Oct. 22, 1940. F. A. HUBBARD 2,218,711

ELECTRICAL SWITCHING DEVICE

Filed Dec. 30, 1938

FIG. 1

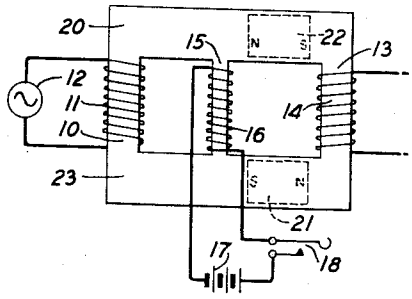


FIG. 2

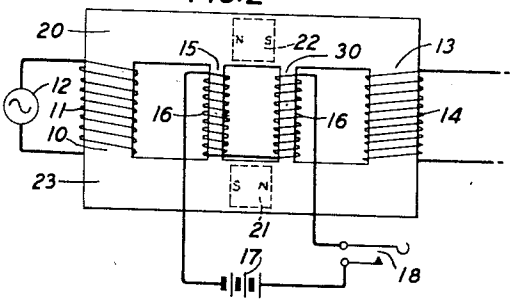


FIG. 3

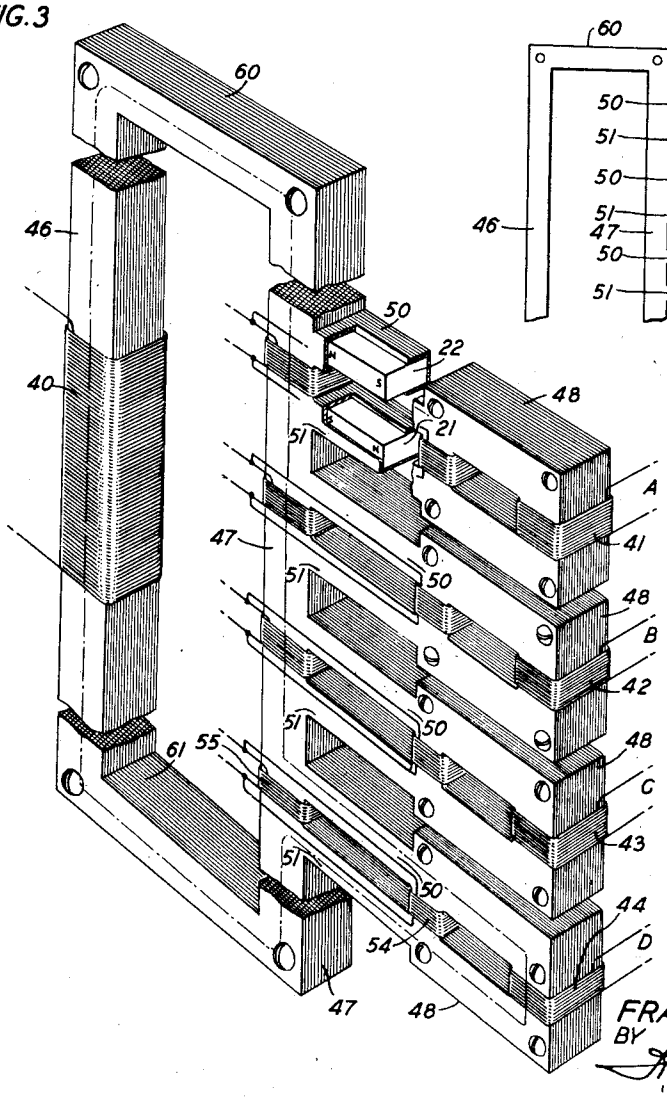
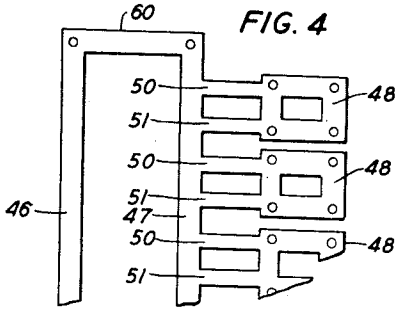


FIG. 4



INVENTOR
FRANCIS A. HUBBARD
BY
A. G. Kingman
ATTORNEY

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ELECTRICAL SWITCHING DEVICE

Francis A. Hubbard, Maplewood, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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8 Claims. (Cl. 171—119)

This invention relates to electrical switching and particularly to alternating-current circuit controlling devices whose switching functions are performed inductively, thus obviating the need for circuit controlling contacts.

It is the object of this invention to provide an improved circuit controller of the type which functions to effectively control circuits without the use of circuit controlling contacts.

