Feb. 20, 1968 W. L. McHALE ET AL 3,369,790

FLUID SYSTEM AND METHOD AND PARTS THEREFOR OR THE LIKE

Original Filed Oct. 1, 1963 4 Sheets-Sheet 1

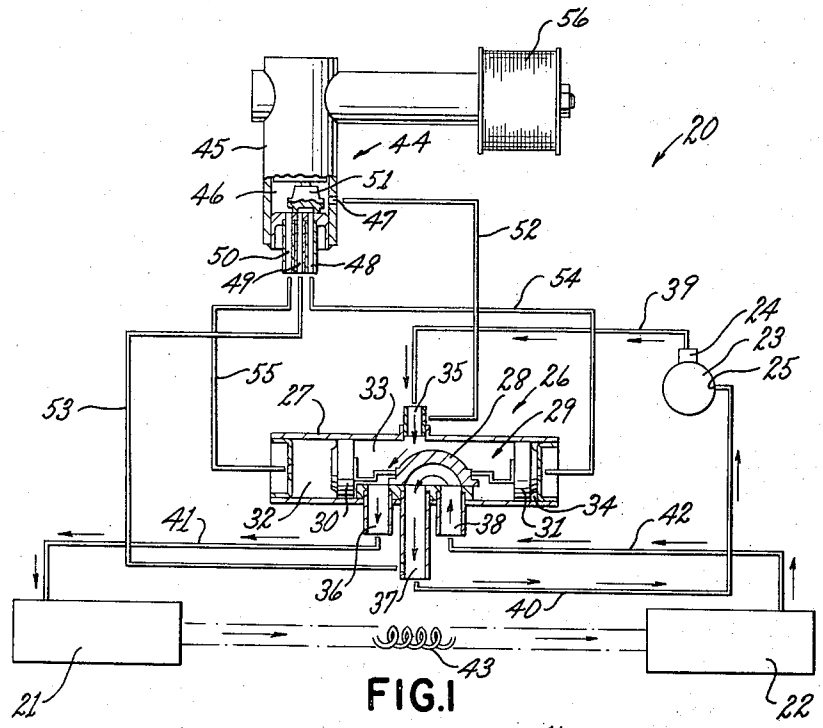


FIG.1

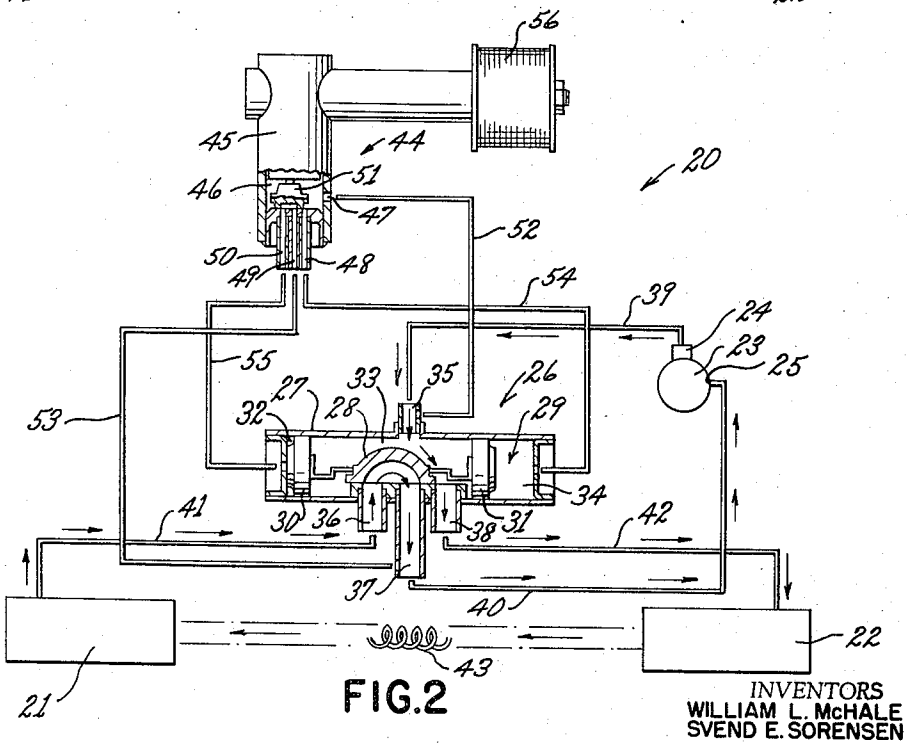


FIG.2

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FLUID SYSTEM AND METHOD AND PARTS THEREFOR OR THE LIKE

Original Filed Oct. 1, 1963 4 Sheets-Sheet 2

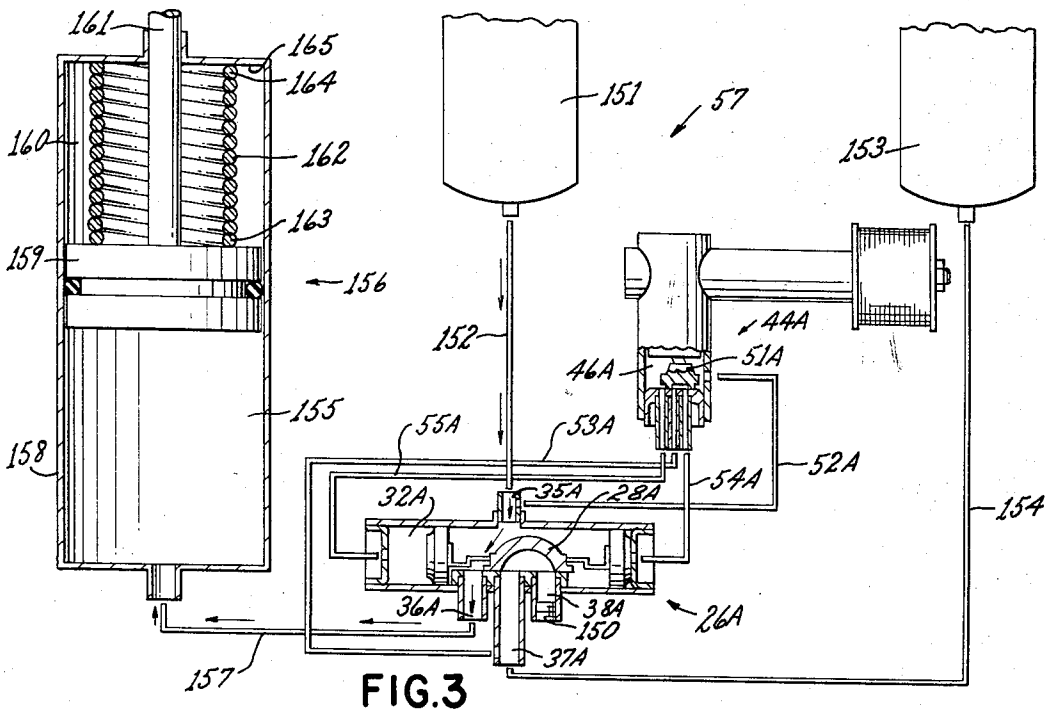


FIG.3

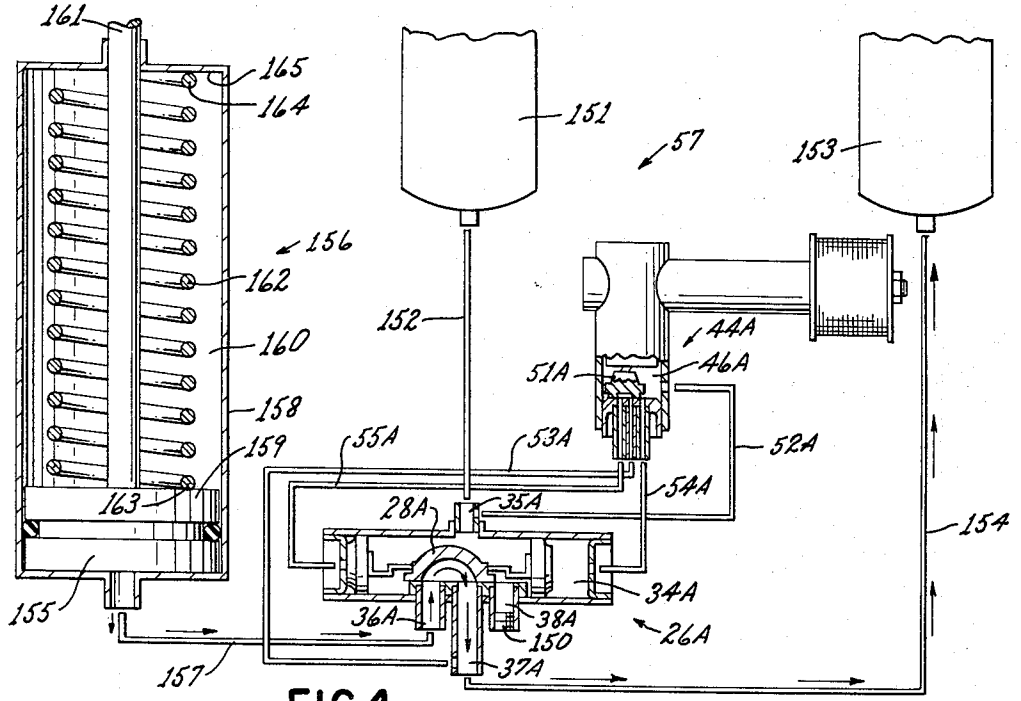


FIG.4

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FLUID SYSTEM AND METHOD AND PARTS THEREFOR OR THE LIKE

Original Filed Oct. 1, 1963 4 Sheets-Sheet 3

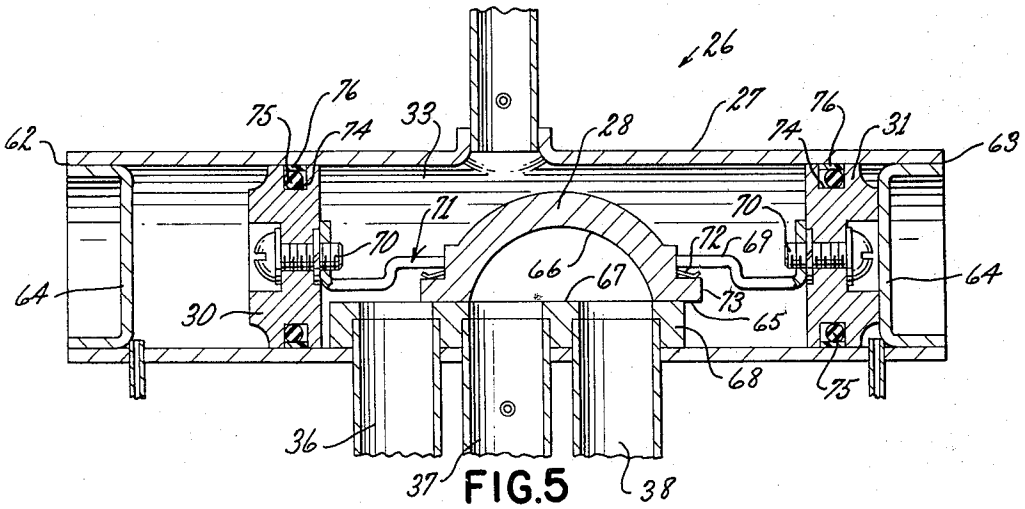


FIG.5

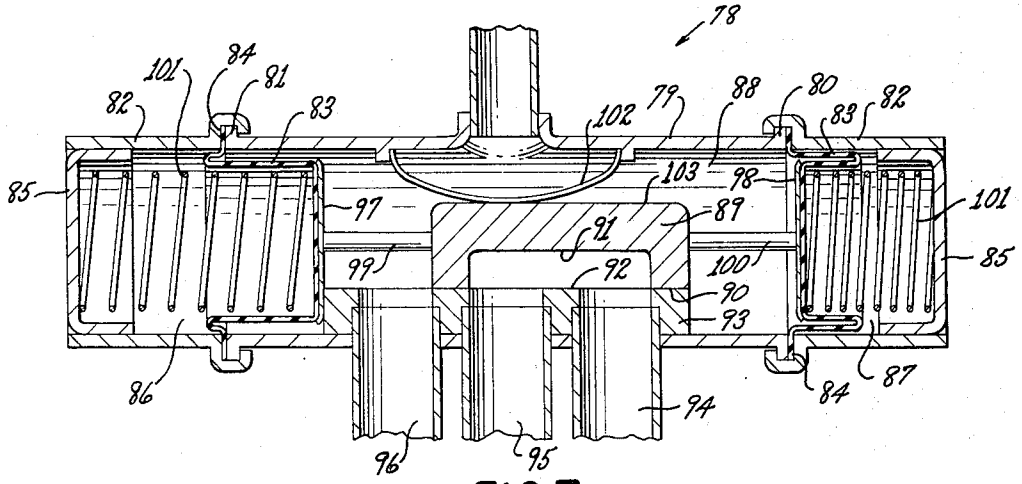


FIG.7

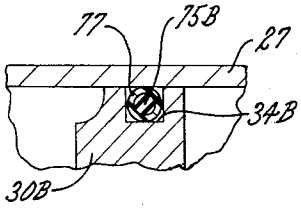


FIG.6

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FLUID SYSTEM AND METHOD AND PARTS THEREFOR OR THE LIKE

Original Filed Oct. 1, 1963 4 Sheets-Sheet 4

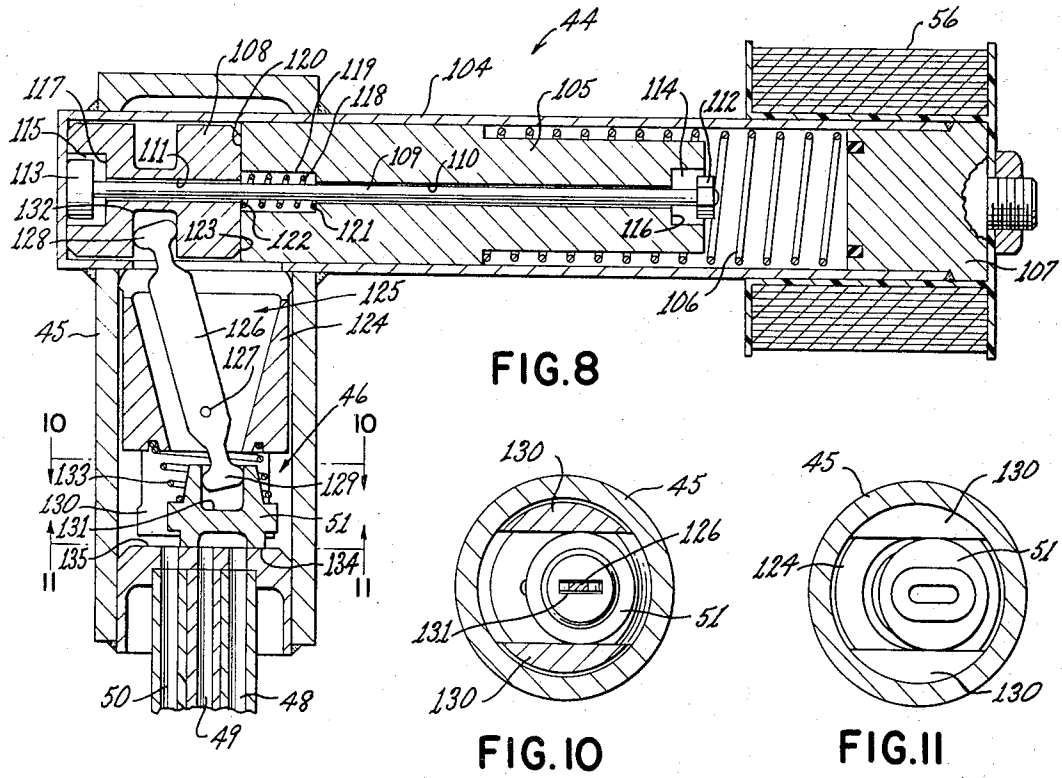


FIG.8

FIG.10

FIG.11

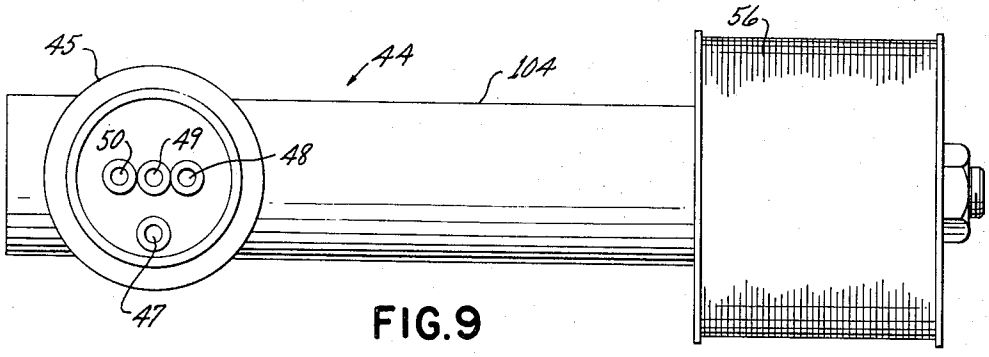


FIG.9

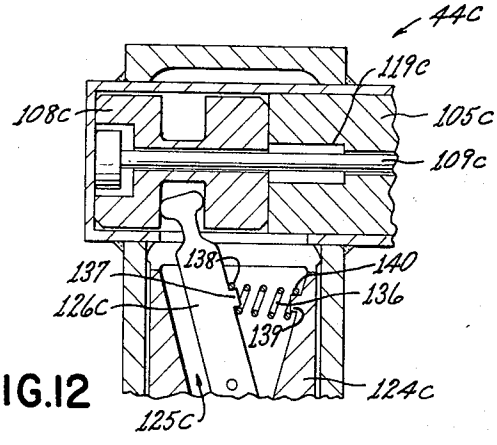


FIG.12

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United States Patent Office

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FLUID SYSTEM AND METHOD AND PARTS THEREFOR OR THE LIKE

