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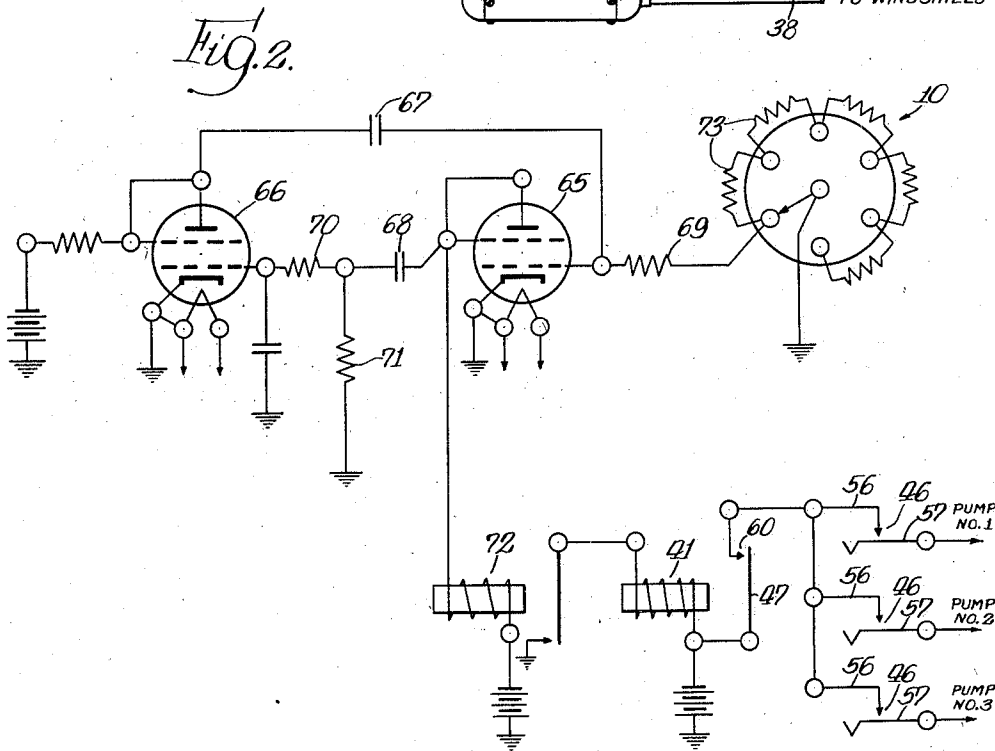
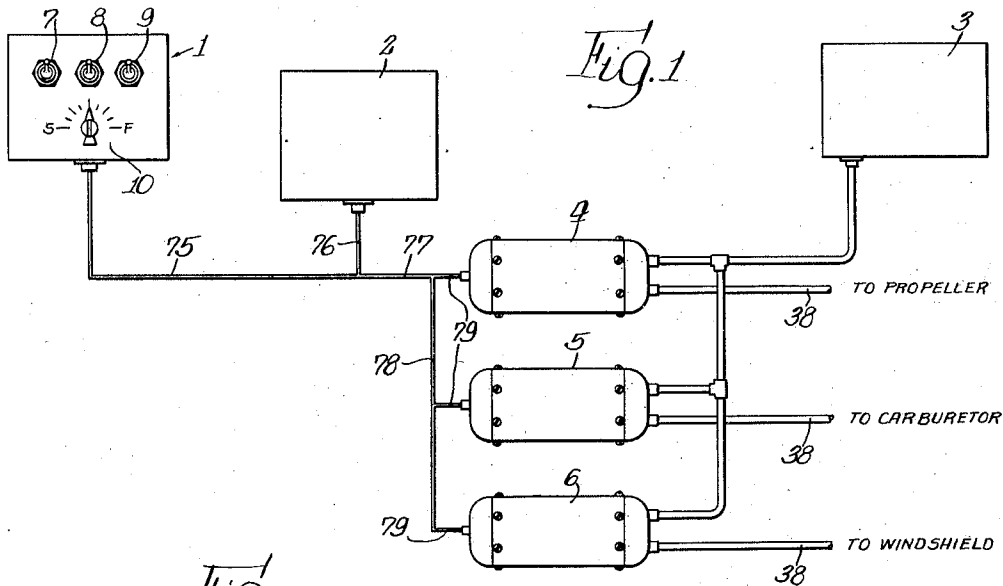
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2,435,003

SYSTEM OF DEICING FOR AIRCRAFT, VESSELS, ETC.

