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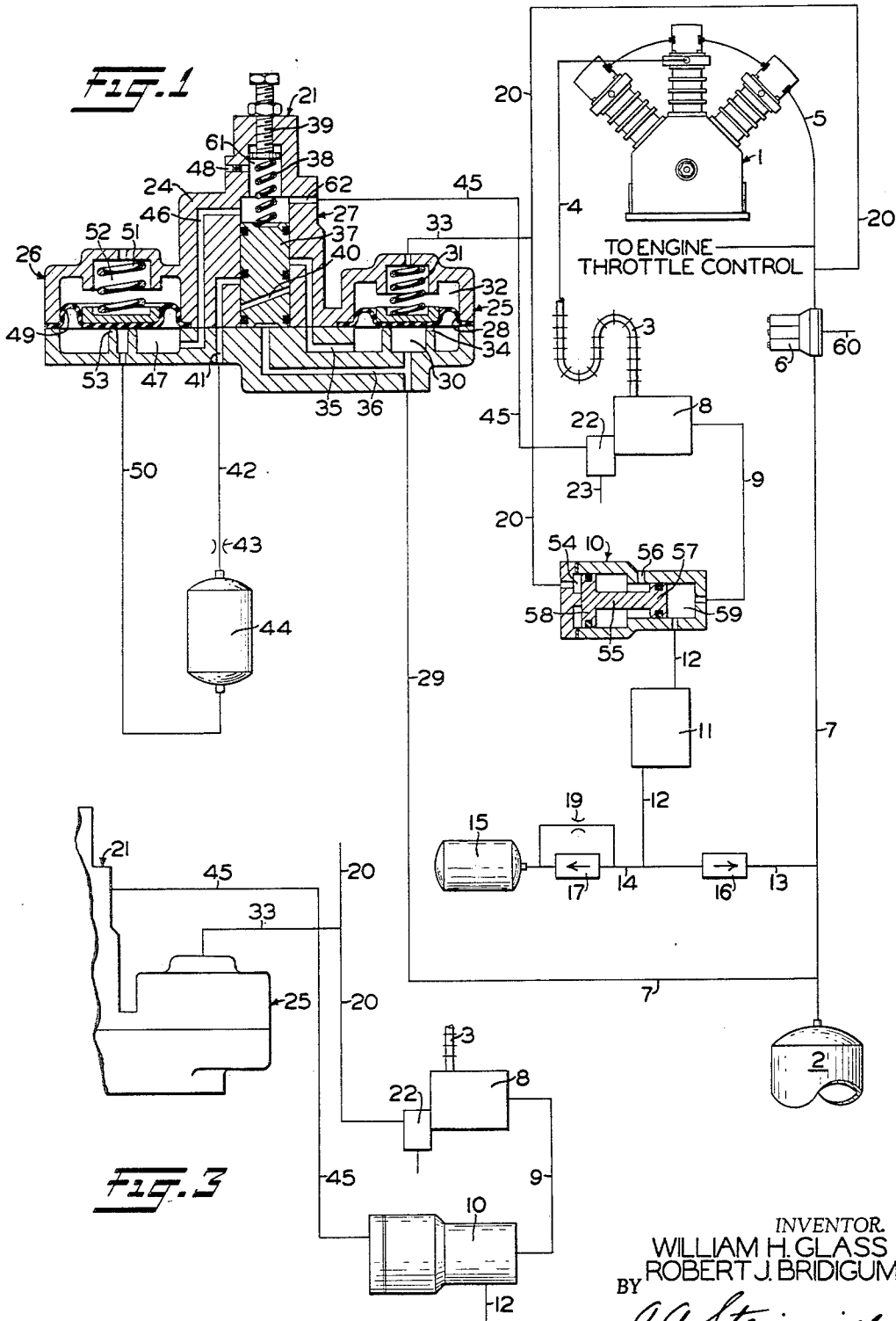
W. H. GLASS ET AL