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Continuation of application Ser. No. 313,040, Oct. 1, 1963. This application May 19, 1967, Ser. No. 639,916

9 Claims. (Cl. 251—78)

ABSTRACT OF THE DISCLOSURE

This disclosure relates to a pneumatic valving means wherein a pilot valve means is moved between operating positions thereof upon the actuation of a solenoid coil, the pilot valve means directing fluid flow to a main valve member to shift the main valve member between its operating position so that the main valve member can control a main fluid flow for a refrigeration system or the like, the pilot valve means having lost motion means not only between a member and an armature that is moved by the coil to first take up the lost motion between the armature and the member before moving the member, but also having lost motion means between the member and a plunger means that directs the fluid flow to the main valve member.

This application is a continuation of my copending application Serial No. 313,040, filed October 1, 1963, now abandoned.

This invention relates to an improved fluid system and to an improved method for controlling such a fluid system or the like.

In addition, this invention relates to improved valve means for such a fluid system or the like.

It is well known that a fluid system can be provided wherein a single compressor is adapted to selectively have its discharge side interconnected to one heat exchanger while the suction side thereof is interconnected to another heat exchanger whereby the first heat exchanger will provide a heating apparatus and the other heat exchanger will provide a cooling apparatus. By providing a proper valve means between the refrigerant compressor and the heat exchangers, the valve means can be utilized to reverse the arrangement by interconnecting the suction side of the compressor to the first heat exchanger and the discharge side of the compressor to the other heat exchanger whereby the first heat exchanger will now act as a cooling means and the second heat exchanger will now act as a heating means.

Such a fluid system is particularly adaptable for providing a cooling means for a home or the like during the summer and a heating means for the same during the winter.

In the past, such a valve means for the above-described fluid system has comprised a main four-way valve means having a movable member.

It has been found that if the valve member of the main four-way valve means is directly actuated by an actuating means, such as a solenoid coil or the like, the force required to move such a valve member is substantially great whereby the overall cost of providing a suitable solenoid coil renders the system relatively expensive.

