July 27, 1954 H. A. ALEXANDERSON 2,684,818

CONTROL DEVICE FOR INFLATABLE ICE ELIMINATING SYSTEMS

Filed Jan. 25, 1951

2 Sheets-Sheet 1

FIG. 1

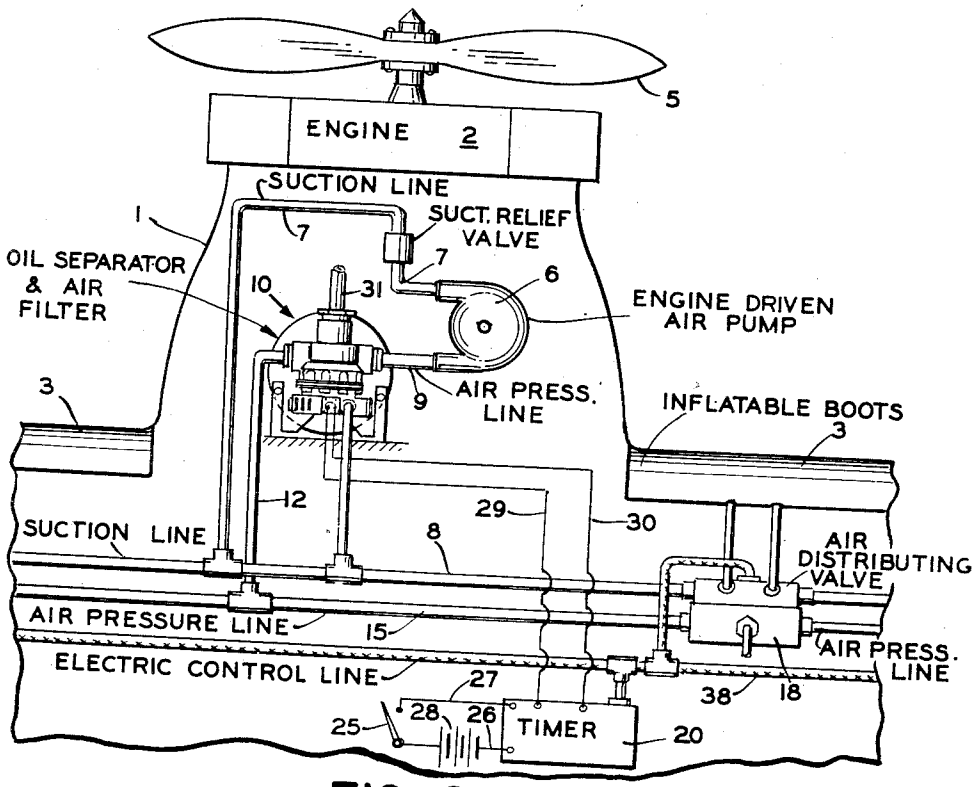
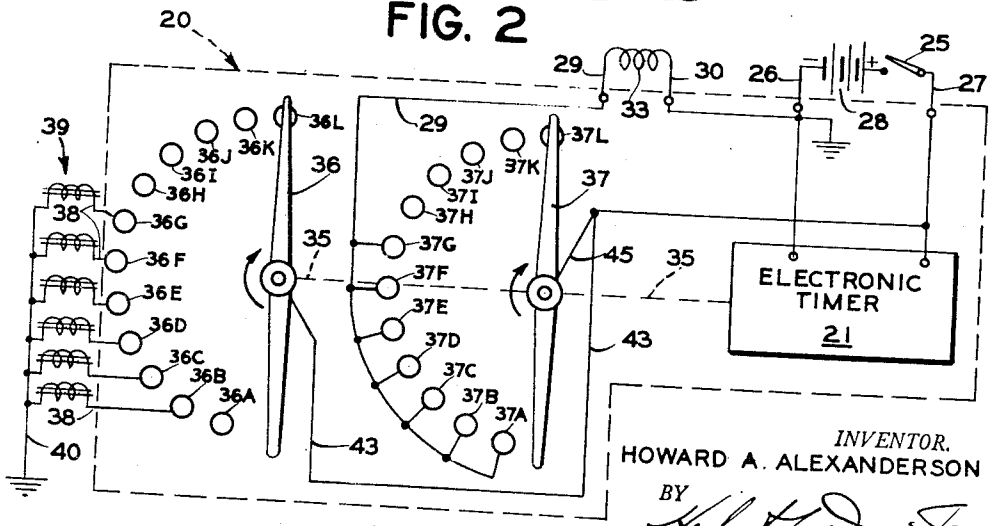