Filed Dec. 6, 1943

2 Sheets-Sheet 1



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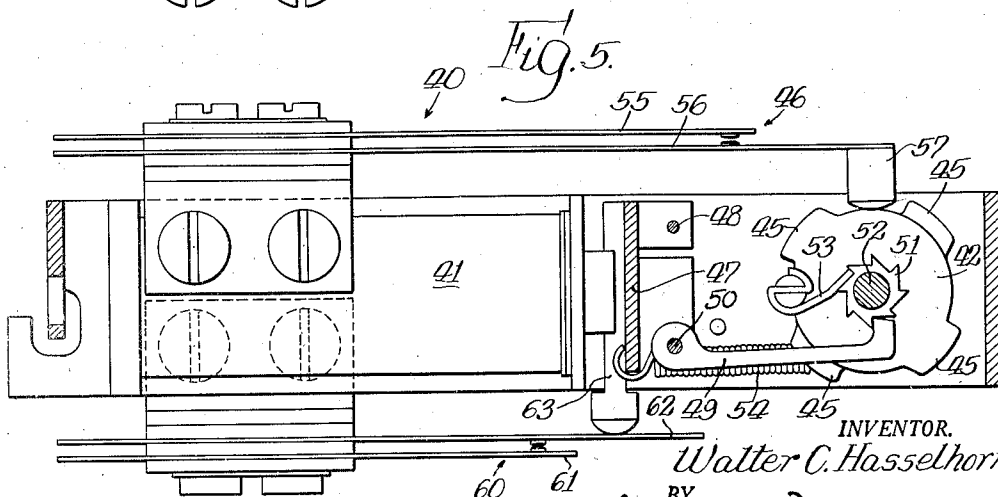
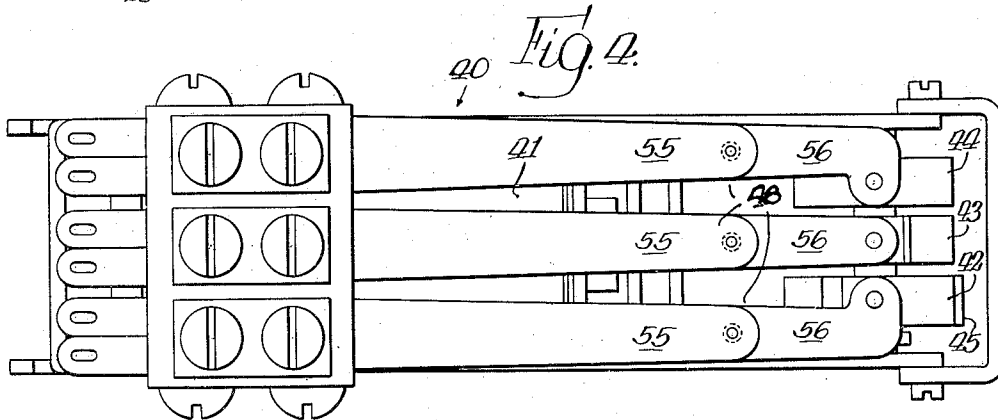
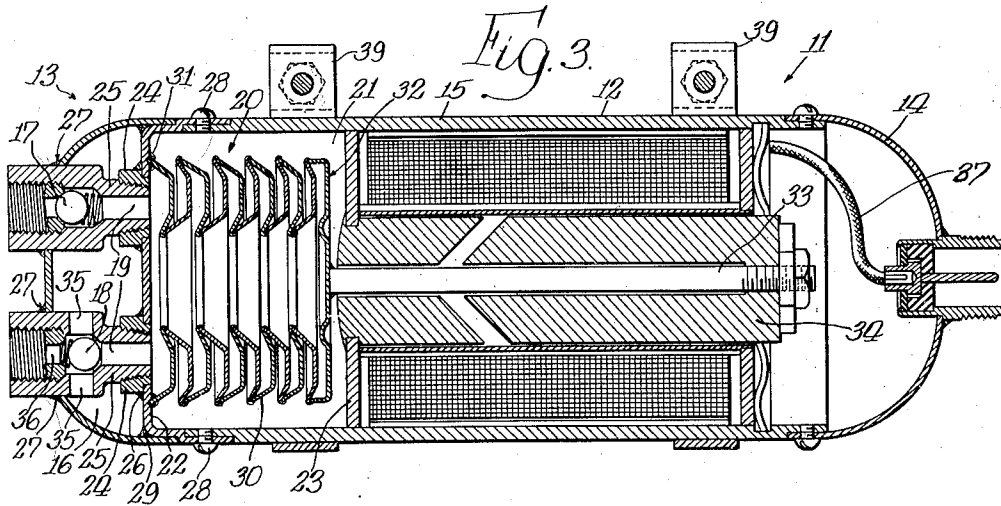
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UNITED STATES PATENT OFFICE