Therefore, in the past, various system manufacturers have utilized a three-way pilot valve means to control the operation of the main valve means, the movable valve member of the pilot valve means being actuated by a relatively small solenoid coil whereby the solenoid coil was relatively inexpensive when compared to the cost of the larger coil required to directly actuate the main valve means.

However, it has been found that when a three-way pilot valve means is utilized with a four-way main valve means in the above manner, the main valve means must be so constructed and arranged that the same has rather complicated structure to control the leakage past the piston members thereof and requires separate valve means in the piston portions thereof in order to have the main valve means function properly in combination with the aforementioned three-way pilot valve means.

However, according to the teachings of this invention, it has been found that when a four-way pilot valve means is utilized in a manner hereinafter set forth, the main valve means can be substantially inexpensively formed as the same does not require the complicated and expensive structure of the prior art main valve means normally utilized with the three-way pilot valve means.

Therefore, it can be seen that the system and method of this invention is relatively inexpensive when compared with prior known systems and methods because of the unique arrangement of the parts of this invention.

Accordingly, it is an object of this invention to provide an improved fluid system having one or more of the novel features set forth above or hereinafter shown or described.

Another object of this invention is to provide an improved method for operating such a fluid system or the like.

A further object of this invention is to provide improved valve means for such a fluid system or the like.

Other objects, uses and advantages of this invention are apparent from a reading of this description which proceeds with reference to the accompanying drawings forming a part thereof and wherein:

FIGURE 1 is a schematic view illustrating one embodiment of the fluid system and method of this invention, the valve means thereof being shown in exaggerated large scale relative to the remaining structure in order to facilitate a disclosure of the same.

FIGURE 2 is a view similar to FIGURE 1 and illustrates the fluid system in another operating position thereof.

FIGURE 3 is a view similar to FIGURE 1 and illustrates another embodiment of this invention.

FIGURE 4 is a view similar to FIGURE 3 and illustrates the fluid system in another operating position thereof.

FIGURE 5 is an axial cross-sectional view of the improved main valve means of this invention.

FIGURE 6 is an enlarged fragmentary view of the piston portion of the valve means illustrated in FIGURE 5 and illustrates another embodiment of this invention.

FIGURE 7 is a view similar to FIGURE 5 and illustrates another embodiment of this invention.

FIGURE 8 is an axial cross-sectional view of the improved pilot valve means of this invention.

FIGURE 9 is a bottom view of the valve means illustrated in FIGURE 8.

FIGURE 10 is a cross-sectional view taken on line 10—10 of FIGURE 8.

FIGURE 11 is a cross-sectional view taken on line 11—11 of FIGURE 8 with background structure removed.

FIGURE 12 is a fragmentary view similar to FIGURE 8 and illustrates another embodiment of this invention.

While the various features of this invention are hereinafter described and illustrated as being particularly adaptable for a refrigerant fluid system or the like, it is to be understood that the various features of this invention can

be utilized singly or in any combination thereof to provide means for other types of fluid systems or the like.

Therefore, this invention is not to be limited to only the embodiments illustrated in the drawings, because the drawings are merely utilized to illustrate one of the wide variety of uses of this invention.

Referring now to FIGURES 1 and 2, an improved fluid system of this invention is generally indicated by the reference numeral **20** and comprises means for selectively causing a first heat exchanger means **21** to act as a heating means in FIGURE 1 while a second heat exchanger means **22** acts as a cooling means, the system **20** being reversible in the manner illustrated in FIGURE 2 to cause the first heat exchanger means **21** to act as a cooling means and the second heat exchanger means **22** to act as a heating means.

For example, the heat exchanger means **21** can be located inside a building or the like while the heat exchanger means **22** is located outside the same. In this manner, during the summer, the system can be disposed in the position illustrated in FIGURE 2 wherein the heat exchanger means **21** will provide a cooling means for the cooling cycle while the heat of the system is dissipated outside the building by the heat exchanger means **22**.

However, during the winter, the system **20** can be disposed in the position illustrated in FIGURE 1 wherein the heat exchanger means **21** dissipates the heat of the system inside the building for the heating cycle thereof while the heat exchanger **22** acts as a cooling means outside the building and, therefore, does not affect the heating cycle.

Therefore, it can be seen that the system **20** of this invention is particularly adaptable for providing heating or cooling means for the building or the like by merely reversing the cycle of operation thereof in a manner later to be described.

The particular details of the system **20** will now be described.

As illustrated in FIGURES 1 and 2, a refrigerant compressor **23** is provided and has a discharge side **24** and a suction side **25**.

The discharge side **24** of the refrigerant compressor **23** is adapted to be selectively interconnected to one of the heat exchangers **21** and **22** while the suction side **25** is simultaneously interconnected to the other heat exchanger **21** or **22** by means of a main four-way valve means **26** of this invention.

In particular, the valve means **26** comprises a housing **27** having a movable valve member **28** disposed in a chamber **29** of the housing, the movable valve member **28** being interconnected to a pair of opposed piston portions **30** and **31** respectively cooperating with the housing **27** to define three compartments **32**, **33** and **34** in the chamber **29** with the slide member **28** being disposed in the compartment **33**.

The housing **27** has four ports **35**, **36**, **37** and **38** provided therein and respectively leading to the compartment **33** thereof.

The port **35** of the valve means **26** is interconnected to the discharge side **24** of the compressor **23** by a conduit means **39**. The port **37** of the valve means **26** is interconnected to the suction side **25** of the compressor **23** by a conduit means **40**. The remaining ports **36** and **38** are respectively interconnected to the heat exchangers **21** and **22** by conduit means **41** and **42**.

Therefore, when the valve member **28** of the valve means **26** is disposed in the position illustrated in FIGURE 1, the compressed refrigerant from the discharge side **24** of the compressor **23** is adapted to flow through the port **35** of the valve means **26** to the port **36** and, thus, to the heat exchanger **21** to cause the same to act as a condenser and provide a heating means, the return from the heat exchanger **21** passing through a restrictor means **43** to the heat exchanger **22** to cause the heat exchanger **22** to act as an evaporator whereby the heat exchanger **22** acts as a cooling means.

The return of fluid from the evaporator **22** passes through the conduit means **42** to the port **38** of the valve means **26** and through the valve member **28** to the port **37** leading back to the suction side **25** of the compressor **23** by the conduit **40**.

When the valve member **28** is shifted to the left in the manner illustrated in FIGURE 2, the discharge side **24** of the compressor **23** is now interconnected to the port **38** leading to the heat exchanger **22** whereby the heat exchanger **22** acts as a condenser for the refrigerant and, thus, forms a heating means. The compressed fluid from the heat exchanger **22** is then directed through the restrictor **43** to the heat exchanger **21** whereby the heat exchanger **21** acts as an evaporator and thereby cools the building or the like, the return from the evaporator **22** passing through the ports **36** and **37** back to the suction side **25** of the compressor **23**.