FIG. 2



INVENTOR.
HOWARD A. ALEXANDERSON
BY Hubert L. Davis Jr.
ATTORNEY

July 27, 1954 H. A. ALEXANDERSON 2,684,818

CONTROL DEVICE FOR INFLATABLE ICE ELIMINATING SYSTEMS

Filed Jan. 25, 1951

2 Sheets-Sheet 2

FIG. 3

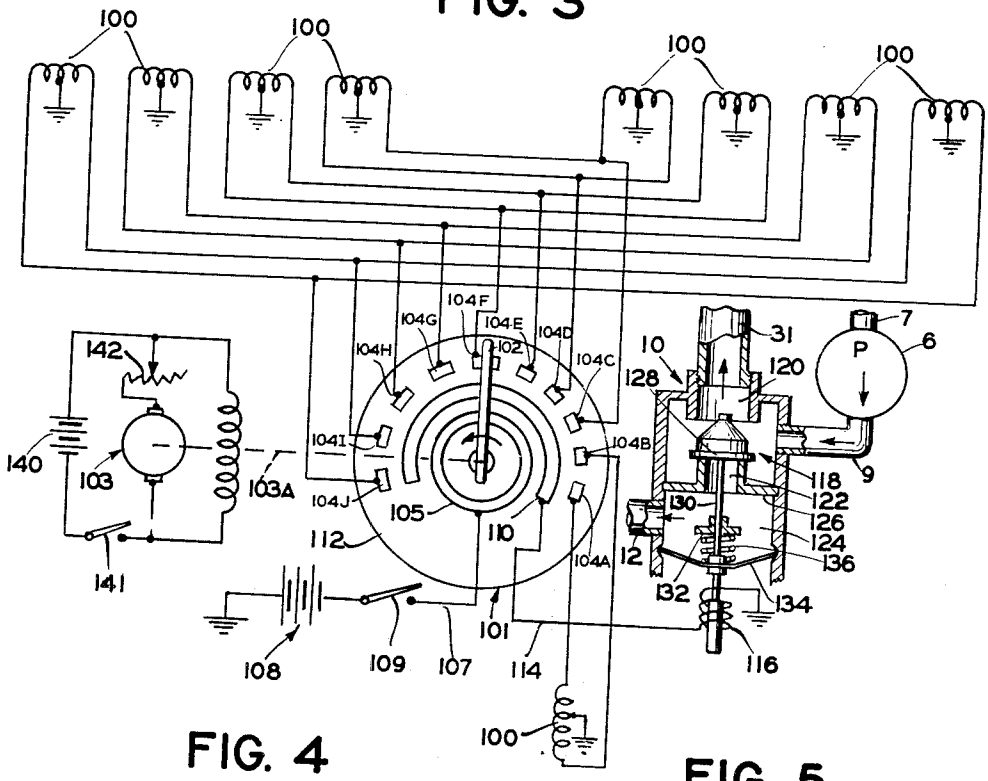


FIG. 4

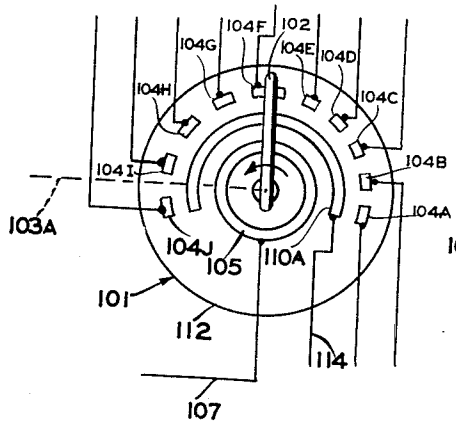
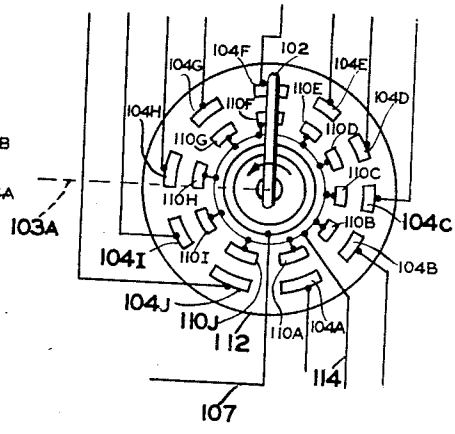


FIG. 5



INVENTOR.
HOWARD A. ALEXANDERSON
BY
ATTORNEY

Patented July 27, 1954

2,684,818

UNITED STATES PATENT OFFICE

2,684,818

CONTROL DEVICE FOR INFLATABLE ICE ELIMINATING SYSTEMS

Howard A. Alexanderson, Hohokus, N. J., assignor to Bendix Aviation Corporation, Teterboro, N. J., a corporation of Delaware

Application January 25, 1951, Serial No. 207,813

5 Claims. (Cl. 244—134)

1

The present invention relates to an inflatable ice eliminating system for aircraft and more particularly to improvements in such a system including control means for unloading a pressure pump in the system for predetermined periods during the cycle of operation of the system and at a time when the inflating pressure is not required for inflation of the several boot elements of the system.

In an inflatable ice eliminating system such as disclosed and claimed in the copending application Serial No. 733,960 filed March 11, 1947, by Donald M. Lawrence and in the Lawrence U. S. Patent No. 2,476,198 granted July 12, 1949, and assigned to Bendix Aviation Corporation, it has heretofore been the practice to operate the pump for supplying the operating pressure for the system under a combined suction and pressure load as shown therein. The suction which may range between 4 and 7 in. Hg is used for holding inflatable boots of the system down and also for instrument operation. Moreover, the air outlet pressure from the supply pump in such an ice eliminating system may range between 8 and 10 p. s. i. and is used for the inflation of the boots of the ice eliminating system.

It has heretofore been customary in the manifold or single main pressure conduit type system, as shown in the application Serial No. 733,960, to unload the pressure from the pump by operation of an unloading valve in a device combining an oil separator, pressure regulator, and unloading valve as disclosed and claimed in the application Serial No. 733,960. However, in the latter system of application Serial No. 733,960, and in the system disclosed in the Lawrence U. S. Patent No. 2,476,198, the pressure unloading occurs only when the inflatable ice eliminating system is turned off. However, during the actual cycle of operation of the inflatable ice eliminating system and so long as the system is in an energized and operating condition, the pump is forced to operate under combined suction and pressure loads.