This object is attained in accordance with a feature of the invention by utilizing, in a circuit controller, a magnetic core structure of permalloy or similar alloy, which can be readily saturated by a steady field and which, when so saturated, becomes virtually non-magnetic to an alternating magnetomotive force of moderate intensity.

Another feature of the invention resides in the use of small permanent magnets embedded in the magnetic core which serve to normally saturate the core structure at particular points in the magnetic circuit, thereby effectively magnetically isolating those portions of the core which are separated from each other by the permanent magnets. By this arrangement a normal condition of substantial electrical uncoupling is maintained between input and output coils carried on separate legs of the magnetic core, which condition may be altered to effectively couple the input and output coils by passing direct current through a control winding carried by an intermediate leg of the core structure in such an amount as to saturate it and in the proper direction to oppose the saturating flux generated by the permanent magnets.

These and other features of the invention will be readily understood from the following detailed description made with reference to the accompanying drawing in which:

Fig. 1 is a diagrammatic illustration of the invention in its simplest form;

Fig. 2 is a diagrammatic illustration of a modification of the invention;

Fig. 3 is a perspective view of a magnetic structure embodying the principles of this invention to provide a multipoint switch by means of which an input winding may be coupled to any one of a plurality of output windings; and

Fig. 4 is a portion of a lamina of the form used in the structure shown in Fig. 3.

Referring particularly to Fig. 1, the magnetic circuit comprises a core structure having a closed H formation which may be built up of laminae of permalloy or other similar alloy. On one of the outer legs 10 of the core there is mounted an input coil 11 connected to a suitable source of alternating current 12. On the other outer leg 13 there is mounted an output coil 14 which may be associated with any type of equipment which responds to alternating current. The input and output circuits shown may constitute sections of a speech transmission circuit. The intermediate leg 15 is provided with a winding 16 which may be connected to a suitable source 17 of direct current by the actuation of a circuit controller such as the switch 18.

The two sections 20 and 23 of the magnetic circuit which interconnect the legs 13 and 15 have embedded therein small permanent magnets 22 and 21 respectively. These magnets may be inserted in slots in the core sections 20 and 23 or may be embedded in the core structure during the time the core is being assembled. The permanent magnets 22 and 21 may, of course, be located in the core structure in any other convenient manner, or the saturating flux might be produced by windings placed around the legs 20 and 23, and carrying direct current in such a direction as to produce flux of the same polarity as indicated by the permanent magnets 22 and 21.

The sections 20 and 23 of the core structure are normally saturated by the unidirectional flux set up by the permanent magnets 22 and 21, it being understood that this flux is largely confined to these sections due to the fact that the permanent magnets are embedded therein. The coupling between the input winding 11 and the output winding 14 is therefore comparatively small and is further reduced by the magnetic leg 15 which acts as a shunt and tends to short-circuit the alternating flux set up by the input winding 11. Under normal conditions, therefore, that is, with the input circuit closed and the control winding 16 open, there is substantially no coupling between the input and output circuits.

When it is desired to couple the input and output coils 11 and 14, direct current is passed through the control coil 16 by the actuation of switch 18 which completes the connection of the control coil to the direct-current source 17. This current is of sufficient magnitude to cause the intermediate leg 15 of the magnetic circuit to become saturated and is in the proper direction to oppose the original saturating flux in the core sections 20 and 23 set up by the permanent magnets 22 and 21 respectively. By correctly proportioning the several elements, the intermediate leg 15 becomes magnetically inert to the alternating flux generated by the input winding 11,

thereby removing the magnetic shunt. The sections 20 and 23 on the other hand become magnetically sensitive and the reversing flux set up by the input winding passes through the output leg 13 to effect the magnetic coupling of the input and output windings 11 and 14. If these windings are employed for terminating the sections of a speech channel, speech currents will now be transmitted over the output circuit.

The structure shown in Fig. 2 is similar to that shown in Fig. 1 except that a second magnetic shunt member 30 is introduced on the output side of the sections 20 and 21. The second shunt leg is effective in further reducing the coupling between the input and output windings, the effect on the magnetic circuit is similar to that of the well-known π type resistance network commonly used as an attenuator in an electric circuit. Otherwise, the structure is the same as that shown in Fig. 1 and like numerals have been employed in Fig. 2 to identify corresponding elements in Fig. 1. It is believed unnecessary to enter into a detailed description of the operation of the modification shown in Fig. 2 since this is apparent from the preceding description of the operation of the structure shown in Fig. 1.