2,435,003

SYSTEM OF DEICING FOR AIRCRAFT,
VESSELS, ETC.Walter C. Hasselhorn, Chicago, Ill., assignor to
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ration of Illinois

Application December 6, 1943, Serial No. 512,999

18 Claims. (Cl. 244—134)

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This invention relates to de-icing systems adapted particularly to the delivery of a de-icing solution to various locations on aircraft, vessels or wherever the prevention of ice or frost formation is desirable.

An object of the invention is to provide a de-icing system embodying certain novel features both in construction and operation that provides new and useful results in a device of this type. Among other things may be mentioned the low power consumption and the efficient operation of the system to maintain a steady supply of a de-icing solution to one or more locations and to measure the fluid so supplied. Although the broad concept of the invention is not limited in application to the kind of power used, in its narrower aspects the invention novelly provides an electric control circuit for the pumping units employed. The pumping units may also be electrically operated when desired and the current impulses of the control circuit used to control the operation of the pumping units. A further novel feature of the invention resides in the actuator employed. This actuator may be designed to operate the pumping units intermittently, which effects energization of the various units but de-energizes each unit before energizing the next unit. A power cut-off is operated by the actuator so that the feed is limited to the stroke of each pump. In this manner, the over-heating of the pumping units and an unnecessary drain on the battery are prevented.

More specifically, this novel type of control circuit embodies certain control characteristics particularly adapting the circuit to the control of this system disclosed. These control characteristics include controlling the duration and frequency of the current impulses produced by the circuit so that the actuator may be made to operate a pumping unit for each current impulse, the pumping unit remaining operated only for the period of the impulses and the time interval between these impulses controlling the interval between operations of these pumping units. Thus, a selector device that can readily be adjusted to vary the time interval between current impulses, may be used to control the rate of supply of each pumping unit. Although it is not necessary, the period or duration of each current impulse may be limited so that a relay operating the actuator can remain energized only long enough to allow each pumping unit as it operates to make a full stroke.

Other objects and advantages of the invention will be apparent from the following description when taken in connection with the accompanying drawings, which form a part hereof:

In the drawings:

Figure 1 is a diagrammatic layout of a de-icing system embodying the invention;

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Fig. 2 is a wiring diagram of the same;
Fig. 3 is a longitudinal sectional view of one of the pumping units.

Fig. 4 is a top view of the actuator; and

Fig. 5 is a side view of the actuator.

Referring to the drawings, the de-icing system herein disclosed includes a control panel 1, which may be located in the operator's compartment, an electronic timer 2, a source of de-icing solution 3 and a series of pumping units 4, 5 and 6 discharging their output to a number of locations, which, if an airplane, may comprise the propellers, carburetors, windshields, wings, etc. It will be understood at the outset that the number of pumping units may vary and that more than one pumping unit may be used to supply a single location. These pumping units as well as the electronic timer equipment and solution supply may be located in any convenient place and not necessarily in the operator's compartment. This is decidedly advantageous in the case of aircraft because it does not burden the pilots cabin with additional controls.