As previously set forth, when the valve member **28** of the valve means **26** is shifted between the positions illustrated in FIGURES 1 and 2 by a solenoid coil directly interconnected to the valve member **28**, it has been found that the solenoid coil must be so large that the cost of the same makes the system substantially impractical.

However, according to the teachings of this invention, a four-way pilot valve means **44** is provided to selectively shift the valve member **28** of the main valve means **26** between the positions illustrated in FIGURES 1 and 2 by utilizing the suction and discharge pressures of the compressor **23** for the motive power to shift the valve member **28**.

As previously set forth, prior known fluid systems of the above described types have utilized three-way pilot valve means to shift the main valve member whereby the main four-way valve means of the prior known systems comprise rather complicated and expensive structures rather than the simple and inexpensive structure provided by this invention.

Therefore, by utilizing the four-way pilot valve means **44** of this invention in a manner hereinafter described, it has been found that the main valve means **26** can be a relatively simple structure as will be apparent hereinafter.

The pilot valve means **44** comprises a housing **45** having a chamber **46** defined therein. Four ports **47**, **48**, **49** and **50** are formed in the closing **45** and lead to the chamber **46** thereof for a purpose hereinafter described.

A movable valve member **51** is disposed in the chamber **46** and is adapted to selectively interconnect the ports **48** and **49** together while permitting the ports **47** and **50** to be interconnected together when the valve member **51** is disposed in the position illustrated in FIGURE 1.

However, when the valve member **51** is shifted to the left to the position illustrated in FIGURE 2, the valve member **51** interconnects together the ports **49** and **50** while permitting the ports **47** and **48** to be interconnected together for a purpose now to be described.

As illustrated in FIGURES 1 and 2, the port **47** of the pilot valve means **44** is interconnected to the discharge side **24** of the compressor **23** by a conduit means **52**.

The port **49** of the pilot valve means **44** is interconnected to the suction side **25** of the compressor **23** by a conduit means **53**.

The ports **48** and **50** of the pilot valve means **44** are respectively interconnected to the compartments **34** and **32** of the main valve means **26** by conduit means **54** and **55** for a purpose now to be described.

When the valve member **51** of the pilot valve means **44** is moved to the position illustrated in FIGURE 1 by a relatively small solenoid coil **56** in a manner hereinafter set forth, the valve member **51** permits the port **47** thereof to be interconnected to the port **50** thereof whereby the discharge side **24** of the compressor **23** is interconnected to the compartment **32** of the main valve means

26. Simultaneously, the compartment 34 of the main valve means 26 is interconnected to the suction side 25 of the compressor 23 by the interconnected ports 48 and 49 of the pilot valve means 44 whereby the pressure differential between the compartments 32 and 34 of the main valve means 26 causes the valve member 28 to shift to the position illustrated in FIGURE 1 whereby the heat exchanger means 21 acts as a condenser and the heat exchanger means 22 acts as an evaporator.

When the valve member 51 of the pilot valve means 44 is shifted to the position illustrated in FIGURE 2 by the solenoid coil 56 in a manner hereinafter described, the port 47 of the pilot valve means 44 is interconnected to the port 48 thereof whereby the suction side 24 of the compressor 23 is interconnected to the compartment 34 while simultaneously the compartment 32 of the main valve means 26 is interconnected to the suction side 25 of the compressor 23 by the interconnected ports 49 and 50 of the pilot valve means 44.

In this manner, the pressure differential between the compartments 34 and 32 of the main valve means 26 causes the main valve member 28 thereof to shift to the position illustrated in FIGURE 2 to cause the heat exchanger means 22 to act as a condenser and the heat exchanger means 21 to act as an evaporator.

Therefore, it can be seen that the fluid system 20 of this invention can selectively provide a heating cycle for a building as illustrated in FIGURE 1 or a cooling cycle for the building as illustrated in FIGURE 2 simply upon the shifting of the valve member 51 of the pilot valve means 44 in a manner hereinafter described whereby the main valve means 26 of this invention can be a relatively inexpensive and uncomplicated valve means over prior art structure so that the overall system 20 of this invention can be relatively inexpensive while still performing desired functions in a desired manner.

While the main valve means 26 and pilot valve means 44 of this invention have been previously described as being particularly adaptable for changing a cooling cycle of a building or the like to a heating cycle upon the shifting of the valve members thereof, it is to be understood that the pilot valve means 44 of this invention could be utilized to shift the valve member of a three-way valve means rather than the four-way valve means illustrated in FIGURES 1 and 2.

For example, another fluid system of this invention is generally indicated by the reference numeral 57 in FIGURES 3 and 4 wherein like parts between the systems 20 and 57 are indicated by like reference numerals followed by the reference letter A.

As illustrated in FIGURES 3 and 4, the main valve member 26A and pilot valve member 44A are substantially identical to the valve means 26 and 44 of FIGURES 1 and 2 and are interconnected together in a like manner. However, the port 38A of the main valve means 26A is closed by a suitable plug 150 whereby it can be seen that the main valve means 26A now comprises a three-way valve means rather than a four-way valve means as provided by the valve means 26 previously described.

The inlet port 35A of the main valve means 26A is interconnected to a source 151 of high pressure fluid by a conduit means 152, whereby the high pressure fluid from the source 151 is adapted to be connected to the chamber 46A of the pilot valve means 44A by the conduit 52A in the manner previously described.

The outlet port 37A of the main valve means 26A is interconnected to a source 153 of low pressure fluid by a conduit means 154. The other port 36A of the main valve means 26A is interconnected to a chamber 155 of a piston and cylinder arrangement 156 by a conduit means 157.

The piston and cylinder arrangement 156 comprises a cylinder 158 having a piston 159 disposed therein and dividing the same into two chambers 155 and 160, the piston 159 being interconnected to a suitable piston rod 161 projecting through the chamber 160 of the cylinder 158 and out of the end thereof.

A compression spring 162 is disposed in the chamber 160 and has one end 163 bearing against the piston 159 and the other end 164 bearing against an end wall 165 of the cylinder defining means 158 whereby the compression spring 162 continuously tends to urge the piston to the position illustrated in FIGURE 4.