However, in aircraft employing more recently developed high pressure inflatable ice eliminating elements or boots which operate at between 15 and 20 p. s. i., it has been found necessary to remove the suction load from the pump which is supplying pressure to the inflatable ice eliminating system. Also, in some of the lower 8 p. s. i. systems which require operation of the aircraft at high altitudes of, for example, above 20,000 feet; this is also necessary. This has necessitated then the use of separate suction pumps from the pressure pumps for holding down the inflatable ice eliminating boots and for instrument operation.

2

The main reason for requiring removal of the suction load from the pressure pump in a system of the type disclosed in application Serial No. 733,960 and in the Lawrence U. S. Patent No. 2,476,198 has been the high compression ratio which is encountered at high altitudes and under the high pressure conditions required for operation of the high pressure boots.

For example, a pump operating at sea level under 6 inches of Hg suction load and 15 p. s. i. pressure load operates at a compression ratio of approximately 2.52:1. However, at an altitude of 23,000 feet where the atmospheric pressure is 12.1 in. Hg under the same suction and pressure load the compression ratio is approximately 7:1. Continuous operation at a compression ratio of 7:1 or at even greater ratios at higher altitude involves difficulty to the pump due to the extremely high air temperatures effected by operation under such compression conditions which ultimately result in high internal pump temperature and possible failure. Thus, heretofore, it has been found necessary to provide separate suction and pressure pumps for such high pressure systems.

However, I have found that in such inflatable ice eliminating systems, the air under pump pressure during the cycle of operation may be actually utilized for only about half of the cycle of operation and that by unloading the pump during the period of the cycle of operation when the pressure is not actually needed such difficulties may be alleviated.

Thus, in the present invention, there is provided means whereby additional pump pressure is provided only when actually required by the ice eliminating system during the cycle of operation, while the pressure side of the pump is unloaded to atmosphere during that portion of the cycle of operation when the air pressure is not actually required for inflating the boot.

This arrangement then permits cooling of the pump despite the fact that during the high load portion of the cycle of operation of the inflatable ice eliminating system, the pump is discharging air at extremely high temperatures. Further, through such an arrangement, the average temperature at which such pump may operate is greatly decreased and the pump is conditioned to handle both the suction and pressure sides of the system. This results in elimination of a separate suction source with resulting simplification of the system.

An object of the invention, therefore, is to provide means whereby pump air outlet pressure may be directed into the inflatable ice eliminating system only during that period of the cycle of operation when such pressure is required for inflation of the boots of the system, while such pressure is discharged to atmosphere during that portion of the cycle of operation when the pressure is not actually required.

A further object of the invention is to provide means for providing a short period of pressurization of the main supply conduit of the system of say five seconds prior to the period when air pressure will be required for actual operation of inflatable boots and subsequently maintaining the air pressure in the supply conduit during that portion of the cycle of operation when such pressure is required for inflating the boots and then unloading the pressure from the pump to the atmosphere for the remainder of the cycle so as to permit cooling of the pump during that portion of the cycle of operation of the inflatable boots when the pressure is not actually required for inflation of the boots.

Another object of the invention is to provide control means for a fluid pump operating under high loads for unloading the pump for short periods of operation when the outlet pressure from the pump is not actually required so as to permit cooling of the pump and decrease in the average operating temperature of the pump.

Another object of the invention is to provide a control device for a combination pressure and suction pump of an inflatable ice eliminating system so arranged as to effect unloading of the pump during the cycle of operation of such a system for short periods when the pressure is not required for inflation of the boots of the system so as to permit cooling of the pump and decrease in the average working temperature of the pump so that the same may handle under high loads both the suction and pressure requirements of the system for operation of the boots.

Another object of the invention is to provide a novel unloading control means for the pressure pump of an inflatable ice eliminating system of the single main pressure conduit type to maintain the operating temperature of the pump within a safe range and including means for preventing escape of the pressure medium from the main pressure conduit while the pump is unloaded to atmosphere and control means for effecting the unloading of the pump during the normal cycle of operation of the inflatable elements of the system at such times as the elements are not being inflated.

The above and other objects and features of the invention will appear more fully hereinafter from a consideration of the following description taken in connection with the accompanying drawings wherein one embodiment of the invention is illustrated by way of example.

In the drawings,

Figure 1 is a fragmentary plan view of an aircraft showing diagrammatically the manner in which the novel control system is connected into the inflatable ice eliminating system.

Figure 2 is a schematic diagram illustrating the control system.

Figure 3 is a diagrammatic view illustrating a modified form of the invention.

Figure 4 is a diagrammatic view illustrating a rotary timer embodying another modified form of the invention.

Figure 5 is a diagrammatic view illustrating a rotary timer embodying a further modified form of the invention.

Referring to the drawing of Figure 1, there is shown an aircraft indicated by the numeral 1 having an engine 2 and inflatable elements or boots 3 mounted along the leading edge of the plane and of a type such as disclosed in the copending application Serial No. 733,960 filed March 11, 1947, by Donald M. Lawrence, U. S. Patent No. 2,476,198 granted July 12, 1949, to Donald M. Lawrence and in U. S. Patent No. 2,515,519 granted July 18, 1950, to Donald M. Lawrence et al. and all of which have been assigned to Bendix Aviation Corporation.