3,486,303

MOISTURE REMOVAL APPARATUS FOR COMPRESSED AIR SUPPLY SYSTEM

Filed Nov. 13, 1967

2 Sheets-Sheet 1



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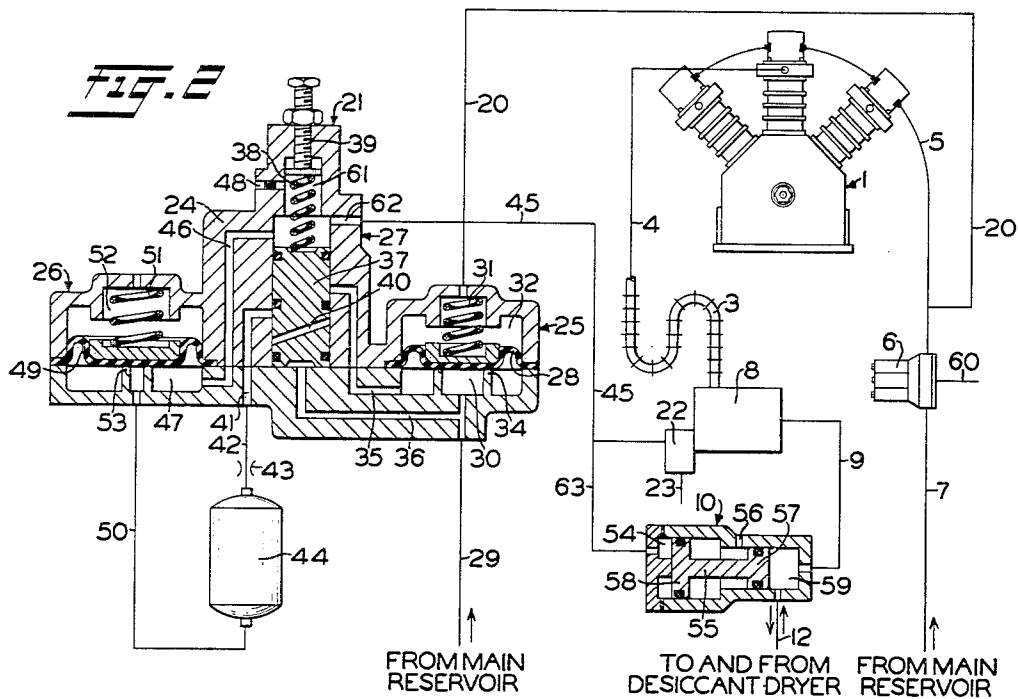
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MOISTURE REMOVAL APPARATUS FOR COMPRESSED AIR SUPPLY SYSTEM

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14 Claims

ABSTRACT OF THE DISCLOSURE

Moisture removal apparatus for a compressed air supply system including an aftercooler, a sump for collecting moisture condensate from the compressed air leaving the aftercooler, and a desiccant type dryer interposed between said sump and a main storage reservoir in which the compressed air from the compressor is stored after having any residual moisture removed therefrom by said dryer, said moisture removal apparatus being characterized by timing mechanism whereby operation of an automatic drain valve device associated with the sump is set to occur periodically after a predetermined time period of operation of the compressor rather than in phase with the rest periods thereof, while purging of the desiccant in the dryer of accumulated moisture may be set to occur either in synchronization with the operation of the drain valve device or during each rest period of the compressor.

As is well known to those skilled in the art, the removal of moisture condensate from a compressed air system is not only vital to the efficiency of the system, but is also necessary in order to prevent such condensate from reaching any of the mechanisms or devices to which the compressed air is supplied and where the presence of such condensate may cause damage or inefficient performance.

In the usual arrangement for removal of condensate, the condensate is allowed to accumulate in a sump associated with and open to the main storage reservoir or the compressor aftercooler where the compressed air has an opportunity to cool down and cause any moisture therein to be condensed and accumulated in said sump. The condensate accumulated in the sump is normally discharged therefrom through a drain valve device which is opened periodically for a predetermined and controlled time interval of sufficient duration to allow the accumulated condensate to be forcibly discharged by the pressure of compressed air in the aftercooler or that stored in the storage reservoir, such pressure also prevailing in the sump, said drain valve usually being connected to and actuated by the compressor governor each time the governor operates either to effect cut-out or cut-in of the compressor, that is, either at the onset of the rest period or at the onset of the compressing period, respectively, of the compressor, said rest period and said compressing period constituting a cycle of compressor operation. It is normally considered better to have the operation of the drain valve coordinated with the operation of the governor device such that the drain valve is opened at the onset of the compressing period, in other words, at the end of the rest period, thereby allowing the compressed air in the storage reservoir to have attained its lowest temperature for effecting maximum condensation and accumulation of moisture before being discharged.

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Characteristically, some compressed air systems, either due to a smaller capacity of the system or the type of compressor employed, for example, do not accumulate condensate in the sump at such a rate or in such quantity as perhaps other systems might and, therefore, do not require operation of the drain valve device at a frequency corresponding with each of the cut-in or cut-out operations of the compressor governor. With less frequency of operations of the drain valve, much of the compressed air in the storage reservoir could thus be preserved and the system thereby operated more economically and efficiently.

Accordingly, the object of the present invention is to provide compressed air apparatus characterized by adjustable timing means for controlling the drain valve device such that the frequency of operation thereof for draining accumulated condensate may be set to occur on a time basis determined by the actual amount of time of compressor operation rather than having such operation of the drain valve occur necessarily with each operation of the compressor governor, either at the cut-in or cut-out point.

The invention, as herein disclosed, comprises air compressing apparatus including: an air compressor; governor means responsive to prevailing pressure in a compressed air storage reservoir between predetermined high and low pressures for cutting out and cutting in compressor operation, respectively; an automatic drain valve device for discharging moisture condensate accumulated in a sump associated with the compressor aftercooler through which the compressed air flows en route to the storage reservoir; adjustable timing valve means including a timing volume charged with compressed air at a controlled rate during the cut-in period of the compressor, said timing valve means being operable responsively to pressure in said timing volume at a predetermined degree for causing said compressed air in the timing volume to be supplied to the drain valve device for opening the drain valve device for a predetermined time interval during which condensate accumulated in the sump is forcibly discharged to atmosphere; a desiccant type dryer interposed between the aftercooler and the storage reservoir for final drying of the compressed air flowing from the aftercooler to the storage reservoir; and a pilot valve device interposed between the aftercooler and the desiccant dryer for periodically cutting off flow of compressed air from the aftercooler to the storage reservoir and concurrently opening a communication via which compressed air accumulated in a purge volume, during the time that the storage reservoir is being charged, may back flow through the dryer to atmosphere for purging the dryer of moisture removed from the compressed air while flowing from the aftercooler to the storage reservoir. The pilot valve device may be alternatively connected in the system either in one manner in which its operation to effect purging of the desiccant dryer is made to coincide with each operation of the governor device in cutting out the compressor, or in another manner in which operation of the pilot valve device is made to coincide with each time operation of the drain valve device occurs.