Control panel 1 includes a number of switches 7, 8 and 9 adapted to be inserted in the respective circuits of pumping units 4, 5 and 6 for selectively cutting in or out any one of these pumping units. In this way, it is not necessary to supply the de-icing solution to all the locations when the system is operating. Control panel 1 also includes a selector switch 10 which will be more fully described hereinafter. It functions to control the frequency of the current impulses of a control circuit so as to predetermine the number of strokes per minute of the pumping units.

The construction of the pumping units is shown in Fig. 3. The motor for each unit may comprise a solenoid 11 suitably mounted within housing 12 having end sections 13 and 14 and an intermediate section 15. Intermediate section 15 encases solenoid 11, while end section 13 comprises a pressure dome having a pressure chamber 16 and inlet and outlet valves 17 and 18. A piston 20 is disposed in a chamber 21 separated from pressure chamber 16 by a partition 22 and from the solenoid 11 by a partition 23. Nipples 24 in which the valve bodies 25 are threadedly disposed are carried in partition 22 and are sealed at 26 to prevent the leakage of the de-icing solution from the pressure chamber 16 at this point about each nipple. Valve bodies 25 extend through the casing of the pressure dome and are likewise sealed at 27 to prevent leakage from pressure chamber 16. Partition 22 is attached by screws 28 to housing 12 while the dome housing is attached to this partition by a sealing connection 29 that prevents leakage at this point.

Piston 20 of each pumping unit may comprise a spring bellows 30 which will return to normal

position after it is compressed. One end of bellows 30 may be sealed at 31 to partition 22. Passages 19 of the inlet and outlet valves 17 and 18 open into the interior of bellows 30. The opposite end of bellows 30 is closed by an end section 32, which may be connected to a piston rod 33 attached at its outer end to core 34 of solenoid 11. When the solenoid is energized, this core 34 is drawn inwardly to compress bellows piston 30 and force the de-icing solution within the chamber of this piston through the passage 19 of the outlet valve body 25 into the pressure chamber 16. During this time, inlet valve 17 is closed by being seated as shown in Fig. 3, and outlet valve 18 is held in the position shown to allow the fluid to flow through side passages 35 into pressure chamber 16 and also through outlet passage 36. The timer control 2 to be hereinafter described in detail is designed to limit the flow of current through the circuit of solenoid 11 to the working stroke of core 34 so that when it reaches the end of this stroke, the solenoid will be de-energized and the spring resiliency of the bellows 30 will return the bellows to its expanded position to draw on another charge of fluid into the piston chamber, and also to return the core 34 to its original position. Current may be fed to the winding of solenoid 11 by wire 37 and return by a grounded connection, if so desired.

Pressure chamber 16 may be allowed to retain a small amount of air therein so that a steady stream of fluid may be fed through outlet passage 36 to connection 38 of the pump leading to the location where the fluid is to be supplied to prevent frost or ice formation and to remove the same if it has already accumulated. The design of the pumping unit is simple and inexpensive. The unit is small, and hence, it occupies very little space. It can be readily replaced by releasing two supporting brackets 39 and disconnecting two nipple joints at the inlet and outlet connections. Consequently, if one of the units should become disabled, it can readily be replaced, even in flight. The compactness of the parts and the smallness in size permit spares to be carried in the tool kit for the purpose of permitting such ready replacement.

Actuator 40 for controlling the current flow to these solenoids 11 of the pumping units is shown in Figs. 4 and 5. It comprises a sequence relay 41 and a plurality of cams 42, 43 and 44; one for each pumping unit. Each cam is provided with one or more risers 45 adapted to close operating switches 46 connected in the respective circuits of the pumping units. Armature 47 of sequence relay 41 is preferably pivoted at 48 and it carries a spring pawl 49 at 50. A toothed sprocket 51, fixed to cam shaft 52 so as to cause shaft 52 to rotate with the rotation of the sprocket, is arranged to turn in clockwise direction only. Opposite rotation is prevented by a detent spring 53. As armature 47 is attracted upon energization of the coil of relay 41, pawl 49 is moved to the left to turn sprocket 51 and consequently the shaft 52. When this coil is de-energized, spring 54 will return armature 47 to its original position, thereby moving pawl 49 forwardly again to engage the next tooth of sprocket 51.

