the normally closed contacts **154** and **156** of suitable, motor overload safety devices, the normally closed contacts **158** of the temperature responsive switch means **108**, the compressor motor starter means **160**, and the pole **162** and constant speed contact **164** of a two-position selector switch **166**, respectively, all of which are connectable in series across the said line sources by leads **168** and **170**, and the switch pole **162**, when the selector switch **166** is in the constant speed position thereof.

The remaining normally closed contacts **172** of the normally closed pressure switch PS–B, and the start-stop contact **174** of the selector switch **166** are connected in series as shown by lead **176**, and the normally closed contacts **178** of the normally closed pressure switch PS–C are connected as shown in parallel with normally closed contacts **172** by lead **180**. As a result it may be understood that the parallel-connected contacts **172** and **178** may be connected in series with the motor starter **160** and the respective contacts **158**, **156** and **154**, respectively, across the line sources **152** and **150** through leads **146**, **180**, **176**, the selector switch pole **162** and lead **170** when the selector switch **166** is in the start-stop position thereof.

The three-way solenoid valve **118** is arranged in the flow diagram of FIG. **3** to connect conduits **120** and **122** when the valve-operating solenoid **142** is deenergized to supply a pressure signal from the air storage tank **110** to the suction control means **92** to close the closure disc **94** and unload the compressor **90**. Concomitantly, deenergization of the valve-operating solenoid **142** will result in the said valve connecting conduits **120** and **130** supplying a pressure signal to the oil air tank bleeddown valve **126** to open the latter to connect conduit **128** with each of restricted bleed conduit **132** and air injection conduit **134**, it being noted that the conduits **132** and **134** are preferably connected to the same bleeddown valve port to simplify the latter.

Conversely, with the valve-operating solenoid **142** energized, three-way solenoid valve **118** is arranged to vent conduit **122**, and accordingly conduit **130**, to atmosphere through vent port **124** with the result that the compressor suction control means **92** will reopen to reload the compressor **90**, while the bleeddown of the oil air tank **104** through restricted bleed conduit **132** is terminated by the closure of bleeddown valve **126**.

## OPERATION

For representative operation of the rotary compressor control system of FIGS. **3** and **4** as, for example, in the control of a rotary compressor **90** which takes the form of the "RS Mono Rotor Air Compressor" as mentioned hereinabove, it may be understood that pressure switch PS–B would be set to open the respective normally closed contacts **140** and **172** thereof when the pressure in air storage tank **110** assumed a predetermined maximum in the order, for example, of 115—120 p.s.i., and to reclose the said contacts when the said pressure assumed a predetermined minimum in the same range but somewhat lower than said predetermined maximum. In like manner, pressure switch PS–C would be set to close the normally open contacts **178** thereof when the pressure in the oil air tank exceeded a predetermined minimum in the order, for example, of 20—25 p.s.i., and to reclose the said contacts when the said pressure returned to the said predetermined minumum. In addition, for such use the restriction **133** in bleed conduit **132** would be sized to provide a bleeddown time of approximately 2 to 3 minutes for the bleeddown of the oil air tank from the 115—120 p.s.i. range to the 20—25 p.s.i. range.

With the two-position selector switch **166** set in the start-stop position thereof, and the rotary compressor **90** operating under loaded conditions, it may be understood that as the pressure within air storage tank **110** assumes the predetermined maximum as discussed above, pressure switch PS–B will function in response thereto to open the normally closed switch contacts **140** and **172**, with the effect of the former being to deenergize the valve-operating solenoid **142** of the three-way valve **118** with resultant supply of pressure signals from the air storage tank **110** on conduits **130** and **122** to the oil air tank bleeddown valve **126** and the suction control means **92**, respectively. The opening of normally closed contacts **172** will, however, have no immediate effect on compressor operation since the compressor motor starter means **160** will remain energized through closed contacts **178** of PS–B in parallel line **180**, whereby the compressor motor will continue to run.

The pressure signal to the suction control means **92** will function to unload the compressor **90** through closure of the closure disc **94**, while the pressure signal to bleeddown valve **126** will function to commence the bleeddown of air from the oil air tank through restricted bleed conduit **132** to atmosphere through the suction control means **92** and the air inlet filter means **100**, and will function to commence the injection of air form the said oil air tank through injection conduit **134** into the compressor inlet ports downstream of the now closed closure disc **94**. As a result of this air injection, it may be understood that some flow of air will be retained through the compressor **90** despite the fact that the same is operating unloaded, and that this flow of air will insure a positive pressure in the oil air tank **104** to in turn insure the continuance of satisfactory compressor lubrication to significant advantage, and will, in addition, insure the continued effectiveness of the temperature responsive switch means **108** by providing for the continued, albeit markedly reduced, flow of compressed air over the switch temperature sensing means, again to significant advantage.