In the drawings, FIG. 1 is a schematic view, mostly in outline and partly in section, of a compressed air system embodying the invention; FIG. 2 is a schematic view of a modified form of the compressed air system shown in FIG. 1; and FIG. 3 is a fragmentary schematic view of a further modification of the compressed air systems shown in FIGS. 1 and 2.

DESCRIPTION AND OPERATION

The schematic arrangement of moisture removal apparatus for a compressed air system, as shown in FIG. 1, comprises an air compressor 1 which may be driven by any suitable means (not shown) such as an electric motor, a gasoline engine, or a power take-off shaft, for example, for supplying compressed air to a main or storage reservoir 2 via an aftercooler 3 connected to said compressor by a pipe 4. If the compressor 1, for example, is driven by a gasoline engine (not shown), a fluid pressure responsive engine throttle control device and a compressor unloader device (neither of which is shown) are connected by a pipe 5 to a standard type governor device 6 which, in turn, is connected by a pipe 7 to the main reservoir 2. The governor device 6, in well known manner, operates responsively to a preselected maximum pressure in the reservoir 2 for causing the throttle control device to reduce the engine speed and, therefore, that of the compressor 1 to an idling speed, and at the same time cause the compressor unloader to unload the compressor by holding the compressor inlet valves (not shown) constantly open to atmosphere and thereby preventing any compression action. Upon reduction of air pressure in reservoir 2 to a preselected minimum pressure, the governor device 6 operates to cause the throttle control device to restore the engine and the compressor 1 to normal running speed and to cause the unloader device to load the compressor by allowing normal operation of the compressor inlet valves. The pressure in reservoir 2 is thus maintained within a range between preselected high and low values corresponding to the preselected maximum and minimum pressures at which the governor device 6 is set to respond.

Compressed air from the aftercooler 3 flows through a sump 8 associated with the aftercooler and in which moisture condensed out of the cooled compressed air is collected. From the sump 8, the compressed air flows through a pipe 9 to and through a pilot valve device 10 (the purpose of which will be explained hereinafter), thence through a dryer 11 containing a desiccant for removing any moisture from the compressed air not condensed and collected in said sump. The dryer 11 is interposed in a pipe 12 connecting the pilot valve device 10 to a pipe comprising a branch pipe 13 connecting to pipe 7 and, therefore, to maintain reservoir 2, and a branch pipe 14 connecting to a purge volume 15, both branch pipes 13 and 14 having one-way check valves 16 and 17, respectively, interposed therein with flow therethrough being in the directions indicated by the arrows. The branch pipe 14 also has a choke 19 interposed therein, in bypassing relation to the check valve 17, for permitting flow therethrough at a preselected restricted rate.

Operation of the pilot valve device 10 is controlled by the governor device 6 in a manner to be more fully described hereinafter, said pilot valve device being connected to said governor device through a pipe 20 connecting with pipe 5.

According to the invention, a timing valve device 21 is provided in the moisture removal apparatus for controlling the frequency of operation of an automatic drain valve device 22 or the pilot valve device 10, or of both said devices concurrently, as desired and as will be explained hereinafter. The drain valve device 22 is a standard type device operable responsively to air pressure supplied thereto, as will be described more fully hereinafter, for periodically opening the sump to atmosphere for a time interval of predetermined duration, whereby condensate accumulated in said sump is forcibly ejected therefrom, via an atmospheric vent 23, by the pressure of compressed air in the sump.

The timing valve device 21 comprises a casing 24 for housing a supply valve portion 25, a delivery valve portion 26, and a control valve portion 27.

The supply valve portion 25 of the timing valve device 21 comprises a diaphragm valve 28 constantly subjected

on one side to compressed air pressure prevailing in the main reservoir 2 via pipe 7 and a pipe 29 interconnecting said pipe 7 with a chamber 30 formed in casing 24 adjacent said one side of said diaphragm valve. The air pressure acting on the one side of diaphragm valve 28 is opposed by the force of a spring 31 acting on the opposite side of said diaphragm valve and disposed in a chamber 32 adjacent said opposite side, said chamber being connected via a branch pipe 33 to the pipe 20, so that said opposite side of said diaphragm valve is also subjectable to air pressure prevailing in pipe 20.

A valve seat 34 cooperates with the diaphragm valve 28, when in a seated position or unseated position relative thereto, for either connecting or cutting off, respectively, supply of compressed air from pipe 29 to a passageway 35 leading to the control valve portion 27. A second passageway 36 formed in casing 24 connects supply of compressed air from pipe 29 directly to the underside, as viewed in the drawing, of a piston valve 37. A spring 38, the compression of which is adjustable by a screw 39, abuts against the upper side of piston valve 37 to exert a force thereon in opposition to air pressure acting on the underside of said piston valve.