The engine 2 is arranged so as to drive an aircraft propellel 5. An air pump 6 is also driven in a conventional manner by the engine 2 and has provided a suction conduit 7 leading to the main suction line 8 through a suitable suction relief valve, as shown.

An air pressure line 9 leads from the pump 6 to the inlet of a pressure unloading valve or device indicated generally by the numeral 10 and which may be of the type disclosed and claimed in the aforementioned application Serial No. 733,960. The air passes through the device 10 and into the outlet conduit 12 upon energization of a control solenoid provided therein as explained in the application Serial No. 733,960. During the passage of the air through the device 10, any particles of oil which may enter the air from the pump 6 or other source, is separated and the air is filtered of dirt and other extraneous matter by an oil separator and air filter provided in the device 10 as disclosed and claimed in the U. S. application Serial No. 733,960. The air flow thus processed, is conducted through the conduit 12 to the air pressure line 15.

The suction and air pressure lines 9 and 15 lead to suitable air distributor valves 18 which are electrically controlled by a timer indicated generally by the numeral 20 so as to operate the inflatable boot elements 3. A plurality of such distributor valves are preferably provided of a type such as disclosed and claimed in the aforenoted U. S. Patent No. 2,515,519. The timer 20 includes as shown in Figure 2 an electronic timer which may be of the type disclosed and claimed in U. S. Patent No. 2,444,210 granted June 29, 1948, to John W. Lauricella and assigned to Bendix Aviation Corporation. The operation of the timer is described in detail in the U. S. Patent No. 2,444,210.

A manually operable switch 25 is arranged to control the operation of the timer 21, as will be readily apparent, through electrical conductors 26 and 27 leading from a source of electrical energy 28, while operation of the unloading valve mechanism of the device 10 is controlled by a solenoid dependent upon subsequent operation of the timer 21, as explained hereinafter.

In the control system of the application Serial No. 733,960, the closing of the switch 25 simultaneously closes both circuits 26—27 and 29—30 to effect operation of the timer 20, as well as cause the unloading valve of the device 10 to direct air under pressure through line 12 to the pressure line 15 so long as the timer 10 remained in operation. In the system disclosed in the latter application, when switch 25 was opened and operation of the inflatable ice eliminating system terminated the unloading valve of the device 10 would close the conduit 12 and direct the air flow from the conduit 9 to an overboard dump 31, as

explained in the application Serial No. 733,960.

In the present invention, the circuit 29—30 controls a corresponding unloading valve in the device 10 through a solenoid indicated diagrammatically in Figure 2 by the numeral 33. The unloading valve and solenoid 33 of the device 10 may be of the type disclosed and claimed in the application Serial No. 733,960 in which the unloading valve is arranged to close the passage 12 and open the passage 31 to the passage 9 upon deenergization of the solenoid 33, and close the passage 31 to passage 9 and open the passage 12 to the passage 9 upon energization of the solenoid 33.

As shown in Figure 2, the control circuit 29—30 is opened and closed during the cycle of operation of the inflatable ice eliminating system in timed relation with the period of inflation of the several boots of the system.

Thus, during the cycle of operation of the inflatable ice eliminating system the suction-pressure pump is unloaded to atmosphere during that part of the cycle of operation when pressure is not required for inflation of the boots of the system so as to permit cooling of the pump and operation of the pump under high load conditions.

Referring to Figure 2, there is shown a shaft 35 indicated by dotted lines for driving switch arms 36 and 37 from a stepper relay mechanism. The stepper relay mechanism is not shown herein, but is provided in the Electronic Timer mechanism 21 and may be of a type such as disclosed and claimed in the U. S. Patent No. 2,444,210.

The switch arms 36 and 37 are each arranged to contact in succession a series of contacts 36A–L and 37A–L. The switch arms 36 and 37 move in a clockwise direction from one contact to the next succeeding contact in a step by step action imparted through shaft 35 by the stepper relay of the Electronic Timer 21 and upon one end of the switch arms 36 and 37 moving out of contacting relation with the contact L the opposite end closes the contact A.

As explained in the U. S. Patent No. 2,444,210, upon cessation of operation of the timer 21 the stepper relay will return the switch arms 36 and 37 to the starting or L position and will continue to adjust the switch arms 36 and 37 in the step by step action until operation is terminated.

The switch contacts 36B–36G are connected respectively through suitable electrical conductors 38 to one terminal of corresponding control solenoids 39.

The opposite terminals of the solenoids 39 are connected by an electrical conductor 40 to the negative terminal of the source of electrical energy 28 through a grounded connection.

The control solenoids 39 serve upon energization to open respective boot inflating valves in the air distributing valves 18 as disclosed and claimed in Lawrence et al. U. S. Patent No. 2,515,519.

The switch arm 36 is connected by a conductor 43 through the control switch 25 to the positive terminal of the source of electrical energy 28. The contacts 36A and 36H–36L are open contacts so that upon the switch arm 36 contacting the same the circuit to all of the control solenoids 39 are open and operation of the inflatable boot elements is not affected during the periods that these contacts are closed by the switch arm 36 and during the cycle of operation of the inflatable ice eliminating system.