The bleeddown of the oil air tank **104** to atmosphere through the restricted bleed conduit **132**, the suction control means **92**, and the air inlet filter means **100**, rather than directly to atmosphere, will, of course, substantially attenuate the bleeddown noise level to significant advantage, while the continued flow of air through the compressor **90** from air injection line **134** will also substantially attenuate the change in pitch of the operational noise of the said compressor as the same changes from loaded to unloaded operation.

Unloaded operation of the compressor **90** will continue for the period of time discussed above until the pressure in oil air tank **104** is bled down to the predetermined minimum, also as discussed above, whereupon the closed contacts **178** of the pressure responsive switch PS–C will open to deenergize the motor starter **160** and discontinue operation of the compressor **90**. Accordingly is believed made clear that the provision of pressure switch PS–C, and the connection of the closed contacts **178** thereof in parallel with normally open contacts **172** of PS–B will positively prevent stopping of the compressor motor until the oil air tank **104** has been bled down to the said predetermined minumum pressure to thus positively prevent the compressor motor from having to restart the compressor **90** against a high-pressure load with resultant possibility of compressor blade damage and high initial torque and electrical power demand as discussed hereinabove. Put another way, it may be understood that since the oil air tank **104** must, of necessity, be bled down before the compressor motor stops, and since there is no way to repressurize the said oil air tank short of compressor motor operation, compressor restarts requiring high initial torque are rendered impossible.

In addition, it is believed clear that since the compressor motor is maintained operative by the closed contacts **178** of PS–C, circumstances in the nature of an immediate large scale demand for compressed air from the air storage tank **110**, to the extent that the pressure therein frequently and quickly falls below said predetermined minumum, will be ineffective to immediately restart the compressor motor for the simple reason that the same is still running, whereby may be understood that excessive restarting of the latter is substantially inhibited.

Without such immediate, large scale demand for compressed air, it may be understood that the control system will remain as described until the pressure in the air storage tank **110** falls below said predetermined minimum, at which time the contacts **172** and **140** of PS–B will reclose to respectively reenergize the motor starter means **160** to restart the compressor **90**, and concomitantly reenergize the valve-operating solenoid **142** to terminate the supply of pressure signals to the suction control means **92** and the bleeddown valve **126** with the results that the compressor **90** will be reloaded and the bleeddown and injection of air through conduits **132** and **134** terminated.

Operation of the control system of FIGS. **3** and **4** with the selector switch **166** in the constant speed position as may, for example, be required by the fact that excessive restarting of the compressor motor during the course of daily operation might occur despite the provision of the 2 to 2.5 minute time delay by restricted bleed conduit **132**, would be substantially the same as above with the obvious exception that the system would never be effective to stop the motor of the rotary compressor **90**. It is believed equally obvious, however, that the significant advantages enumerated hereinabove in addition to those related to the prevention of excessive compressor motor restarting would continue to be provided by the new and improved control system of the invention.

Referring now to the form of the invention depicted in FIGS. **5**, **6** and **7**, it may be understood that the same is substantially identical to that depicted in FIGS. **3** and **4** whereby like reference numerals are utilized to identify like system components of the former.

In the system of FIGS. **5**, **6** and **7**, however, the fixed restriction **133** in bleed line **132** is replaced as indicated by a controlled restriction bleeddown valve **190** which, as illustrated in cross section in FIG. **6**, comprises an outer valve body **192** having a stepped port **194** extending therethrough. An inner valve body **196** is slidably disposed as shown in the port **194** and biased toward the inlet end **198** of the latter by a compression spring **200**. A restricted valve port **202** is formed to extend as shown through the inner valve body **196**.

In operation of the control system of FIGS. **5**, **6** and **7**, which operation is substantially identical to that of the control system of FIGS. **3** and **4**, it may be understood that immediately upon the opening of the oil air tank bleeddown valve **126** to connect conduit **128** to the bleeddown conduit **132**, the controlled restriction bleeddown valve **190** will open, as by the slidable movement of the inner valve body **196** from the position thereof of FIG. **6** to the position thereof of FIG. **7** to enable the substantially rapid passage of air from the oil air tank **104** through both the resultant space **204** between the said outer and inner valve bodies, and the restricted valve port **202** of the latter, respectively.

Once the pressure in the said oil air tank has fallen below a certain level, in the range for example of 37 to 44 p.s.i. as determined by the force constant of the compression spring **200**, the controlled restriction bleeddown valve **190** will return to the position thereof of FIG. **6** whereby the passage of air therethrough can occur only through restricted valve port **202**.

By the provision of the controlled restriction bleeddown valve **190**, it may be understood that rapid oil air tank bleeddown to a low compressor power consumption level may be achieved, followed by controlled oil air tank bleeddown through restricted valve port **202** to establish the predetermined oil air tank bleeddown time as discussed hereinabove.