The piston valve 37 has a passageway 40 formed therein and when in a lower or delivery position, in which it is shown in the drawing, that is, when air pressure on the underside thereof is insufficient for overcoming the effect of spring 38, interrupts communication between passageway 35, via said passageway 40, and a passageway 41 which connects with a pipe 42 leading, via a choke 43 of predetermined flow capacity, to a timing volume 44 of predetermined capacity. Also when in its lower or delivery position, the piston valve 37 serves to communicate a pipe 45 leading from the automatic drain valve device 22 with a passageway 46 opening to a chamber 47 of the delivery valve portion 26, while, at the same time, opening said pipe and said passageway to atmosphere via a restricted or choked vent portion 48 formed in casing 24.

When air pressure on the underside of piston valve 37 is sufficient for overcoming the effect of spring 38, said piston valve is moved to an upper or charging position in which passageway 40 therein registers with passageways 35 and 41 to open communication therebetween while, at the same time, interrupting communication between pipe 45 and passageway 46 and closing them to atmosphere via vent port 48.

The delivery valve portion 26 comprises a diaphragm valve 49 subject on its lower side, as viewed in the drawing, to air pressure prevailing in the adjacent chamber 47 which is connected via a pipe 50 to the timing volume 44. Any air pressure in chamber 47 is opposed by the effect of a spring 51 disposed in an atmospheric chamber 52 and acting on the upper side of the diaphragm valve 49. A valve seat 53 cooperates with diaphragm valve 49, when in a seated position thereon, to cut off communication between pipe 50 and passageway 46, and, when in an unseated position off the valve seat, to effect communication between said pipe and said passageway.

In considering the operation of the moisture removal apparatus shown in FIG. 1, it will be assumed that the compressor 1 is loaded, as above explained, and is supplying compressed air, via pipe 4 and the aftercooler 3 (where most of the moisture therein is condensed and collected in the sump 8), to the main or storage reservoir 2 by way of pipe 9, pilot valve 10, pipe 12, dryer 11, check valve 16, pipe 13, and pipe 7. Any remaining moisture present in the compressed air is removed therefrom by the desiccant in the dryer 11. At the same time, the purge volume 15 is also charged with compressed air from pipe 14, check valve 17, and what little passes through pipe 18 and choke 19.

When the pressure of compressed air in main reservoir 2 and, therefore, in pipe 7 reaches the preselected maximum pressure at which the governor device 6 is correspondingly set to respond, said governor device opens to admit compressed air at said maximum pressure to

pipe 5, thence to the engine throttle control device (not shown) and the unloader device (not shown) of compressor 1 to cut out or unload the compressor, as above described. At the same time, compressed air is supplied via pipe 20 to a pressure chamber 54 of the pilot valve device 10 to cause a piston-valve member 55 therein to be shifted in a right-hand direction, as viewed in the drawing, out of a normal or supply position in which pipes 9 and 12 are in communication, to a cut-off position in which such communication is interrupted and said pipe 12 is placed in communication with an atmospheric vent port 56 formed in said pilot valve device. The piston-valve member 55 comprises a piston 57 arranged oppositely to a piston 58, said piston 57 having a smaller pressure area than piston 58 subject to air pressure in a chamber 59 through which pipes 9 and 12 communicate when said piston-valve member is in its supply position, and said piston 58 having a larger pressure area than piston 57 subject to air pressure in chamber 54, such differential between said pressure areas thus enabling the piston-valve member to be shifted to its cut-off position, notwithstanding that the respective unit pressures in both said chambers are equal at the time such shifting occurs.

With pipe 12 connected with atmosphere via vent port 56, as above described, compressed air in the purging volume 15 is released to atmosphere, at a rate determined by choke 19, via pipe 12, dryer 11, and said vent port, so as to purge the desiccant in said dryer of any moisture absorbed by the desiccant during flow of compressed air from the sump 8 to the main reservoir 2 during the loaded or compressing phase of the compressor 1. The check valve 16 prevents back flow of compressed air from the main reservoir 2 when pipe 12 is connected to vent port 56.

When the pressure of compressed air in the main reservoir 2, either from usage, leakage or other causes, has been reduced to the preselected minimum pressure at which the governor device 6 is set to respond, said governor device operates to cut off air pressure from pipe 7 and, therefore, to the compressor unloader and the throttle control device, and opens said throttle control device, said unloader device and pipe 5 to atmosphere via a vent 60 provided in the governor device to release actuating air pressure from said unloader and throttle control devices. With actuating air pressure released therefrom, the throttle control device operates to restore the engine and the compressor 1 to normal running speed, and the compressor unloader operates to cut in or load the compressor (which continued to run at idling speed during the unloaded period) for supplying compressed air, as above described, to the main reservoir 2 and thereby restoring the pressure therein to the preselected maximum pressure.

Thus, with the apparatus as shown in FIG. 1 and above described, purging of moisture from the desiccant in the dryer 11 is initiated at the onset of each rest period of the compressor 1, that is, the period during which the compressor operates at idling speed or in an unloaded state, and continues during said rest period or until the pressure in purge volume 15 is exhausted. Thus, the dryer 11 is purged of moisture once during each complete cycle of operation of the compressor, said cycle constituting one compressing or loaded period and a subsequent rest or unloaded period.