The switch arm 37 is connected by a conductor 45 through the switch 25 to the positive terminal of the source of electrical energy 28 and is arranged to sequentially close contacts 37A–37G which contacts are connected through the conductor 29 to the control solenoid 33 of the unloading valve of device 10. The opposite terminal of the control solenoid 33 is connected through conductor 30 to the negative terminal of the source of electrical energy 28. The contacts 37H–L corresponding in position to the contacts 36H–L are open contacts. Thus, when the switch arm 37 closes one of the contacts H–L the control solenoid 33 is deenergized and the pressure from the pump 6 is directed by the unloading valve 10 to atmosphere through the exhaust conduit 31 rather than through the pressure conduit 12. However, upon the switch arm 37 closing one of the contacts 37A–G, the solenoid 33 controlling the unloading valve 10 is energized causing the unloading valve 10 to connect the pump 6 directly to the pressure conduit 12 and closing the connection of the pump 6 to atmosphere through the conduit 31.

The electronic timer 21 as explained in the U. S. Patent No. 2,444,210 controls through adjustment of shaft 35 the period of time that the switch arm 36 rests on the contacts 36A–L as well as the period of time that the switch arm 37 rests on the contacts 37A–L. Thus, the electronic timer 21 controls through the distributor valves 18 the periods of inflation of a series of solenoid controlled inflatable elements or boots 3 for preventing the accumulation of ice on or the removal of ice from airfoil surface of the aircraft as well as controlling in timed relation therewith the period of energization of the solenoid controlled unloading valve 10.

It will be seen then that in the operation of the improved control system forming the subject matter of invention herein that as the switch arm 37 closes contact 37A and thus affects the energization of the unloading valve control solenoid 33 so as to direct the pressure of air from the pump 6 into the pressure conduit 12 a switch arm 36 will simultaneously close the open contact 36A. The arms 36 and 37 will rest on the respective contacts 36A and 37A for a short period of time determined by the electronic timer 21 of for example five seconds, sufficient to assure full inflating pressure in the line 15 before the closing of contact 36B by the switch arm 36 for effecting the inflation of the first boot 3 of the ice eliminating system. The control solenoid 33 of the unloading valve 10 is kept energized by the successive closing of contacts 37B–G by the switch arm 37 during the successive inflation of all of the several boot elements controlled by the switch contacts 36B–G. However, upon the switch arm 36 moving from contact 36G to contact 36H and the switch arm 37 moving from the contact 37G to contact 37H the control solenoid 33 will be deenergized causing the unloading valve 10 to connect the pressure outlet 9 of the pump 6 to atmosphere through the conduit 31 while closing the passage 12 so that the pump 6 will now operate without the pressure load during each of the time periods of closure of the contacts 36H–L and 37H–L by the switch arms 36 and 37, respectively. During the latter period of the cycle of operation of the inflatable ice eliminating boots the pump 6 serves only as a suction pump, while during the periods when the switch arm 37 closes the contacts 37A–G the pump 6 serves the dual function of a suction and pressure pump for the ice eliminating system.

However, by permitting the pump 6 to unload to atmosphere during a portion of the cycle of operation of the inflatable ice eliminating system the average working temperature of the pump 6 is greatly decreased and the pump 6 is enabled to handle both the suction and pressure sides of the system during the cycle of operation.

Modified form of Figure 3

In Figure 3, there is shown diagrammatically a modified form of electrical timer for operating suitable control solenoids or electromagnets 100 of the pressure distributing valve 18 of Figure 1 and which valves may be of the type disclosed and claimed in the Lawrence et al. U. S. Patent No. 2,515,519 granted July 18, 1950 and assigned to Bendix Aviation Corporation. Corresponding numerals are used in Figure 3 to indicate like parts to those previously shown and described with reference to Figure 1.

As shown in Figure 3, a control circuit is provided for the electromagnets 100 which circuit includes a timer indicated by the numeral 101. The timer 101 is of the rotary type, such as disclosed and claimed in the Lawrence et al. U. S. Patent No. 2,515,519 and comprises a rotary arm 102 driven by an electric motor 103 through a shaft 103A so as to open and close in sequence control contacts indicated by the numeral 104A–J to selectively control the energization of electromagnets 100.

The control contacts 104A–J, as shown in Figure 3, vary in size so that the period of energization of each of the said electromagnets 100 will be in proportion to the time interval required to properly inflate the respective inflatable elements or boots controlled thereby, which time interval may be based upon the proportionate capacity of the respective elements. The inflatable elements are indicated generally in Figure 1 by the numeral 3.

The rotary arm 102 also moves in contacting relation along a conductor ring 105, which electrically connects the arm 102, through an electrical conductor 107, to one terminal of a suitable source of electrical energy 108. A switch 109 is arranged to open and close the circuit to the source of electrical energy 108. The opposite terminal of the source of electrical energy 108 is grounded as shown in Figure 3.

Thus, upon the switch 109 being closed, the arm 102 on contacting one of the contacts 104A–J will close a circuit to the electromagnet 100 controlled thereby, causing a flow of electrical energy to pass through the switch 109, conduit 107, ring 105, arm 102, the contact 104A–J closed thereby through the electromagnet 100 connected to the closed circuit, and returning through the grounded connection of the electromagnet 100, as shown, to the grounded opposite terminal of the source of electrical energy 108.

Thus, the closing of any one of the contacts 104A–J will cause the energization of the corresponding electromagnet 100 connected to the closed circuit for effecting the operation of the distributor valve 18 controlled thereby, as described in the Lawrence et al. U. S. Patent No. 2,515,519.

