April 5, 1949. R. G. HOOF 2,466,238

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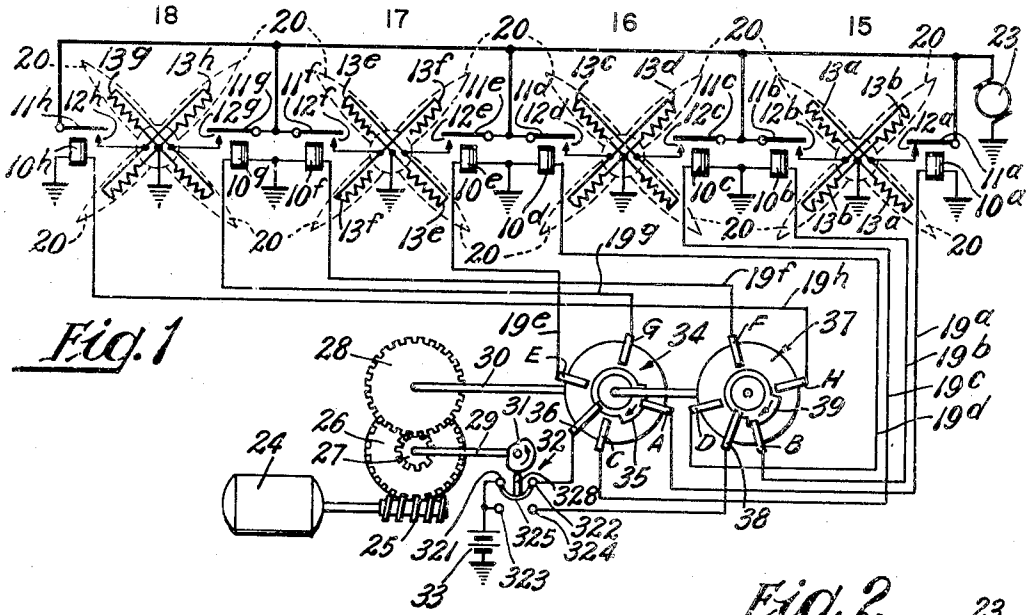