As was above noted, when the compressor 1 is cut in or in its loaded phase, compressed air is supplied to and stored in the main reservoir 2. At the same time, such compressed air also flows via pipe 29, which branches off from pipe 7, to passageway 36 and the underside of piston valve 37. For best results, the compression of spring 38, when fully extended, that is with piston valve 37 in its lower position (above defined), is adjusted by screw 39 such that compressed air at what may be called a preset control pressure or a pressure slightly higher, such as 2 p.s.i. higher, for example, than the preselected minimum pressure at which the governor device 6 responds to effect cut-in of the compressor 1, will be effective for operating

said piston valve to its upper position. Upon attainment of such preset control pressure on the underside of piston valve 37, therefore, said piston valve is operated to its upper or charging position (above defined) in which passageway 40 is in registry with passageways 35 and 41. At practically the same time, diaphragm valve 28 of the supply valve portion 25, due to air pressure acting on the underside thereof, is moved to its unseated or an open position off valve seat 34 against opposition of spring 31, which is of preselected compression rating corresponding very nearly to, but not greater than, that at which spring 38 is adjusted, as above described.

With piston valve 37 and diaphragm valve 25 in their charging and unseated positions, respectively, compressed air flows past said unseated diaphragm valve, through passageway 35, passageway 40 and passageway 41 into pipe 42, whence such compressed air flows into timing volume 44 at a restrictedly controlled rate determined by choke 43 to commence building up air pressure in said timing volume. Build-up of pressure in timing volume 44 is an accumulative process intentionally made so by interposition of the choke 43 in the pipe 42, so as to require several successive operating cycles (above defined) of the compressor 1 before the air pressure in said timing volume, which is acting via pipe 50 on the area within valve seat 53 on the underside of diaphragm valve 49 of the delivery portion 26, is sufficient for overcoming the opposing force of spring 51. The flow capacity of choke 43, the capacity of timing volume 44, and the compression rating of spring 51 jointly determine the number of compressor operating cycles required for accumulating pressure in the timing volume 44 to a degree sufficient for unseating the diaphragm valve 49.

Each time the governor device 6 operates responsively to the maximum or high pressure setting for supplying compressed air, via pipe 5, to the engine throttle control device and the compressor unloader for unloading the compressor 1, such compressed air, in addition to being supplied to the pilot valve device 10 in the manner and for the purpose above set forth, is also supplied via branch pipe 33 to chamber 32 of the supply valve portion 25, whereby air pressures on opposite sides of the diaphragm valve 28 are balanced to thereby render spring 31 effective for reseating said diaphragm valve almost immediately at the onset of the rest period of the compressor. This is necessary in order to prevent backflow of compressed air from the timing volume 44, because the piston valve 37 will remain in its charging position until such time that pressure in main reservoir 2 and, therefore, that acting on the underside of said piston valve has been reduced below the preset control pressure above defined, otherwise pressure in said timing volume would reduce along with that in said main reservoir by flowing back through said piston valve, thence past said diaphragm valve 28 were it in its unseated position. Eventually the piston valve 37 will be returned to its lower or delivery position by the spring 38 when the pressure acting on the underside thereof has been reduced by reduction of main reservoir pressure to a value below the preset control pressure, thereby positively blocking backflow of pressure from timing reservoir 44.

Assuming, however, that, after a single phase of loaded operation of the compressor 1, compressed air in timing volume 44 and, therefore, that acting on the area within valve seat 53 on the lower side of the diaphragm valve 49 of the delivery valve portion 26, has not been built up to a pressure sufficient for unseating diaphragm valve 49, charging of said timing reservoir with compressed air will continue through as many subsequent consecutive cycles of compressor operation, in the manner above described, as is necessary to build up the pressure in said timing reservoir and, therefore, on said underside of said diaphragm valve to a degree sufficient for causing the diaphragm valve to be unseated.

Eventually, during one of the subsequent cycles of compressor operation, the pressure acting on the under-

side of diaphragm valve 49 will have attained a force sufficient for unseating or operating said diaphragm valve to an open position so that compressed air from pipe 50 may flow therethrough through chamber 47 and into passageway 46. Since the other end of passageway 46, however, is blocked off at this time by the piston valve 37, which is in its upper or charging position (due to main reservoir pressure acting on the underside thereof), further flow of compressed air beyond said passageway is cut off momentarily. This situation prevails until unloading of the compressor 1 is effected by operation of the governor device 6 responsively to pressure in main reservoir 2 at the preselected maximum pressure and thereafter until such pressure in said main reservoir has been reduced to a value below the preset control pressure (above defined), whereupon spring 38 is effective for operating piston valve 37 to its lower position.