The rotary arm 102 is further arranged to open and close an additional segmental conductor ring contact 110 which is mounted as shown in Figure 3 together with the conductor ring 105 and contacts 104 on a base plate 112 formed of a suitable electrical insulating material. The motor 103 is arranged to drive the rotary arm 102 in a counter-clockwise direction and the contact 110 is so arranged in relation to the contacts 104A–J that the arm 102 first closes the contact 110 before closing the contact 104A.

The contacts 104A–J are arranged in spaced relation on the base plate 112 so that as the arm 102 passes from one contact 104A–J to the next succeeding contact the arm 102 rests for a relatively short interval of time out of a contacting relation with any of the contacts 104A–J.

However, in the form of the invention illustrated in Figure 3, the rotary arm 102 continues to close the contact 110 after the initial closing thereof until the rotary arm 102 has been driven by the motor 103 to a position opening contact 104J at which position the arm 102 simultaneously opens both contact 104J and the contact 110 after which the rotary switch arm 102 remains in circuit open relation to the contacts 104A–J and 110 until the rotary arm 102 is driven by the motor 103 so as to once again close contact 110.

The contact 110 is connected by a conductor 114 to one end of an electromagnetic winding or solenoid 116 which is connected at its opposite end to a grounded conductor. The electromagnetic winding 116 controls operation of a pressure unloading valve mechanism indicated generally by the numeral 10 and which may be of the type disclosed and claimed in the aforementioned U. S. Patent No. 2,476,198 or of the type disclosed and claimed in application Serial No. 733,960 filed March 11, 1947, and assigned to Bendix Aviation Corporation or may be of the type shown diagrammatically in Figure 3.

The pressure unloading valve mechanism 10, as indicated diagrammatically in Figure 3, includes a chamber 118 into which opens the pressure conduit 9 leading from the air pump 6. A discharge passage 120 opens from the chamber 118 into the discharge conduit 31 opening to atmosphere, while an oppositely disposed passage 122 opens from the chamber 118 into a second chamber 124 formed in the mechanism 10. The chamber 118 is separated from the chamber 124 by a partition 126. As shown in Figure 3, the conduit 12 leads from the chamber 124 and to the main pressure conduit 15 as shown in Figure 1.

Controlling the opening of the passages 120 and 122 from the chamber 118 is a valve 128 which cooperates with the open end of the passages 120 and 122 so as to open one while closing the other and thereby permit the passage of air under pressure from the pump either to the atmosphere through the passage 120 or to the main air pressure conduit 15 through the passage 122, chamber 124 and conduit 12. A stem 130 controlling the valve 128 is slidably mounted in the passage 122 by a bracket 132. Stem 130 is affixed to a flexible diaphragm member 134 and is normally biased by spring 136 so as to close the passage 122 while opening passage 120. The electromagnet 116, as shown diagrammatically in Figure 3, directly controls the valve stem 130 so that upon energization of the electromagnet 116 the valve 128 is biased in opposition to the spring 136 to close passage 120 and open passage 122 and thereby direct air from the pump 6 to the pressure conduit 12 through the chamber 124. Upon deenergization of the electromagnet 116 the valve 128 is biased by the spring 136 so as to close the passage 122 preventing the air pressure in line 15 from leaking to atmosphere through the device 10, while per-

mitting the pump 6 to unload to atmosphere as heretofore explained.

While the valve mechanism 10 is preferably of the form disclosed and claimed in the Lawrence application Serial No. 733,960 in which there is provided a control solenoid to operate the valve 128 through a pressure servo mechanism and means providing a pressure regulating action of the valve 128 in addition to the control action heretofore explained, the invention herein disclosed and claimed is not limited thereto and may include a pressure unloading valve mechanism of the type such as shown in the Lawrence U. S. Patent No. 2,476,198 granted July 12, 1949, or a pressure unloading valve mechanism of a type in which the valve mechanism is arranged to alternately unload the pressure side of the pump to atmosphere or connect the pressure side of the pump to the main air pressure line for providing a suitable supply of air under pressure for operating the several inflatable elements or boots of an ice eliminating system as heretofore described with reference to Figure 3.

As further shown in Figure 3, the rotary arm 102 of the timer 101 is driven by the shunt motor 103 energized by a suitable source of electrical energy indicated by the numeral 140, such as an aircraft motor driven generator, battery, or other suitable means. A switch 141 is provided for controlling the motor circuit.

There is further connected in the motor circuit a variable resistance 142 whereby the speed of rotation of the motor may be varied as described in the Lawrence et al. U. S. Patent No. 2,515,519. It will be seen that by varying the speed of rotation of the motor 103 the period of inflation of each inflatable ice eliminating element or boot may be proportionately increased or decreased with the variance of the speed of the motor. Thus, as explained in the U. S. Patent No. 2,515,519, there is provided convenient means whereby the period of inflation of the inflatable ice eliminating elements may be varied so as to compensate for changes in icing conditions. Thus, under relative hard ice conditions the motor 103 may be driven at a relatively slow rate of speed so as to increase the inflation period, while under slushy or soft ice conditions the more rapid inflation and deflation of the inflatable elements may be effected by increasing the speed of the motor 103 through adjustment of the variable resistance 142. The more efficient ice removal may thereby be effected.