Fig. 1

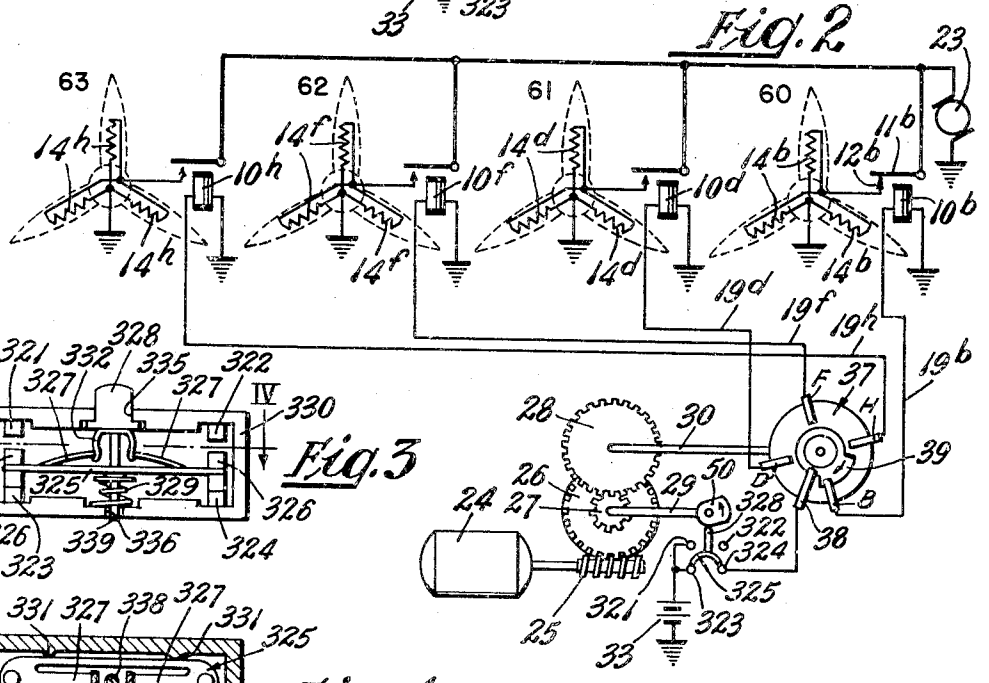


Fig. 2

Fig. 3

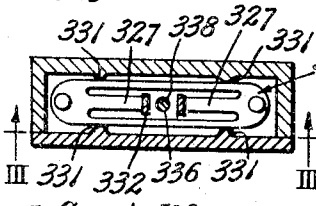


Fig. 4

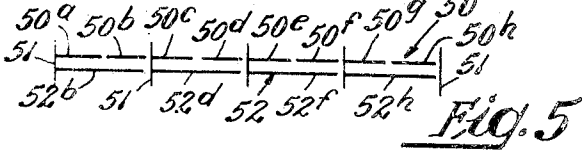


Fig. 5

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1 Claim. (Cl. 171—97)

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This invention relates to electrical switching systems for successively connecting a source of current to a plurality of circuits, and will be described as applied to the electrical deicing of airplane propellers.

An object of the invention is to provide a current distributor that is simple, reliable and remains in accurately timed condition indefinitely so that there is negligible pause and no overlap between the breaking of the current flow to one circuit and instigation of the current flow to the next circuit.

Other more specific objects and features of the invention will appear from the detailed description to follow of certain embodiments thereof.

In the deicing of airplane propellers by electric heating elements built therein, it is more effective to apply a heavy current for a short time than a lighter current for a proportionately longer time. However, the total current capacity available on an airplane is usually insufficient to supply a heavy current to all the propellers simultaneously, or in some instances even to all the blades of a single propeller simultaneously. It has therefore been customary to employ some form of motor-driven switch for successively switching all the heating current to different propellers or propeller blades. In the case of an airplane having four, 4-blade propellers, in which the current is concentrated in one pair of opposite blades of one propeller at a time, distribution must be made to eight different circuits.

Heretofore, the distributors used have either been of the commutator type or of the cam-actuated-contact type, both of which have serious disadvantages. The commutator type does not require adjustment, but is expensive and short-lived because of arcing. The cam-actuated-contact type is long-lived, but is undesirable because of the difficulty of making and maintaining the adjustment of the contacts so that they make and break at the right instants.

The present invention eliminates the mentioned defects of the prior systems by employing a combination of commutator type switches and cam-actuated switches. In accordance with the invention, the commutator type switches successively prepare paths to the different heating circuits in overlapping relation, and the circuits are completed by cam actuation of a double throw switch, which simultaneously breaks one of the paths created by the commutator switch and completes the other path. When the cam-actuated, double throw switch is next actuated, the commutator-type switch will have prepared a new

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circuit to be completed thereby. Because of the fact that the commutator type switches merely prepare the paths to the heating circuits, and do not break the current, the switches can be of relatively inexpensive construction, thereby materially reducing their cost.

In the drawing:

Fig. 1 is a schematic diagram showing a switching system in accordance with the invention for distributing heating current to four 4-blade propellers;

Fig. 2 is a schematic diagram showing an application of the invention to the distribution of heating current to four 3-blade propellers;

Fig. 3 is a sectional view illustrating one type of switch unit that can be employed in practising the invention, the view being taken in the plane III—III of Fig. 4;

Fig. 4 is a section taken in the plane IV—IV of Fig. 3; and

Fig. 5 is a graph illustrating the operation of the systems of Figs. 1 and 2.

Referring first to Fig. 1, there are shown four propellers 15, 16, 17, and 18, each having four blades 20. Each of the blades 20 contains an electrical heating element 13 for deicing the blade.