When it is desired to move the piston 159 of the piston and cylinder arrangement 156 from the position illustrated in FIGURE 4 to the position illustrated in FIGURE 3 to actuate a suitable device or the like, the valve member 51A of the pilot valve means 44A is moved to the position illustrated in FIGURE 3 to interconnect the source of high pressure fluid 151 to the chamber 32A of the main valve means 26A and thereby cause the valve member 28A of the main valve means 26A to move to the position illustrated in FIGURE 3 whereby the source 151 of high pressure fluid is interconnected to the port 36A thereof and can be directed by the conduit 157 to the chamber 155 of the piston and cylinder arrangement 156. With the source 151 of high pressure fluid now being connected to the chamber 155 of the piston and cylinder arrangement 156, it can be seen that the same forces the piston 159 toward the end wall 165 thereof in opposition to the force of the compression spring 162 to move the piston rod 161 upwardly in FIGURE 3 for any suitable purpose.

As long as the source 151 of high pressure fluid is interconnected by the main valve means 26A to the chamber 155 of the piston and cylinder arrangement 156, the piston 159 thereof is disposed in the position illustrated in FIGURE 3.

However, when it is desired to return the piston 159 from the position illustrated in FIGURE 3 to the position illustrated in FIGURE 4, the valve member 51A of the pilot valve means 44A is shifted to the left to the position illustrated in FIGURE 3 to interconnect the source 151 of high pressure fluid to the chamber 34A of the main valve means 26A and cause movement of the valve member 28A from the position illustrated in FIGURE 3 to the position illustrated in FIGURE 4. With the valve member 28A now disposed in the position illustrated in FIGURE 4, the valve member 28A bridges the ports 36A and 37A thereof so that the fluid pressure in the chamber 155 of the piston and cylinder arrangement 156 will be vented to the low pressure source 153 while the high pressure source 151 is disconnected from the chamber 155 of the piston and cylinder arrangement 156.

Thus, the force of the compression spring 162 of the piston and cylinder arrangement 156 is adapted to move the piston 159 from the position illustrated in FIGURE 3 to the position illustrated in FIGURE 4 as the pressure fluid in the chamber 155 is being vented by the main valve means 26A to the source 153 of low pressure fluid.

Therefore, it can be seen that by selectively moving the valve member 51A of the pilot valve means 44A between the positions illustrated in FIGURES 3 and 4, the piston 159 of the piston and cylinder arrangement 156 can be moved upwardly or downwardly for any desired purpose.

Accordingly, it can be seen that the four-way pilot valve means 44 or 44A of this invention can be selectively utilized with a four-way main valve means 26 or with a three-way main valve means 26A to accomplish a desired operation of a fluid system or the like, the pilot valve means 44 and 44A being adapted to use the pressure differential between a low pressure source and a high pressure source to move the valve member 28 or 28A of the main valve means 26 or 26A without requiring the main valve means 26 or 26A to have complicated valves and leakage control means in the manner provided by prior known fluid systems.

The particular details of the main four-way valve means 26 will now be described and reference is made to FIGURE 5.

As illustrated in FIGURE 5, the main four-way valve means **26** has the housing **27** thereof formed in substantially cylindrical fashion with the opposed open ends **62** and **63** thereof respectively sealed closed by cup-shaped retainers **64**.

The main valve member **28** that is disposed in the compartment **33** of the housing **27** comprises a D-shaped slide member having a flat surface **65** interrupted by a recess **66** adapted to selectively bridge the ports **36** and **37** or the ports **37** and **38** formed in a flat valve surface **67** of a valve head **68** disposed in the housing **27**.

The opposed piston portions **30** and **31** of the valve means **26** are respectively interconnected together by a rigid member **69** respectively secured to the piston portions **30** and **31** by fastening member **70**. The rigid member **69** has an opening **71** provided therein and telescopically receiving the D-shaped slide member **28** in the manner illustrated in FIGURE 5.

In order to maintain the surface **65** of the slide member **28** into sealing contact with the surface **67** of the valve block **68**, a leaf type spring **72** is disposed between the rigid member **69** and an annular shoulder **73** of the valve member **28** in the manner illustrated in FIGURE 5.

Because the value means **26** is only shifted between its operating positions, in the manner previously described, a relatively few times a year whereby the value member **28** will normally be disposed in one operating position thereof for several months, it is desirous that the sealing means sealing the piston portions **30** and **31** to the internal peripheral surface of the housing **27** not stick to the housing **28** while still providing a sealing relationship therewith.

Accordingly, each piston portion **30** and **31** of the valve means **26** is provided with an annular recess **74** receiving a conventional rubber O-ring **75** or the like. However, a boot or annular band **76** of polytetrafluoroethylene normally sold under the trademark "Teflon" or polytrifluorochloroethylene normally sold under the trademark "Kel-F" is disposed around the O-ring **75** in the manner illustrated in FIGURE 5 to provide the engaging surface of the piston portion **30** or **31** against the internal peripheral surface of the housing **27**, the boot **76** not only providing a good sealing relation with the internal peripheral surface of the housing **27** but also reducing the friction between the piston portion **30** or **31** in the housing **27** to readily permit the valve member **28** to be shifted between its operating position in the manner previously described without sticking thereto.

While the embodiment of the valve means **26** illustrated in FIGURE 1 has a boot **76** separate from the O-ring **75**, it is to be understood that the same could be made together, if desired.

For example, reference is made to FIGURE 6 wherein another embodiment of the valve means **26** is illustrated and the O-ring **75B** disposed in the recess **74B** of either piston portion **30B** or **31B** is completely coated with a coating **77** of polytetrafluoroethylene or polytrifluorochloroethylene to provide the aforementioned functions of the sealing means of the piston means **30B** and **31B**.

Therefore, it can be seen that the valve means **26** of this invention can be readily simply formed from uncomplicated parts because the same does not require complicated valve structures in the piston portions **30** and **31** thereof as required by other four-way valve means utilized in combination with three-way pilot valve means in the manner previously described.

While one type of four-way valve means **26** has been previously described as being particularly adaptable to be utilized in the systems **20** and **57** of this invention, it is to be understood that other types of four- and three-way valve means can be utilized therewith.

For example, another valve means of this invention is generally indicated by the reference numeral **78** in FIGURE 7 and will now be described.

As illustrated in FIGURE 7, the valve means **78** of this invention comprises a housing **79** having a pair of opposed ends **80** and **81** respectively interconnected to a pair of collars **82** for a purpose now to be described.

A pair of substantially cup-shaped flexible diaphragms **83** respectively have the outer peripheries **84** thereof sandwiched between the collars **82** and the ends **80** and **81** of the housing **79** in the manner illustrated in FIGURE 7 whereby the cup-shaped diaphragms **83** are secured to the valve means **78** and respectively cooperate with cup-shaped retainers **85** to define compartments **86** and **87** in the opposed ends of the valve means **78** and separate from a middle compartment **88** thereof.

A slide valve member **89** is disposed in the compartment **88** and has a flat end surface **90** interrupted by a recess **91**, the flat surface **90** of the slide member **89** engaging a flat surface **92** of a valve block **93** disposed in the housing **79**.