It will be seen then that in the operation of the modified form of invention shown in Figure 3 that as the rotary switch arm 102 closes contact 110 and thus effects energization of the unloading valve control electromagnet 116 so as to direct the pressure of air from the pump 6 into the pressure conduit 12, the inflating pressure in the conduit 12 will be conditioned for the subsequent closing of the contact 104A so as to assure sufficient pressure for inflating the boot controlled thereby. The rotary switch arm 102 may rest on the contact 110 for a short interval of, for example, five seconds prior to the closing of contact 104A and sufficient to assure full inflating pressure in the line 15 before the closing of the contact 104A by the switch arm 102 for effecting inflation of the first boot 3 of the ice eliminating system. The control electromagnet 116 of the unloading valve 10 is completely energized by the closure of the contact 110 by the switch arm 102 during the successive closing of contacts 104A–J by the switch arm 102 and during the successive inflation of all of the several boot elements 3 controlled by the switch contacts 104A–J.

However, upon the rotary switch arm 102 moving from contact 104J the switch arm 102 simultaneously opens the contact 110 causing deenergization of the control solenoid 116 of the unloading valve 10 so that the valve element 128 of the unloading valve 10 will now connect the pressure outlet 9 of the pump 6 to atmosphere through the conduit 31, while closing the passage 122 so that the inflating pressure in line 15 may not escape and the pump 6 may now operate without the pressure load during the period of time when the rotary arm 102 is driven by the motor 23 between the open ends of the contact 110. During the latter period of the cycle of operation of the inflatable ice eliminating boots the pump 6 serves only as a suction pump while during the period when the rotary switch arm 102 closes the contact 110, the pump 6 serves the dual function of a suction and pressure pump for the ice eliminating system.

However, by permitting the pump 6 to unload to atmosphere during a portion of the cycle of operation of the inflatable ice eliminating system, the average working temperature of the pump 6 is greatly decreased and the pump 6 is enabled to handle both the suction and pressure side of the system during the cycle of operation.

Modified form of Figure 4

While in the form of the invention shown in Figures 1 and 3, there is provided means for connecting the pump 6 to the pressure line for a short period of five seconds prior to inflation of any of the inflatable elements 3 so as to assure that full inflating pressure is provided in the pressure line 12, it will be seen that this safety provision may be disregarded provided that the pressure unloading valve 128 of the mechanism 10 sufficiently closes the conduit 12 to atmosphere to prevent escape of the inflating pressure in the main pressure line 15 during the period of time that the pressure conduit 9 of the pump 6 is unloaded to atmosphere.

In the latter event the safety provision of providing a short period of pre-inflating pressure be eliminated and the timer 101 may well take the form shown in Figure 4 in which the contact 110A may be simultaneously closed with the first control contact 104A. Operation of the timer in the form of invention shown in Figure 4 is otherwise the same as that heretofore described with reference to the invention shown in Figure 3 and like numerals on Figure 4 indicate corresponding parts to those heretofore described with reference to the form of invention shown in Figure 3.

Modified form of Figure 5

A further form of the invention is shown by Figure 5, in which successive contacts 110A–110J are opened and closed by the rotary arm 102 simultaneously with the opening and closing of contacts 104A to 104J. In the latter arrangement, the pump 6 may be connected to the main pressure line 15 for a period of time proportionate to the inflating period so as to assure maintenance of the pressure in line 15 to the desired value for operating the several inflating boots at such times as any one of the contacts 104A–104J are closed, while at such other times as the arm 102 moves off of the contacts 104A to 104J and contacts 110A to 110J deenergization

of the electromagnet or solenoid 116 will cause valve 128 to unload the pump 6 to atmosphere while closing the passage 122 so as to prevent escape of the inflating pressure in the line 15.

By thus permitting the pump 6 to unload to atmosphere during a portion of the cycle of operation of the inflatable ice eliminating system the average working temperature of the pump 6 may be decreased and the pump enabled to handle both the suction and pressure requirements of the system during the cycle of operation.

It will be seen from the foregoing that the present invention provides novel means for controlling the unloading of a pressure pump of an inflatable ice eliminating system of the manifold or single main pressure conduit type disclosed in the Lawrence et al. U. S. Patent No. 2,515,519 and includes valve means for preventing the escape of back pressure from the main pressure conduit while the pump is unloaded to atmosphere, together with novel control means for such valve means for effecting the unloading of the pressure pump to atmosphere during the normal cycle of operation of the inflatable elements of the system at timed intervals and at such times as the elements are not inflating. The invention may be applied to such an inflatable ice eliminating system to provide control means for periodically unloading the pressure pump to atmosphere for cooling the pump and maintaining the average working temperature of the pump within a safe range under high pressure operating conditions and may be applied to such a system in which the pressure pump provides a source of suction, as well as to such a system in which a separate source of suction or negative pressure is provided for completely deflating the several ice eliminating elements of the system.

Although only several embodiments of the invention have been illustrated and described various changes of the form and relative arrangements of the parts may be made to suit requirements.