One terminal of each heating element 13 is connected to ground. The other terminals of each pair of heating elements in each pair of opposite blades 20 of the propeller are connected together and to a common relay contact. Thus the two heating elements 13*a* in one pair of opposite blades 20 of the propeller 15 are connected to a relay contact 12*a*, and the heating elements 13*b* in the other pair of opposite blades 20 are connected to a relay contact 12*b*. Considering propeller 16, one pair of heating elements 13*c* are connected to a relay contact 12*c*, and the other pair 13*d* are connected to a relay contact 12*d*. The various pairs of heating elements of propellers 17 and 18 are similarly connected to relay contacts 12*e*, 12*f*, 12*g*, and 12*h*, respectively.

Each of the contacts 12 constitutes, together with an armature 11, parts of a relay 10. All of the armatures 11*a* to 11*h*, inclusive, are connected to one terminal of a source 23 of heating current. The other terminal of the source 23 is grounded, so that closure of any armature 11 on its contact 12 completes a circuit to one pair of heating elements 13*a* or 13*b*, et cetera.

The relays 10*a* to 10*h*, inclusive, are adapted to be successively energized by a switching system in accordance with the invention. This system includes a pair of wafer switches 34 and 37, each having a segment 35 in the case of switch

34, and 39 in the case of switch 37, which segment is constantly connected to a contact 36 or 38 and is adapted to successively make with each of four fixed contacts. In the case of switch 37 these four fixed contacts are identified with the reference numerals B, D, F, and H, respectively, and in the case of switch 34 by the reference numerals A, C, E, and G, respectively. The segments 35 and 39 are connected to a common shaft 30 so that they move in synchronism with each other. The segments 35 and 39 are so oriented with respect to each other and their fixed contacts that each makes with a new fixed contact before the other breaks from its associated fixed contact. Thus in the position in which the switches are shown in Fig. 1, the segment 35 is shown closed on the contact A and the segment 39 is shown closed on the contact B. Segment 35 will leave contact A and close on contact C before segment 39 leaves contact B. Each of the fixed contacts A to H inclusive of the switches 34 and 37 is connected directly to one terminal of the relay 10 bearing the corresponding suffix letter, the other terminal of the relay being grounded. The segments 35 and 39 are constantly connected through the contacts 36 and 38 respectively, with contacts 322 and 324 of a cam-actuated switch 32. This switch has a leaf spring 325 which is adapted to either connect the contact 322 with a contact 321 or connect the contact 324 with a contact 323. The contacts 321 and 323 are connected to one terminal of a current source 33, the other terminal of which is grounded, so that although the two wafer switches 34 and 37 may simultaneously complete circuits from the switch 32 to more than one of the relays 10*a* to 10*h*, inclusive, the switch 32 functions to energize only one of those relays at a time.

The switch 32 is of the snap-action type disclosed in Figs. 3 and 4. It comprises a casing 330 having the four fixed contacts 321, 322, 323, and 324 anchored in opposite walls of the casing, and two movable contacts 326, 326 on opposite ends of the leaf spring 325. The spring 325 floats in the casing, being guided by ribs 331 on the front and rear walls of the casing. The spring 325 has slots cut therein to form two tongues 327 which extend inwardly toward each other from opposite ends of the spring into engagement with a U shaped clip 332 on the plunger 328, the latter being guided by an opening 335 in the front wall of the casing 330 through which it projects. The plunger 328 also has a stem 336 which extends through a central recess 338 in the spring 325 and through an opening 339 in the rear wall of the casing 330.

When the plunger 328 is unrestrained by any external force, as shown in Fig. 3, the tongues 327 are bowed upwardly, holding the contacts 326, 326 against the stationary contacts 323 and 324, respectively, and closing a circuit therebetween. When the plunger 328 is pressed inwardly, the ends of the tongues 327 are bent downwardly until they pass the mid-point of the spring 325, whereupon they snap into a reverse bowed position in which the contacts 326, 326 are snapped away from the stationary contacts 323 and 324, and into contact with the stationary contacts 321 and 322. When the plunger 328 is released, a helical compression spring 329 forces the stem 336 and the plunger 328 into the normal position shown in Fig. 3.