With piston valve 37 in its lower or delivery position, compressed air from timing volume 44 may flow through pipe 50, past unseated diaphragm valve 49, through chamber 47, passageway 46, a spring chamber 61 (in which spring 38 is disposed), a passageway 62 connecting said spring chamber to pipe 45, thence through said pipe 45 to the drain valve device 22 for effecting operation thereof from a normal or closed position to an open position and consequent ejection, via vent 23, or the moisture condensate accumulated in the sump 8. Although the compressor 1 is unloaded at the time moisture condensate is ejected from the sump 8, and pressure in main reservoir 2 is isolated from said sump by the pilot valve device 10, which is in its cut-off position at the time, there is sufficient pressure trapped in the sump, the aftercooler 3, and pipes 4 and 9 at the time the compressor 1 is unloaded to provide the necessary pressure for ejecting the condensate from the sump. The length of time during which the drain valve 22 is subject to the pressure of compressed air in the timing volume 44 and, therefore, remains open, is determined by the flow capacity of choke 48 in the timing valve device 21, since compressed air in said timing volume and, therefore, that acting in the drain valve device is released to atmosphere through said choke at a predetermined controlled rate. As was above noted, pressure of a sufficient degree acting on the area of diaphragm valve 49 within the valve seat 53 causes said diaphragm to be unseated, whereupon such pressure thereafter acts on the entire area of the underside of the diaphragm valve to maintain the valve unseated until such pressure acting thereon (the pressure in timing volume 44) has been reduced sufficiently to render spring 51 effective for reseating the valve. Since such pressure is now acting over the entire area of the underside of valve 49, it should be apparent that such pressure (that is, the pressure in volume 44) must be reduced to a relatively low degree (compared to the degree at which the valve was unseated) in order to render spring 51 effective for reseating the valve. Thus, pressure in timing volume 44 is so depleted as to leave said volume in condition for subsequent recharging, as above described.

Both diaphragm valves 28 and 49 are so arranged to provide snap action when unseated from the respective valve seats 34 and 53. In the respective seated positions of the diaphragm valves 28 and 49, only a portion of the pressure area of each valve, as is particularly noted above in connection with diaphragm valve 49, is subject to the pressures in pipes 29 and 50 that is, the areas within the valve seats 34 and 53, respectively. Upon initial unseating of the valves 28 and 49, however, the entire pressure area of each valve is exposed to the respective pressures in pipes 29 and 50 so as to cause prompt positive

movement to their respective unseated positions. Each time the diaphragm valve 49 is operated to its unseated position, the frequency of operation of said drain valve device, therefore, relative to the number of operat-

ing cycles of the compressor (or to the total time during which the compressor operates under a loaded condition) is determined by the flow capacity of choke 43, the capacity of timing volume 44, and the compression rating of spring 51. The choke 43, the timing volume 44, and the spring 51, therefore, are accordingly preselected, so that the drain valve will operate at a frequency commensurate with the moisture accumulating characteristics of the compressed air system in which the moisture removal apparatus is employed while at the same time preventing unnecessary waste of compressed air caused by too frequent operation of the drain valve.

From the above description of operation it should be noted that the pilot valve device 10 is operated during each rest period of the compressor 1 (that is, at the time the governor device 6 operates to unload the compressor) for purging moisture from the dryer 11, whereas the frequency of operation of the drain valve device 22 (that is, opening thereof for draining condensate from the sump 8) is controlled by the flow capacity of choke 43, the capacity of timing volume 44, and the compression of spring 51, such opening of the drain valve device, however, being set to occur, by adjustment of spring 38 as above noted, almost at the end of the rest period or just prior to loading or cut-in of the compressor by the governor device.

The moisture removal apparatus shown in FIG. 2 is a modified version of that shown in FIG. 1 above described, and is intended to be used in a compressed air system in which the moisture accumulating characteristics are such that it is not deemed necessary to purge the dryer 11 with each cycle of operation of the compressor 1, and, therefore, purging of moisture from the dryer is synchronized with the operation of the drain valve device 22. With the exceptions set forth hereinafter, the moisture removal apparatus shown in FIG. 2 is generally similar to that shown in FIG. 1, and, therefore, all components common to both apparatus are identified with corresponding reference numerals. The apparatus shown in FIG. 2 differs from that of FIG. 1 in that pipe 20 is disconnected from the pilot valve device 10, and said pilot valve device, instead, is connected to pipe 45 from the timing valve device 21 via a branch pipe 63. Thus, each time the timing valve device 21 operates, as above described in connection with the apparatus shown in FIG. 1, to supply compressed air from the timing volume 44 to the drain valve device 22, via pipe 45, for effecting operation of said drain valve device, compressed air, via said pipe 45 and branch pipe 63, is also simultaneously supplied to the pilot valve device 10 which operates in the manner above described for removing any moisture accumulated in the dryer 11. In this manner frequency of operation of the pilot valve device 10 and the drain valve device 22 is synchronized to cause operation of both said valve devices simultaneously.

It should also be apparent that, if so desired or advisable, the pilot valve device 10 may be connected to pipe 45 while the drain valve device 22 may be connected to pipe 20, as shown in FIG. 3, so that the frequency of operation of said pilot valve device would be controlled by the timing valve device 21, whereas the frequency of operation of the drain valve device would be synchronized with and controlled solely by operation of the governor device 6, such an arrangement being the reverse of that shown in FIG. 1 and above described.