It will be noted that each operating switch 46 of the pumping units comprises two contact springs 55 and 56, the lower contact spring 56 being provided with a button 57. As the relay 41 is energized and the pawl 49 is actuated to turn shaft 52, the riser 45 of one of the cams 42; 43 or

44 will engage and lift one of the buttons 57 to close the contacts of the contact springs 55 and 56 of one of the operating switches 46 and thereby close the particular circuit of the pumping unit to be operated. To effect this operation after the operating switch 46 is closed, a power switch 60 is also closed but only for the period current is supplied to sequence relay 41.

This power switch 60 comprises two contact springs 61 and 62 suitably supported upon the frame structure of relay 41 as are the operating switches 46. A lever 63 secured to armature 47 and movable therewith is adapted to press contact spring 62 into circuit closing position with contact spring 61. The power circuit is thereby closed and power is supplied to the operating switch 46 that may be closed at the time. This power switch 60 may be connected in multiple with the operating switches 46 so that closing of any one of the latter and closing the power switch 60 will supply current to the circuit of the pumping unit in which the closed operating switch is connected. In this connection, it will be noted that power switch 60 will be opened as soon as the current flow through the coil of relay 41 ceases. This is accomplished by the movement of armature 47 by means of spring 54 to its original position and the consequent movement of lever 63 to a position breaking the circuit closing relation between the contact springs 61 and 62.

The time control circuit heretofore designated as the electronic timer 2 is illustrated in Fig. 2. It may comprise two vacuum tubes 65 and 66, condensers 67 and 68, resistances 69, 70 and 71, a control relay 72 and a selector resistor 73 also termed a selector switch 10. The vacuum tube circuit is so arranged that when the control circuit is closed, condenser 67 starts to draw a charging current. This current passes through resistance 69, and the selector resistor 73 biases tube 65, which prevents current from passing therethrough. When condenser 67 has become nearly charged so that its charging current no longer maintains a voltage above cut-off, tube 65 begins to pass current and condenser 67 discharges. This operates control relay 72 and at the same time charges condenser 68.

The charging current for condenser 68 in passing through resistance 71 biases tube 66 and prevents it from passing current. As condenser 68 approaches a full charge, the current drops to a point where it no longer produces sufficient voltage to prevent the passage of current through tube 66. When this value is reached, the current passing through tube 66 discharges condenser 68 and charges condenser 67, thus starting the cycle once again.

By changing the resistance in series with condenser 67 by means of the selector resistor 73, which may be manually operated, the time required to charge this condenser 67 is varied. Since this time represents the off time or the time between strokes of the pumping units, the number of strokes per minute can be controlled by changing this resistance. Resistance 71 controls the time that control relay 72 remains operated and may be so chosen as to capacity that control relay 72 remains energized just long enough to allow the cores 34 of solenoids 11 to make a full stroke.

It is apparent from Fig. 2 that control relay 72 may be advantageously used to operate sequence relay 41. Sequence relay 41 may be in the power circuit of the pumping units as illustrated, but

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it will be understood that a different arrangement of the parts may be provided as long as the same result is obtained. The control relay 72 is in the timer control circuit and the period the current flows through its coil will be controlled by resistance 71, and, as disclosed in the preferred embodiment of the invention illustrated herein, this resistance 71 is selected so that it will permit the current to flow through the coil of the control relay 72 long enough for the pumping units to effect a forward working stroke. It will be observed that resistance 71 may be changed to vary this period of current flow so that pumping units of different strokes or capacities may be readily used or replaced for those in service if a change should be desirable.

It is also possible to vary the period between the impulses of the control circuit by changing the time required to charge condenser 67. As previously explained, this is accomplished by manually operating the selector switch 10 so as to vary the resistance placed in the circuit by this switch. Switch 10 may be disposed upon panel 1, and therefore, it, as well as switches 7, 8 and 9, may be made readily accessible to the pilot by placing panel 1 in the cabin. Also, any number of pumping units may be used by use of switches 7, 8 and 9, and the number of strokes each shall make per minute can be controlled from this panel 1.