Referring back to Fig. 1, the plunger 328 of the switch 32 is actuated by a cam 31 on a shaft 29 which is geared to the shaft 30. Thus the shaft 30 has a large spur gear 28 meshing with a smaller spur gear 27 on the shaft 29. To drive the entire switching mechanism, a worm wheel 26 is also provided on the shaft 29 which meshes with a worm 25 on the shaft of the driving motor 24.

The speed of rotation of the shaft 29 depends upon the length of time that the heating current is to be applied to each pair of opposite heating elements 13, 13 of the propellers and can be regulated by properly choosing the speed of the motor 24 and the speed reduction produced by the worm 25 and the worm wheel 26. However, the ratio of the speed of the shaft 30 to the shaft 29 is one to four, and the cam 31 is so shaped that it reverses the switch 32 at the end of each half revolution.

The phasing of the cam 31 with respect to the segments 35 and 39 is such that the switch 32 is reversed before one segment breaks from one of its associated four fixed contacts, but after the other segment has made with a new one of its four fixed contacts.

Thus as shown in Fig. 1, current flows from the source 33 through the upper contacts 321 and 322 of the switch 32, through the contact 36 and the segment 35 to the fixed contact A, and thence over a conductor 19*a* to the relay 10*a*, energizing the latter to close its armature 11*a* on its contact 12*a* and energize the heating elements 13*a*, 13*a* of propeller 15. The circuit is shown in position just before the cam 31 reverses the switch 32. It will be observed that although segment 35 is still contacting the fixed contact A, it is just about to leave it. Furthermore, the segment 39 has just made contact with the fixed contact B. Therefore, at the instant the switch 32 reverses, it cuts current off the relay 10*a* and almost simultaneously applies it over the contacts 323 and 324 of switch 32, the contact 38, segment 39, and contact B of switch 37, and over a lead 19*b* to the relay 10*b*, energizing the latter to close its armature 11*b* on its contact 12*b* and energize the heating elements 13*b*, 13*b* of propeller 15.

It is important to note that the relative timing of the breaking of the circuit to relay 10*a*, and the making of the circuit to relay 10*b* is determined by the switch 32 and not by the wafer switches 34 and 37. In practice, snap action switches, such as the switch 32, switch so rapidly from one pair of contacts to the other that the interruption in current flow is extremely short, thereby permitting maximum use of the available heating current, without danger of overloading the current source by simultaneously energizing two of the relays 10.

The switching action described repeats itself to successively close the circuit from the source 33 to the relays 10*c*, 10*d*, 10*e*, 10*f*, 10*g*, and 10*h*. Thus when the segment 39 is just about to leave the fixed contact B, the segment 35 will have left the contact A and closed on the contact C, so that the next reversal of the switch 32 back into the position shown in Fig. 1 will apply current over the fixed contact C and the lead 19*c* to the relay 10*c*.

The timing of the energizations of the different relays 10*a* to 10*h* inclusive is illustrated by the upper line 50 of Fig. 5, in which the period of energization of each of the relays is indicated by one of the segments 50*a* to 50*h* inclusive. The line 50 is divided into four equal parts by the vertical lines 51, the distance between successive

vertical lines **51** representing the time required for one quarter revolution of the shaft **30** and one revolution of the shaft **29**. It will be noted that the cam **31** reverses the switch **32** at the end of each half revolution, thereby applying current successively to the eight different relays **10***a* to **10***h* during each complete cycle (represented by one complete revolution of the shaft **30**).

The lines **50***a*, **50***b*, et cetera, are of equal length because the cam **31** is shaped to actuate the switch **32** at 180° intervals. Obviously, if unequal heating periods in successive circuits is desired, the cam **31** would be shaped to successively actuate the switch at angular intervals that are unequal, but the sum of which is 360°.