The valve member **89** is so constructed and arranged that the same is adapted to selectively bridge the bridge ports **94** and **95** in the valve block **93** when the valve member **89** is disposed in the position illustrated in FIGURE 7. However, when the valve member **89** is shifted to the right-hand diaphragm **83** folds upon itself in the manber **89** is adapted to bridge the port **95** and another port **96** in the manner previously described.

A pair of piston portions **97** and **98** are respectively interconnected to the slide member **89** by rigid members **99** and **100** in the manner illustrated in FIGURE 7, whereby the piston portions **97** and **98** respectively cooperate with the flexible diaphragms **83**.

The flexible diaphragms **83** are so constructed and arranged that the same are adapted to fold or unfold without stretching thereof depending upon the position of the valve member **89**.

In particular, when a relatively high pressure fluid is supplied to the compartment **86** and a relatively low pressure fluid is supplied to the compartment **87**, the valve member **89** is shifted to the position illustrated in FIGURE 7 whereby the left-hand diaphragm **83** unfolds while the righ-hand diaphragm **83** folds upon itself in the manner illustrated in FIGURE 7.

Conversely, when a relatively high pressure fluid is supplied to the compartment **87** and a relatively low pressure fluid is supplied to the compartment **86**, the pressure differential between the compartments **86** and **87** shifts the valve member **89** to the right whereby the left-hand diaphragm **83** folds upon itself and the right-hand diaphragm **83** unfolds. Thus, it can be seen that each diaphragm **83** of this invention either rolls upon itself or unrolls to permit shifting of the valve member **89** whereby seals and frictional engagement between the piston portions **97** and **98** and the housing means **79** and **82** are eliminated.

While return springs **101** are respectively disposed in the compartments **86** and **87**, it is to be understood that such return springs **101** could be eliminated if the valve means **78** of this invention is utilized in combination with the pilot valve means **44** of this invention in the manner previously described.

However, if only one rolling diaphragm **83** is utilized with the valve member **89** of this invention, it can be seen that a return spring **101** would be necessary to return the valve member **89** to one selected position thereof after a reduced pressure has been provided in the respective compartment **86** or **87** to draw the valve member **89** from the position it normally has been moved to by the spring **101**.

In order to maintain the surface **70** of the valve member **89** in sealing contact with the surface **92** of the valve block **93**, a leaf spring **102** is disposed between the housing **78** and the upper surface **103** of the valve member **89**, the valve member **89** being adapted to be axially moved relative to the spring **102** while the spring **102** urges the

same into sealing contact with the surface 92 of the valve block 93.

Therefore, it can be seen that another valve means is provided in FIGURE 7 which is adapted to be utilized with the systems 20 and 57 previously described.

The pilot valve means 44 will now be described and reference is made to FIGURES 8–11.

As illustrated in FIGURES 8–11, the housing 45 is interconnected in any suitable manner to a cylindrical housing 104 disposed at right angles relative thereto, the housing 104 carrying the solenoid coil 56 on the outer right hand thereof for a purpose hereinafter described.

A movable armature 105 is disposed in the housing 104 and is normally urged to its left-hand position by a compression spring 106 disposed between the armature 105 and a plug means 107 in the right hand of the housing 104.

A plunger 108 is also disposed in the housing 104 and is disposed in the left-hand end thereof in coaxial relationship with the armature 105.

The plunger 108 is operatively interconnected to the armature 105 by a lost motion means provided by a shaft-like member 109 respectively passing through aligned bores 110 and 111 respectively formed in the armature 105 and the plunger 108.

The shaft-like member 109 has enlarged ends 112 and 113 respectively received in recesses 114 and 115 provided in the outer ends of the armature 105 and the plunger 108 and are normally spaced from the end surfaces 116 and 117 of the armature 105 and plunger 108 for a purpose hereinafter described.

A compression spring 118 is disposed in a recess 119 formed in the end 120 of the armature 105 and has one end 121 bearing against the armature 105 and the other end 122 thereof bearing against the end 123 of the plunger 108.

In this manner, when the solenoid coil 56 is deenergized, the compression spring 106 forces the armature 105 and plunger 108 against the left-hand end of the housing 104 in the manner illustrated in FIGURE 8 to cause the valve member 51 to be disposed in the position illustrated in FIGURE 8, the compression force of the spring 106 being greater than the force of the spring 118.

However, when the solenoid coil 56 is energized, the same draws the armature 105 to the right in opposition to the force of the compression spring 106.

Because of the lost motion between the armature 105 and the plunger 108 provided by the shaft-like member 109, the armature 105 initially moves to the right while the spring 118 holds the plunger 108 in the position illustrated in FIGURE 8 until the enlarged heads 112 and 113 of the shaft-like member 109 are respectively engaging the surfaces 116 and 117 of the armatures 105 and 108 whereby the plunger 108 is then also moved to the right by further movement of the armature 105 to cause the valve member 51 to move from the position illustrated in FIGURE 8 to the position illustrated in FIGURE 2 in a manner hereinafter described.

Therefore, it can be seen that a break-away force is provided by the armature 105 initially moving to the right before the plunger 108 is moved to the right so that the plunger 108 will have a relatively large force applied thereto to move the valve member 51 from the position illustrated in FIGURE 8 to the position illustrated in FIGURE 2 whereby the coil 56 of this invention can be relatively small and still produce the required movement of the valve member 51.

Because the solenoid coil 56 of the pilot valve means 44 of this invention is relatively small, means are provided for amplifying the force of movement of the plunger 108 to the valve member 51 to permit the valve member 51 to shift between the positions thereof.

In particular, it can be seen in FIGURE 8 that a substantially cylindrical positioner or retainer 124 is disposed in the chamber 46 of the housing 45 and has a slot means 125 passing therethrough.

A lever 126 is disposed in the slot means 125 of the retainer 124 and is pivotally interconnected thereto by a pivot pin 127 disposed intermediate the ends 128 and 129 of the lever 126.

The retainer 124 has a pair of legs 130 extending downwardly from the same and respectively are disposed on opposite sides of the D-shaped slide valve member 51 to guide the movement of the valve member 51 between the operating positions thereof in the manner illustrated in FIGURE 11.

Further, the legs 130 of the retainer 124 facilitate assembly of the lever 126 relative to the valve member 51 by guiding the end 129 of the lever 126 into a recess 131 of the valve member 51 when the retainer 124 and valve member 51 are being assembled together.

The other end 128 of the lever 126 is received in an annular cavity 132 formed in the plunger 108 whereby movemeent of the plunger 108 causes the lever 126 to pivot and move the valve member 51 in the manner previously described.