Actuator 40 functions to effect intermittent actuation of the pumping units 4, 5 and 6 although it is readily apparent that more than one unit may operate at one time by having risers 45 on cams 42, 43 and 44 differently disposed. Cam 42 is shown as provided with two risers 45 so as to effect two strokes of the pumping unit, which it controls, during each cycle of operation. The arrangement of the cam risers can obviously be changed even to the extent of having one of the pumping units in continuous operation, while the others may operate less frequently. Using power switch 60 does not require actuation of the sequence relay 41 to de-energize a pump circuit. The operating switch 46 of the particular pump circuit energized will remain closed and not open until the next operation of the relay 40. This pump circuit will be broken however by the opening of this power switch 60 as soon as the current ceases to flow through the relay coil on each operation. The flow of current is thus accurately controlled and is made to correspond to the period of the current impulses produced by the control circuit.

From the foregoing description, it will readily be observed that a novel system of supplying a de-icing solution to one or more locations has been disclosed and that it incorporates certain novel features producing exceptional useful results in this field.

An advantage obviously resides in the fact that only one pumping unit is made to work at a time so that the source of power will not be taxed beyond the demand of a single pumping unit at any one time. This is important in the use of a de-icing system when applied to moving vehicles and particularly to airplanes, which are limited in the equipment weight that they may carry and should not carry more batteries than may be necessary. Moreover, the parts may be compactly arranged and simply assembled as a complete accessory for mounting. For example, the wiring comprising ten in number may be neatly encased in a small conduit 75 leading from panel 1 to the electronic timer control 2, this conduit 75 joining a conduit

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76 containing 13 wires and continuing as conduit 77 to join conduit 78 which connects with branch conduit 79 connecting with the individual pumping units 4, 5 and 6.

The arrangement permits any pumping unit to be cut out and the timer control is designed to permit a change in the energizing impulse for effecting operation of the pumping units by minimum effort through the change of a single resistance in order to permit change of the size of the pump motor to be used. If the stroke of the motor is to be increased to increase the stroke of the pump piston, resistance 71 may be accordingly changed. On the other hand, simple manipulation of resistor switch 10 on panel 1 will change the number of strokes per minute of the pumping units in operation. Various other features will be apparent.

Without further elaboration, the foregoing will so fully explain the gist of my invention that others may, by applying current knowledge, readily adapt the same for use under varying conditions of service, without eliminating certain features, which may properly be said to constitute the essential items of novelty involved, which items are intended to be defined and secured to me by the following claims.

I claim:

1. A de-icing system for aircraft, vessels, or the like, comprising a plurality of pumps adapted to be intermittently operated, mechanism for operating said pumps, said mechanism comprising an electrically operated actuator having means for de-energizing one pump before energizing the next pump, an electric timing circuit for said actuator, said circuit including means for controlling the period of current impulses for said actuator and means for controlling the period between said current impulses.

2. A de-icing system for aircraft, vessels, or the like, comprising a plurality of pumps adapted to be intermittently operated, mechanism for operating said pumps, said mechanism comprising an electrically operated actuator having means for de-energizing one pump before energizing the next pump, an electric timing circuit for said actuator, said circuit including means for predetermining the duration of current impulses effecting operation of said actuator.

3. A de-icing system for aircraft, vessels, or the like, comprising a plurality of pumps adapted to be intermittently operated, mechanism for operating said pumps, said mechanism comprising an electrically operated actuator having means for de-energizing one pump before energizing the next pump, an electric timing circuit for said actuator, said circuit including means for predetermining the frequency of current impulses effecting operation of said actuator.

4. A de-icing system for aircraft, vessels, or the like, comprising a plurality of pumps adapted to be intermittently operated, mechanism for operating said pumps, said mechanism comprising an electrically operated actuator for said pumps, an electric timing circuit for said actuator, said circuit including a control relay for operating said actuator and means for controlling current impulses energizing said control relay.

5. A de-icing system for aircraft, vessels, or the like, comprising a plurality of pumps, mechanism for operating said pumps, said mechanism comprising an electrically operated actuator for said pumps, an electric timing circuit for said actuator, said circuit including a resistance control for determining the frequency of operation of

each pump, and means for selectively cutting out one or more pumps without disabling the operation of the other pumps.