With four-blade propellers it is feasible to energize the heating elements in only half the blades at a time because the two blades of each pair are diametrically opposite and are in balanced relation. It is not desirable to de-ice one blade without simultaneously de-icing the opposite blade, because of vibration resulting from unbalance. Therefore where three-blade propellers are involved, it is the usual practice to apply the heating current to the heating elements in all three blades simultaneously. Hence on an airplane having four 3-blade propellers, the switching system must successively concentrate all of the heating current in all the blades of successive propellers. This requires a switch having a four position cycle instead of an eight position cycle. Thus heating current would be applied to each circuit for 25% of the cycle instead of 12½% as in the case with the timer shown in Fig. 1. If current is required for a shorter portion of the cycle it is still desirable to make certain that heating current is applied to each propeller for equal periods of time. This requirement can be met with only the one wafer switch **37** instead of the two wafer switches **34** and **37** as described in connection with Fig. 1.

Thus, in Fig. 2 the four fixed contacts B, D, F, and H of switch **37** are connected by the leads **19***b*, **19***d*, **19***f*, and **19***h* to four relays **10***b*, **10***d*, **10***f*, and **10***h*, each of which functions when energized to close an armature **11** on a contact **12** and connect the source **23** simultaneously to all three heating elements **14** of the associated propeller **60**, **61**, **62**, or **63** as the case may be.

As in the system of Fig. 1, the segment **39** is of such arcuate length that it breaks from one of the contacts B, D, F, or H before it makes with the next one. Since the switch **34** of Fig. 1 is omitted in the system of Fig. 2, the contacts **321** and **322** of the switch **32** perform no function and could be omitted. It is only when the switch **32** is in position to interconnect its contacts **323** and **324** that current flows from the source **33**.

In the operation of the system shown in Fig. 2 the switch **32** is in the position shown, in which its contacts **323** and **324** are interconnected, shortly after the segment **39** has contacted one of the fixed contacts B, D, F, or H. As in the system of Fig. 1, the switch **32** serves to make and break the circuit, thereby relieving the segment **39** of this function and preventing arcing and burning.

Referring to Fig. 5, the interrupted line **52** shows the time during which circuits are completed over the four contacts B, D, F, and H, respectively. It will be observed that each circuit is completed an equal portion of a quarter cycle.

The shape of cam **50** determines the length of time current is applied to each propeller circuit. With the cam shown, the circuit from contact **38** through segment **39** to contact B is made for approximately 75% of each revolution of shaft **29**. At the time cam **50** operates switch **32** to break the circuit between contacts **323** and **324**, segment **39** is about to leave contact B. Segment **39** leaves contact D during the portion of the cycle that cam **50** has opened the circuit between contacts **323** and **324**, thus preventing any arcing on the wafer switch.

Although for the purpose of explaining the invention, a particular embodiment thereof has been shown and described, obvious modifications will occur to a person skilled in the art, and I do not desire to be limited to the exact details shown and described.

I claim:

A distributor of the type described for successively applying a continuous potential from a common source to a plurality of circiuts in predetermined sequence comprising: first and second switches, each having a master terminal and a plurality of branch terminals and having means for successively switching its master terminal from one branch terminal to another, successive branch terminals of each switch being connected to alternate circuits in said sequence; means driving said first and second switches in synchronism with each other and in such phase relation that their respective master terminals are alternately switched to different branch terminals; a double-throw snap-action switch and means for reversing it between its two positions in timed relation with said first and second switches, said double-throw switch continuously connecting said source to the master terminal of said first switch in one position and to the master terminal of said second switch in the other position; each of said first and second switches connecting its master terminal to each branch terminal for an interval of time exceeding the interval between successive reversals of said double-throw switch and being so phased with respect to the double-throw switch that it maintains its master terminal connected to a single branch terminal throughout the interval between successive reversals of said double-throw switch from one position to the other, whereby said source is progressively connected to successive ones of said circuits in said sequence, said double-throw switch, by virtue of its snap action, reversing at a speed independent of the speed of said driving means, and substantially instantaneously, whereby interruption of current flow from said source to said said circuits is minimized.

ROBERT G. HOOF.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,445,066	Brocke	Feb. 13, 1923
1,856,561	Keil	May 3, 1932
2,018,159	Walker et al.	Oct. 22, 1935
2,278,481	Peters et al.	Apr. 7, 1942