In instances wherein the rotary compressor system is marketed without an air storage tank **110**, it is believed clear that each of conduits **116** and **120** would be suitably connected in compressor discharge means in the nature of conduit **112** so as to insure that pressure switch PS–B would remain effective to accurately sense compressor discharge pressure, while conduit **120** would remain effective to supply the requisite pressure signals for application through the three-way solenoid valve **118** as described.

While there have been shown and described preferred embodiments of the invention, it will be understood that the invention may be embodied otherwise than as herein specifically illustrated or described, and that in the illustrated embodiments certain changes in the details of construction and in the form and arrangement of the parts may be made without departing from the underlying ideal and principals of this invention within the scope of the appended claims.

What I claim is:

1. In a compressor control system for use with a motor driven compressor including compressor suction control means which are operable to load and unload said compressor, oil air tank means connected to the compressor discharge, air storage tank means connected to the discharge of said oil air tank means, and control means operatively associated with said air storage tank means and said compressor motor, and operable to respectively operate said suction control means to unload said compressor, and to start and stop operation of said compressor motor, in response to the pressure in said air storage tank means; the improvements comprising, bleeddown means operatively associated with said oil air tank means and operable in response to compressor-unloading operation of said control means to bleeddown said oil air tank means at a predetermined rate, and means operatively associated with said oil air tank means and said compressor motor, respective-

ly, and responsive to the pressure in the former to prevent stopping of said compressor motor by said control means until the pressure in said oil air tank means has been bled down to a predetermined level, whereby immediate restarting of said compressor against a high high-pressure in said oil air tank is prevented.

2. In a compressor control system as in claim 1; said improvements further comprising, air injection means operatively associated with said oil air tank means and operable in response to compressor-unloading operation of said control means to inject air from said oil air tank means into the suction of said compressor during unloaded operation thereof to maintain a flow of air therethrough to prevent bleeddown of said oil air tank to atmospheric pressure to insure adequate compressor lubrication.

3. In a compressor control system as in claim 1 wherein said bleeddown means comprise a restricted conduit in fluid flow communication with said oil air tank means.

4. In a compressor control system as in claim 2 wherein said bleeddown means comprise a restricted conduit in fluid flow communication with said oil air tank means.

5. In a compressor control system as in claim 1 wherein said bleeddown means are effective to bleeddown said oil air tank through said compressor suction control means to substantially attenuate the noise attendant oil air tank bleeddown.

6. In a compressor control system as in claim 2 wherein said bleeddown means are effective to bleeddown said oil air tank through said compressor suction control means to substantially attenuate the noise attendant oil air tank bleeddown.

7. In a compressor control system as in claim 6 wherein said bleeddown means comprise a restricted conduit in fluid flow communication with said oil air tank means.

8. In a compressor control system as in claim 1 wherein, said bleeddown means comprise variable rate bleeddown means which are operable to bleeddown said oil air tank at varying rates in accordance with the pressure in the latter.

9. In a compressor control system as in claim 2 wherein, said bleeddown means comprise variable rate bleeddown means which are operable to bleeddown said oil air tank at varying rates in accordance with the pressure in the latter.

10. In a compressor control system as in claim 5 wherein, said bleeddown means comprise variable rate bleeddown means which are operable to bleeddown said oil air tank at varying rates in accordance with the pressure in the latter.

11. In a compressor control system as in claim 6 wherein, said bleeddown means comprise variable rate bleeddown means which are operable to bleeddown said oil air tank at varying rates in accordance with the pressure in the latter.

12. In a compressor control system as in claim 8 wherein, said variable rate bleeddown means comprise a controlled restriction bleeddown valve in the fluid flow communication with said oil air tank means, said valve including an outer valve body and an inner valve body having first and second relative positions, said valve being operable to bleeddown said oil air tank at a different rate when said valve bodies are in said first relative positions than when the same are in said second relative positions.

13. In a compressor control system as in claim 10 wherein, said variable rate bleeddown means comprise a controlled restriction bleeddown valve in the fluid flow communication with said oil air tank means, said valve including an outer valve body and an inner valve body having first and second relative positions, said valve being operable to bleeddown said oil air tank at a different rate when said valve bodies are in said first relative positions than when the same are in said second relative positions.

14. In a compressor control system as in claim 1 wherein, said control means comprise first pressure switch means having normally closed contacts and being responsive to the pressure in said air storage tank to open said contacts only when said pressure assumes a predetermined level, said means operatively associated with said oil air tank means comprise second pressure switch means having normally closed contacts and being operable to open the same only when the pressure in said oil air tank means assumes a predetermined level, series connected energization circuit means for said compressor motor, and means connecting said first and second pressure switch means contacts in parallel in said series connected energization circuit means whereby, energization of said compressor motor will be continued albeit the opening of said first pressure switch means contacts until the opening of said second pressure switch means contacts.