Having now described the invention, what we claim as new and desire to secure by Letters Patent is:

1. In a compressed air system having an air compressor, a storage reservoir charged with compressed air from the compressor, and governor means operable responsively to preselected maximum and minimum pressures in the reservoir for cyclically unloading and loading the compressor, respectively, to maintain the pressure in the reser-

voir between said maximum and minimum pressures, the combination therewith of:

- (a) an automatic drain valve device operable to drain condensed moisture from the compressed air in a supply line from the compressor to the storage reservoir, 5
- (b) a desiccant dryer through which the compressed air supply flows to the storage reservoir,
- (c) pilot valve means operable for cutting off flow of compressed air supply through said dryer to the reservoir and concurrently therewith effecting reverse flow of air therethrough to purge said dryer, and 10
- (d) timing means including energy storing means operative, upon the completion of a selected number of consecutive cycles of operations of the governor means, for effecting operation of at least one of said drain valve device and said pilot valve means. 15
2. Moisture removal apparatus for a compressed air supply system and comprising, in combination: 20
 - (a) automatic drain valve means operative for draining condensed moisture from compressed air in a supply line,
 - (b) a desiccant dryer through which compressed air supply flows to a storage reservoir,
 - (c) cycling means for periodically effecting cut-off of flow of compressed air through said desiccant dryer and concurrently therewith effecting reverse flow of air therethrough to purge said dryer, and 25
 - (d) timing means including energy storing means for effecting operation of said automatic drain valve means according to a certain multiple of the number of times said cycling means operates to effect purging of said dryer. 30
3. Moisture removal apparatus for a compressed air supply system having a storage reservoir, said moisture removal apparatus comprising, in combination: 35
 - (a) automatic drain valve means operative for draining condensed moisture from compressed air in a supply line, 40
 - (b) a desiccant dryer through which the compressed air supply flows to the storage reservoir,
 - (c) cycling means controlled by variations in the air pressure in the storage reservoir for periodically effecting cut-off of the flow of the compressed air through said desiccant dryer and concurrently therewith effecting reverse flow of said air therethrough to purge said dryer, and 45
 - (d) timing means including energy storing means for effecting operation of said automatic drain valve means according to a certain multiple of the number of times said cycling means operates to effect purging of said dryer. 50
4. In combination with a compressed air system of the type having a storage reservoir and means for charging said reservoir with compressed air between preselected maximum and minimum pressure limits, apparatus for removing moisture from compressed air supplied to said reservoir, said apparatus comprising: 55
 - (a) automatic drain valve means operative for draining condensed moisture from the compressed air supplied to the reservoir, 60
 - (b) a desiccant dryer through which the compressed air supply flows to the storage reservoir,
 - (c) cycling means for periodically effecting cut-off of the flow of compressed air through said desiccant dryer and concurrently therewith effecting reverse flow of air therethrough to purge said dryer, and 65
 - (d) timing means including energy storing means for effecting operation of said automatic drain valve means according to a certain multiple of the times said cycling means operates to effect purging of said dryer. 70
5. In combination with a compressed air system of the type having a storage reservoir and means for charging 75

said reservoir with compressed air between preselected maximum and minimum pressure limits, apparatus for removing moisture from compressed air supplied to said reservoir, said apparatus comprising:

- (a) automatic drain valve means operative for draining condensed moisture from the compressed air supplied to the reservoir,
- (b) a desiccant dryer through which the compressed air supply flows to the storage reservoir,
- (c) pilot means operative for effecting cut-off of the flow of compressed air through said desiccant dryer and concurrently therewith effecting reverse flow of air therethrough to purge said dryer, and
- (d) means for controlling operation of said drain valve means and said pilot means so as to effect operation of one only responsively to a multiple of a number of operations of the other.
6. A compressed air supply system comprising, in combination:
 - (a) an air compressor,
 - (b) a supply line,
 - (c) a reservoir for storing compressed air supplied thereto from said air compressor via said supply line,
 - (d) a sump interposed in said supply line between said air compressor and said reservoir for collecting moisture condensate from compressed air supplied to said reservoir,
 - (e) a drain valve device having a normally closed position, and being operable responsively to operating air pressure to an open position in which condensate accumulated in said sump is discharged to atmosphere,
 - (f) dryer means interposed in said supply line between said sump and said reservoir for absorbing residual moisture remaining in said compressed air after having passed through said sump, said dryer means including a purge volume chargeable with such compressed air flowing through said dryer means,
 - (g) a pilot valve device interposed in said supply line between said sump and said dryer means, said pilot valve device having a normal position in which communication through said supply line to said reservoir is open, and being operable responsively to operating air pressure to a cut-off position in which said supply communication is closed and an atmospheric communication is opened through which said compressed air in said purge volume is released reversely through said dryer means to atmosphere for purging said dryer means,
 - (h) governor means responsive to preselected maximum and minimum pressures in said reservoir for alternately and cyclically causing said air compressor to be unloaded for interrupting supply of compressed air to said reservoir and to be loaded for resuming supply of compressed air to said reservoir, respectively, and
 - (i) timing control means including energy storing means cooperative with said governor means responsively to a preselected number of compressor operating cycles for effecting supply of operating pressure to at least one of said drain valve and pilot valve devices.
7. A compressed air supply system, as defined in claim 6, wherein said control means is further characterized by choke means via which said operating air pressure is reduced to atmosphere over a certain period of time, thereby to effect restoration of said one of said drain valve and pilot valve devices to its normal position upon dissipation of said operating pressure.
8. A compressed air supply system, as defined in claim 6, wherein said pilot valve device comprises a piston-valve member having a first piston of a certain pressure area subject constantly to pressure of the compressed air

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supplied from said compressor and having a second piston arranged oppositely to and of a larger pressure area than said first piston and subjectable to said operating pressure supplied to the pilot valve device, the differential pressure area therebetween being effective, when said second piston is subjected to such operating pressure, for causing the pilot valve device to be operated to its said cut-off position, and said first piston being effective, upon release of said operating pressure acting on said second piston, for restoring the pilot valve device to its said supply position.