What is claimed is:

1. For use in a system for the removal of ice from an aircraft having a plurality of inflatable units, a pump to supply a pressure medium for inflating said units, a plurality of distributor valves for controlling the pressure medium from said pump to inflate and deflate said units, and an independently operable valve for unloading the pressure medium from said pump to atmosphere; the combination comprising means for controlling operation of said distributor valves, a timing device operatively connected to said control means in such a manner as to cause operation of said distributor valves so as to selectively inflate and deflate said units and to maintain all of said units in a deflated condition for a predetermined interval of time, means for controlling operation of said unloading valve, means operatively connecting the timing device to said last-mentioned control means to cause operation of said unloading valve in relation to the operation of said distributor valves so as to prevent the unloading valve from unloading the pressure medium from the pump during the inflation of the inflatable units and effect the unloading of said pump for at least a part of the predetermined interval of time during which all of the units are maintained in said deflated condition.

2. For use in a system for the removal of ice from an aircraft having a plurality of inflatable units, a pump to supply a pressure medium for inflating said units, a plurality of distributor valves for controlling the pressure medium from said pump to inflate and deflate said units, and an independently operable valve for unloading the pressure medium from said pump to atmosphere; the combination comprising a plurality of electrical contacts for selectively controlling operation of the distributor mechanisms and electrical contact means for controlling operation of the unloading valve, switch arm means for selectively cooperating with said contacts and electrical contact means, a motor, said switch arm means being adjustably positioned relative to said electrical contacts and contact means by said motor, said plurality of contacts being opened and closed by said switch arm means to effect selective operation of the distributor mechanisms in such a manner as to selectively inflate and deflate said units and to maintain all of said units in a deflated condition for a predetermined interval of time, and said contact means being opened and closed by said switch arm means to effect selective operation of the unloading valve relative to the operation of said distributor mechanisms so as to prevent said unloading valve from unloading the pressure medium from the pump during the inflation of the inflatable units and effect the unloading of said pump for at least a part of the predetermined interval of time during which all of the units are maintained in said deflated condition.

3. For use in a system for the removal of ice from an aircraft having a plurality of inflatable units, a pump to supply a pressure medium for inflating said units, a plurality of distributor valves for controlling the pressure medium from said pump to inflate and deflate said units, and an independently operable valve for unloading the pressure medium from said pump to atmosphere; the combination comprising a first set of electrical contacts for selectively controlling operation of the distributor mechanisms and a second set of electrical contacts for controlling operation of the unloading valve, switch arm means for selectively cooperating with said first and second sets of contacts, a motor, said switch arm means being adjustably positioned relative to said contacts by said motor, said first set of contacts being opened and closed by said switch arm means to effect selective operation of the distributor mechanisms in such a manner as to selectively inflate and deflate said units and to maintain all of said units in a deflated condition for a predetermined interval of time, and said second set of contacts being simultaneously opened and closed by the switch arm means with the contacts of the first set so as to prevent said unloading valve from unloading the pressure medium from the pump during the inflation of the inflatable units and effect the unloading of said pump for at least a part of the predetermined interval of time during which all of the units are maintained in said deflated condition.

4. For use in a system for the removal of ice from an aircraft having a plurality of inflatable units, a pump to supply a pressure medium for inflating said units, a plurality of distributor valves for controlling the pressure medium from said pump to inflate and deflate said units, and an independently operable valve for unloading the pressure medium from said pump to atmosphere; the combination comprising an electrical contact means including a plurality of contacts for selectively controlling operation of the distributor mechanisms and an additional contact

for controlling the unloading valve, switch arm means for selectively cooperating with said contacts, a motor, said switch arm means and said contacts being adjustably positioned relative one to the other by said motor, said plurality of contacts of said contact means being opened and closed by said switch arm means to effect selective operation of the distributor mechanisms in such a manner as to sequentially inflate and deflate said units and to maintain all of said units in a deflated condition for a predetermined interval of time, and said additional contact being closed by the switch arm means immediately prior to the closing of the first of the contacts controlling the distributor mechanisms so as to prevent the unloading valve from unloading the pressure medium from the pump during the inflation of any one of the inflatable units and to assure that full inflating pressure is provided during the sequential inflation of the inflatable units.

5. For use in a system for the removal of ice from an aircraft having a plurality of inflatable units, a pump to supply a pressure medium for inflating said units, a plurality of distributor valves for controlling the pressure medium from said pump to inflate and deflate said units, and an independently operable valve for unloading the pressure medium from said pump to atmosphere; the combination comprising an electrical contact means including a plurality of contacts for selectively controlling operation of the distributor mechanisms and an additional contact for controlling the unloading valve, switch arm means for selectively cooperating with said contacts, a motor, said switch arm means and said contacts being adjustably positioned relative one to the other by said motor, said plurality of contacts of said contact means being opened and closed by said switch arm means to effect selective operation of the distributor mechanisms in such a manner as to sequentially inflate and deflate said units and to maintain all of said units in a deflated condition for a predetermined interval of time, and said additional contact being closed by the switch arm means simultaneously with the closing of the first of the contacts controlling the distributor mechanisms so as to prevent the unloading valve from unloading the pressure medium from the pump during the inflation of any one of the inflatable units and to assure that full inflating pressure is provided during the sequential inflation of the inflatable units, and said additional contact being simultaneously opened by the switch arm means with the opening of the last of the plurality of contacts controlling the distributor mechanisms so as to permit the unloading valve to unload the pump to atmosphere upon termination of the period of sequential operation of the inflatable units.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,444,208	Taylor et al.	June 28, 1948
2,444,210	Lauricella	June 29, 1948
2,476,198	Lawrence	July 12, 1949
2,515,519	Lawrence et al.	July 18, 1950