15. In a compressor control system as in claim 2 wherein, said control means comprise first pressure switch means having normally closed contacts and being responsive to the pressure in said air storage tank to open said contacts only when said pressure assumes a predetermined level, said means operatively associated with said oil air tank means comprise second pressure switch means having normally closed contacts and being operable to open the same only when the pressure in said oil air tank means assumes a predetermined level, series connected energization circuit means for said compressor motor, and means connecting said first and second pressure switch means contacts in parallel in said series connected energization circuit means whereby, energization of said compressor motor will be continued albeit the opening of said first pressure switch means contacts until the opening of said second pressure switch means contacts.

16. In a compressor control system as in claim 5 wherein, said control means comprise first pressure switch means having normally closed contacts and being responsive to the pressure in said air storage tank to open said contacts only when said pressure assumes a predetermined level, said means operatively associated with said oil air tank means comprise second pressure switch means having normally closed contacts and being operable to open the same only when the pressure in said oil air tank means assumes a predetermined level, series connected energization circuit means for said compressor motor, and means connecting said first and second pressure switch means contacts in parallel in said series connected energization circuit means whereby, energization of said compressor motor will be continued albeit the opening of said first pressure switch means contacts until the opening of said second pressure switch means contacts.

17. In a compressor control system as in claim 8 wherein, said control means comprise first pressure switch means having normally closed contacts and being responsive to the pressure in said air storage tank to open said contacts only when said pressure assumes a predetermined level, said means operatively associated with said oil air tank means comprise second pressure switch means having normally closed contacts and being operable to open the same only when the pressure in said oil air tank means assumes a predetermined level, series connected energization circuit means for said compressor motor, and means connecting said first and second pressure switch means contacts in parallel in said series connected energization circuit means whereby, energization of said compressor motor will be continued albeit the opening of said first pressure switch means contacts until the opening of said second pressure switch means contacts.

18. In a compressor control system for use with a motor driven compressor including compressor inlet suction control means which are operable to load and unload said compressor, oil air tank means connected to the compressor discharge, air storage tank means connected to the discharge of said oil air tank means, and control means operatively associated with said air storage tank means and said compressor motor, and operable to respectively operate said suction control means to unload said compressor, and to start and stop operation of said compressor motor, in response to the pressure in said air storage tank means; the improvements comprising, air injection means operatively associated with said oil air tank means and operable in response to compressor unloading operation of said control means to inject air from said oil air tank means into the inlet of said compressor downstream of the suction control means during initial unloaded operation thereof to

prevent sudden changes of operational load on the compressor.

**19**. In a compressor control system as in claim **18**; said improvements further comprising, bleeddown means operatively associated with said oil air tank means and operable in response to compressor-unloading operation of said control means to bleeddown said oil air tank means at a predetermined rate.

**20**. In a compressor control system as in claim **19** wherein; said bleeddown means are effective to bleeddown said oil air tank through said compressor suction control means to substantially attenuate the noise attendant oil air tank bleeddown.

**21**. A compressor assembly comprising:
a compressor having an inlet and an outlet;
a motor operatively associated with said compressor to drive said compressor;
conduit means connected to said outlet of said compressor to carry the discharge of said compressor;
means to unload said compressor by throttling the inlet thereof, operatively associated with the inlet of said compressor;
control means operatively associated with said compressor discharge conduit means and said motor to actuate said compressor unloading means and to start and stop said motor in response to the pressure in said compressor discharge conduit means;
bleeddown means operatively communicated with said compressor discharge conduit means and the compressor inlet and actuated by said compressor unloading means to inject a portion of the compressor discharge into the inlet and through the compressor while bleeding down said compressor discharge conduit means at a predetermined rate;
said control means including means to continue operation of said motor until the pressure in said compressor discharge conduit means has been bled down below a predetermined value, so that immediate restarting of said compressor against a high-pressure load in said compressor discharge conduit means is prevented.

**22**. A compressor assembly comprising:
a compressor having an inlet and an outlet;
a motor operatively associated with said compressor to drive said compressor;
receiving means connected to said outlet of said compressor to receive the discharge of said compressor;
means operatively associated with the inlet of said compressor to unload said compressor by throttling the inlet thereof;
control means operatively associated with said compressor discharge receiving means and said motor to actuate said compressor unloading means and to start and stop said motor in response to the pressure in said compressor discharge receiving means;
bleeddown means communicating with said compressor discharge receiving means and actuated by said compressor unloading means to bleeddown said compressor discharge receiving means at a predetermined rate; and
injecting means connected with the compressor discharge receiving means and the compressor inlet for injecting a limited portion of the compressor discharge into the compressor during bleeddown;
said control means including means to delay stopping of the compressor motor after unloading of the compressor to prevent immediate restarting of the motor against high pressure in the compressor discharge receiving means.