6. A de-icing system for aircraft, vessels, or the like, comprising a pressure chamber for receiving and holding a de-icing solution under pressure, pumping means for supplying said solution to said chamber, mechanism for operating said pumping means, said mechanism comprising an electrically operated actuator, an electronic timing circuit, said circuit including a thermionic device with a control grid supplying current impulses adapted to effect operation of said actuator, and means in said circuit for predetermining the duration of each current impulse.

7. A de-icing system for aircraft, vessels, or the like, comprising a fluid supply chamber, pumping means for supplying a de-icing solution to said supply chamber, mechanism for operating said pumping means, said mechanism comprising an electrically operated actuator, an electronic timing circuit, said circuit including a thermionic device with a control grid supplying current impulses adapted to effect operation of said actuator, and means in said circuit for predetermining the period between said current impulses.

8. A de-icing system for aircraft, vessels, or the like, comprising a plurality of electrically operated pumps, switch means for closing the respective circuits of said pumps when energized, an actuator for selectively operating said switch means to effect intermittent operation of said pumps, a relay for operating said actuator, and a timing circuit to energize said relay.

9. A de-icing system for aircraft, vessels, or the like, comprising a plurality of electrically operated pumps, an operating switch for each pump, an actuator for selectively closing said switches to effect intermittent operation of said pumps, a switch for controlling the power to each operating switch, said actuator having means to predetermine the period of closing of said power switch to limit the flow of current to the pump energized.

10. A de-icing system for aircraft, vessels, or the like, comprising a plurality of electrically operated pumps, an operating switch for each pump, a cam unit for selectively closing said operating switches to intermittently operate said pumps, an actuator for said cam unit, and a switch for controlling the power to each operating switch, and means to limit the flow of current through said operating switches and to said pumps irrespective of the action of said cam unit to open said operating switches.

11. A de-icing system for aircraft, vessels, or the like, comprising a plurality of electrically operated pumps, a pump relay assembly including an operating switch for each pump and a switch for controlling the power to each operating switch, an actuator for closing said switches, and means to limit the period of closing of said power control switch.

12. A de-icing system for aircraft, vessels, or the like, comprising a plurality of electrically operated pumps, a pump relay including an operating switch for each pump and a switch for controlling the power to each operating switch, an actuator for closing said switches, means to limit the period of closing of said power control switch, and means to control the frequency of said periods of closing of said power control switch.

13. A de-icing system for aircraft, vessels, or the like, comprising a plurality of electrically op-

erated pumps, a pump relay including an operating switch for each pump and a switch for controlling the power to each operating switch, an actuator for closing said switches, means to limit the period of closing of said power control switch, means to control the frequency of said periods of closing of said power control switch, and means to selectively cut out any one of said pumps without disrupting the operation of the remaining pumps.

14. A de-icing system for aircraft, vessels, or the like, comprising a plurality of pumps adapted to be intermittently operated, mechanism for operating said pumps, said mechanism comprising an actuator having means for de-energizing one pump before energizing the next pump, and a timing control for determining the period of operation of each pump and the time interval between each period of operation.

15. A de-icing system for aircraft, vessels, or the like, comprising a plurality of pumps adapted to be intermittently operated, motor means to actuate said pumps, an actuator for said motor means, and control mechanism for energizing said motor means to actuate first one pump and then another pump, said control mechanism including a timing control for determining the period of actuation of each pump and the frequency of said periods.

16. A de-icing system for aircraft, vessels, or the like, comprising a plurality of pumps adapted to be intermittently operated, an electric motor for each pump, an electrically operated actuator for energizing one motor before energizing the next motor, and an electric circuit for energizing said actuator, there being means to predetermine the period of operation of said actuator and the frequency of the same.

17. A de-icing system for aircraft, vessels, or the like, comprising a plurality of pumps adapted to be intermittently operated, an electric motor for each pump, a sequence relay for opening and closing the circuits of said motors, and an electric timing circuit including actuating means therein for said sequence relay and means for energizing said actuating means by current impulses of predetermined frequency and duration.

18. A de-icing system for aircraft, vessels, or the like, comprising pumping means for supplying a de-icing solution, motor means for operating said pumping means, an actuator for said motor means, a control relay for operating said actuator, and an electronic timing circuit for supplying current impulses to said control relay, said circuit including means to predetermine the frequency and duration of said current impulses.

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