9. A compressed air supply system, as defined in claim 6, wherein the energy storing means of said control means comprises a timing volume chargeable with compressed air at a predetermined pressure and a timing valve device operable cooperatively with said governor means for effecting such charging of said timing volume over a time interval corresponding to that required for said preselected number of compressor operating cycles, said timing valve device being operable responsively to pressure in said timing volume at said predetermined pressure for effecting said supply of operating pressure and being operable responsively to pressure in said reservoir at substantially said preselected minimum pressure for causing such supply of said operating pressure to occur substantially near the end of the last unloaded period of the compressor in each respective time interval.

10. A compressed air supply system, as defined in claim 9, wherein said control means further comprises choke means via which said timing volume is charged, the capacity of said timing volume and the flow capacity of said choke means jointly determining said preselected number of compressor operating cycles occurring during each interval.

11. A compressed air supply system, as defined in claim 9, further characterized in that said timing valve device is operable responsively to pressure in said timing volume at said predetermined pressure for effecting supply of operating air pressure to said pilot valve device and said drain valve device concurrently.

12. A compressed air supply system comprising, in combination:

- (a) an air compressor,
- (b) a supply line,
- (c) a reservoir for storing compressed air supplied thereto from said air compressor via said supply line,
- (d) a sump interposed in said supply line between said air compressor and said reservoir for collecting moisture condensate from compressed air supplied to said reservoir,
- (e) a drain valve device having a normally closed position and being operable responsively to actuating air pressure to an open position in which condensate accumulated in said sump is discharged to atmosphere,
- (f) a desiccant dryer interposed in said supply line between said sump and said reservoir for absorbing residual moisture remaining in said compressed air after having passed through said sump,
- (g) a purge volume connected with said desiccant dryer and chargeable with compressed air from said compressed air supply passing through said dryer,
- (h) a pilot valve device interposed in said supply line between said sump and said dryer, said pilot valve device having a normal position in which communication through said supply line to said reservoir is open, and being operable responsively to operating air pressure to a cut-off position in which said supply communication is closed and an atmospheric communication is opened through which said compressed air in said purge volume is released reversely to atmosphere through said dryer for purging said dryer,
- (i) governor means responsive to a preselected maximum and minimum pressures in said reservoir for alternately and cyclically causing said air compressor

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to be unloaded for interrupting supply of compressed air to said reservoir and to be loaded for resuming supply of compressed air to said reservoir, respectively, said governor means being operable concurrently with unloading of the compressor for effecting supply of operating pressure to said pilot valve device and concurrently with loading of the compressor for effecting relief of said operating pressure from the pilot valve device, and

- (j) timing valve means cooperative with said governor means responsively to a preselected number of compressor operating cycles for controlling supply and release of actuating air pressure to and from, respectively, said drain valve device during each time interval corresponding to said preselected number of compressor operating cycles, said timing valve means comprising:

- (i) a timing volume of preselected capacity,
- (ii) choke means via which said timing volume is charged, the capacity of said timing volume and the flow capacity of said choke means determining said preselected number of compressor operating cycles occurring during each time interval,
- (iii) supply valve means subject intermittently on one side to said operating pressure supplied to said pilot valve device and constantly on the other side to pressure of compressed air supplied to said reservoir, said supply valve means being operable at such time that said one side is void of said operating pressure, to an open position for partially establishing a charging communication via which, upon complete establishment thereof, said timing volume may be charged with compressed air,
- (iv) first spring means effective at such time that both sides of said supply valve means are concurrently subjected to said operating pressure and to said compressed air supply pressure for operating said supply valve means to a closed position in which said charging communication is closed,
- (v) delivery valve means normally biased toward a closed position and being operable responsively to a certain air pressure established in said timing volume to an open position for partially establishing a delivery communication via which, upon complete establishment thereof, actuating air pressure may be supplied from said timing volume to said drain valve device,
- (vi) piston valve means subject to the pressure of compressed air in said reservoir and operable responsively to such compressed air at a preset control pressure greater than said preselected minimum pressure but less than said preselected maximum pressure to a charging position in which, cooperatively with said supply valve means in its said open position, said charging communication is completely established, and
- (vii) second spring means effective, upon reduction of air pressure in said reservoir to a pressure less than said pre-set control pressure, for biasing said piston valve means to a delivery position in which said charging communication is closed and in which, cooperatively with said delivery valve means in its said open position, said delivery communication is completely established.

13. A compressed air supply system, as defined in claim 12, further characterized by choke means of preselected flow capacity for effecting a timed release of said actuating air pressure from said drain valve device, said drain valve device being automatically operative to its said closed position upon dissipation of said actuating air pressure.

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14. A compressed air supply system, as defined in claim 12, further characterized by means for pre-setting said control pressure at such a degree that operation of said piston valve means to its said delivery position is caused to occur substantially near the end of the last unloaded period of the compressor in each respective time interval.

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