A compression spring 133 is disposed between the retainer 124 and the valve member 51 to tend to urge the surface 134 of the valve member 51 into sealing engagement with the valve surface 135 of the housing 45, the valve surface 135 having the ports 48, 49 and 50 formed therein in aligned relation while the port 47 previously described is formed in the valve surface 135 out of alignment with the ports 48–50 and valve member 51 in the manner illustrated in FIGURE 9.

Thus, it can be seen that the lever 126 amplifies the force of movement of the plunger 108 to the valve member 51 to cause the valve member 51 to move relative to the valve surface 135 when very little force is being utilized to move the plunger 108 whereby the solenoid coil 56 can be relatively small.

Further, because of the lost motion provided by the means 109 previously described, the break-away force required to move the valve member 51 from the position illustrated in FIGURE 2 can be relatively small as the armature 105 builds up momentum before the same moves the plunger 108.

Therefore, it can be seen that the valve means 44 of this invention is relatively simple to manufacture while still providing the desired valve movement to control the main valve means 26 and 26A in the manner previously described.

While the lost motion spring means 118 has been previously described and illustrated as being disposed between the armature 105 and the plunger 108, it is to be understood that similar spring means can be utilized on the lever means 106 to provide the same function.

For example, reference is made to FIGURE 12 wherein another embodiment of the valve means 44 is generally indicated by the reference numeral 44C and parts thereof similar to the valve means 44 are indicated by like reference numerals followed by the reference letter C.

As illustrated in FIGURE 9, the spring 118 has been eliminated from the recess 119C of the armature 105C and a compression spring 136 has been disposed between the lever 126C and the retainer 124C in the slot means 125C thereof, the lever 126C having a locating projection 137 for the end 138 of the spring 136 while the retainer 124 has a locating projection 139 for the other end 140 of the spring 136.

Therefore, it can be seen that the compression spring 136 tends to hold the plunger 108C in its extreme left-hand position when the armature 105C is initially moved to the right until the lost motion means 109C causes the plunger 108C to move to the right to cause the valve member to be moved by the pivoting movement of the lever 126C in the manner previously described.

Accordingly, it can be seen that various modifications can be made in the valve means of this invention while the resulting structure still falls within the scope of the appended claims.

Thus, it can be seen that not only does this invention provide improved fluid systems or the like, but also this invention provides improved methods of operating such fluid systems or the like.

In addition, this invention provides improved valve means for such a fluid system or the like.

However, it is to be understood that the various valve means of this invention can be utilized with other systems or for other purposes as desired.

While the form of the invention now preferred has been disclosed as required by the statutes, other forms may be used, all coming within the scope of the claims which follow.

What is claimed is:

1. A valve means comprising a housing having a chamber therein, a movable valve member disposed in said chamber, a movable armature carried by said housing, a solenoid coil carried by said housing and being adapted to move said armature to one position thereof, spring means carried by said housing and tending to maintain said armature in another position thereof, a movable plunger carried by said housing and interconnected to said armature by a lost motion member that provides a lost motion respectively with said armature and said plunger, said lost motion member and plunger and armature being so constructed and arranged that the lost motion between said lost motion member and said armature is taken up before the lost motion between said lost motion member and said plunger is taken up to cause movement of said plunger, and means interconnecting said plunger to said valve member to cause movement thereof upon movement of said plunger.

2. A valve means as set forth in claim 1 wherein said plunger and said armature are coaxially aligned.

3. A valve means as set forth in claim 1 wherein said last-named means comprises a pivotally mounted lever.

4. A valve means comprising a housing having a chamber therein, a movable valve member disposed in said chamber, a movable armature carried by said housing, a solenoid coil carried by said housing and being adapted to move said armature to one position thereof, a first spring means carried by said housing and tending to maintain said armature in another position thereof, a movable plunger carried by said housing and interconnected to said armature by a lost motion member that provides a lost motion respectively with said armature and said plunger, said lost motion member and plunger and armature being so constructed and arranged that the lost motion between said lost motion member and said armature is taken up before the lost motion between said lost motion member and said plunger is taken up to cause movement of said plunger, a second spring means carried by said housing and tending to hold said plunger from movement when said armature is first moved toward said one position thereof, and means interconnecting said plunger to said valve member to cause movement thereof upon movement of said plunger.

5. A valve means as set forth in claim 4 wherein said second spring is disposed between said armature and said plunger.

6. A valve means comprising a housing having a chamber therein, a movable valve member disposed in said chamber, a retainer disposed in said chamber and having a slot means passing therethrough, a lever disposed in said slots means and being pivotally interconnected to said retainer intermediate the ends of said lever, one end of said lever being operatively interconnected to said valve member, a movable armature carried by said housing, a solenoid coil carried by said housing and being adapted to move said armature to one position thereof, first spring means carried by said housing and tending to maintain said armature in another position thereof, a movable plunger carried by said housing and interconnected to said armature by a lost motion member that provides a lost motion respectively with said armature and said plunger, said lost motion member and plunger and armature being so constructed and arranged that the lost motion between said lost motion member and said armature is taken up before the lost motion between said lost motion member and said plunger is taken up to cause movement of said plunger, and second spring means carried by said housing and tending to hold said plunger from movement when said armature is first moved toward said one position thereof, said plunger being operatively interconnected to the other end of said lever.

7. A valve means comprising a housing having a chamber therein, a movable valve member disposed in said chamber, a movable armature carried by said housing, a solenoid coil carried by said housing and being adapted to move said armature to one position thereof, spring means carried by said housing and tending to maintain said armature in another position thereof, a movable plunger carried by said housing and interconnected to said armature by lost motion means, and means interconnecting said plunger to said valve member to cause movement thereof upon movement of said plunger, said lost motion means comprising a shaftlike member passing respectively through said armature and said plunger and having ember therein, a movable valve member disposed in said plunger.

8. A valve means comprising a housing having a chamber therein, a movable valve member disposed in said chamber, a movable armature carried by said housing, a solenoid coil carried by said housing and being adapted to move said armature to one position thereof, a first spring means carried by said housing and tending to maintain said armature in another position thereof, a movable plunger carried by said housing and interconnected to said armature by lost motion means, a second spring means carried by said housing and tending to hold said plunger from movement when said armature is first moved toward said one position thereof, and means interconnecting said plunger to said valve member to cause movement thereof upon movement of said plunger, said second spring means being disposed between said housing and said means interconnecting said plunger to said valve member.

9. A valve means comprising a housing having a chamber therein, a movable valve member disposed in said chamber, a retainer disposed in said chamber and having a slot means passing therethrough, a lever disposed in said slot means and being pivotally mounted to said retainer at a point intermediate the ends of said lever, one end of said lever being operatively interconnected to said valve member to move said valve member upon pivotal movement of said lever, means operatively interconnected to the other end of said lever to cause pivotal movement of said lever, and spring means disposed between said retainer and said valve member to urge said valve member into sealing engagement with said housing.

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