Fig. 3 illustrates the application of the principle involved in the modification shown in Fig. 2 to a multi-point switch by means of which an input winding 40 may be coupled to any one of a plurality of output windings such as 41, 42, 43 and 44. The magnetic core structure may be built up of permalloy laminae, a portion of one of which is shown in Fig. 4, in the same manner as are the structures illustrated in Figs. 1 and 2.

The core structure consists of a relatively large rectangular portion comprising the input leg 46 and an oppositely disposed leg 47 joined by the shorter sections 60 and 61. The leg 47 is provided with a plurality of integral projections each of which comprises a small rectangular portion 48 connected to the leg 47 by means of two connecting or bridge pieces 50 and 51. The input coil 40 is wound upon the input leg 46 of the core whereas each of the output windings 41, 42, 43 and 44 is wound upon an outer leg of the smaller rectangular portions 48. The control circuit for each of the smaller output sections consists of two coils 54 and 55 wound respectively, on the inner legs of the small rectangular portions 48 of the core and on that portion of the leg 47 which interconnects the respective connecting or bridge pieces 50 and 51.

The control circuits may be connected to a direct-current source through the operation of switches such as the switch 18 illustrated in Figs. 1 and 2. It is to be understood that each control circuit of the four shown in Fig. 3 is provided with its individual switch so that the circuits may be separately energized as desired.

The first two connecting pieces 50 and 51 of Fig. 3 are broken away to illustrate the position of the permanent magnets 22 and 21 which magnets may be embedded in the connecting pieces in any suitable manner.

Under normal conditions, that is, when none of the control windings is energized, each pair of connecting pieces 50 and 51 is saturated by the flux set up by their respective permanent magnets 22 and 21 so that these portions of the magnetic circuit are virtually non-magnetic to the alternating flux generated by the input winding 40. Under these conditions, the leg 47 constitutes a magnetic shunt to short-circuit the reversing flux and the second shunt, which for each circuit, consists of that portion of the rectangular core 48 upon which the coil 54 is wound serves to further reduce the coupling between the input and output coils. There is therefore substantially no coupling between the input winding 40 and the output windings 41 to 44 inclusive, the flux traversing a path including the legs 46, 60, 47 and 61.

It will now be assumed that it is desired to effect a coupling between input coil 40 and the output coil 44, which terminates a speech channel D, for example. A switch, corresponding to the switch 18, Figs. 1 and 2, associated with the control windings 54 and 55 is actuated to connect a direct-current source (not shown) thereto. The portions of the core encircled by the lower windings 54 and 55 thereupon become saturated by the steady flux set up by these windings and the normal saturating flux produced by the permanent magnets 22 and 21 embedded in the bridge pieces 50 and 51 is neutralized, it being understood that the direction of the flux generated by the control windings is such as to oppose that set up by the permanent magnets. The connecting pieces 50 and 51, which normally were inert to the alternating current flux, now become sensitive and those portions about which the control windings 54 and 55 are wound are now inert. The alternating current flux now travels a path indicated on the drawing by the broken line. This flux cuts the output coil 44 so that a coupling between this coil and the input coil 40 is now effected and speech currents may be relayed from the input circuit to the output circuit D. It will be noted that the connecting pieces such as 50 and 51 which separate the other output circuits from the leg 47 are still saturated by the steady flux set up by their respective permanent magnets so that the alternating current flux does not cut the corresponding output windings 41, 42 and 43 at this time. It will also be understood that those portions of the leg 47 and the corresponding portions of the small rectangular cores 48 which are encircled by the other control windings are in their normal unsaturated condition so that they serve to short-circuit the flux with respect to the output windings 41, 42 and 43.

Coupling between the input coil 40 and any of the other output coils 41, 42 and 43 is effected in the same manner, that is, by connecting a source of direct current with the corresponding control windings. It is believed unnecessary to trace the path of the alternating current flux under each condition since such paths are obvious from the above description of the coupling of coils 40 and 44. It is equally obvious that the closure of any number of the control circuits will result in the coupling of a corresponding number of output windings with the input winding 40. In this manner any one of the output circuits A, B, C or D may be coupled with the input circuit either separately or in combination with other output circuits.

What is claimed is:

1. An electrical control device comprising a closed saturable magnetic core, input and output coils wound on separate legs of said core, means including said input coil for generating an alternating flux, a third leg of said core intermediate said separate legs, means normally saturating those core portions which connect said third leg with the leg upon which said output coil is wound whereby the alternating flux traverses a path including said third leg and means for saturating said third leg and neutralizing the effect of said normally saturating means whereby said alter-

nating flux traverses a path including the core leg upon which said output coil is wound.

2. An electrical control device comprising a closed saturable magnetic core, input and output coils wound on separate legs of said core, means including said input coil for generating an alternating flux, a third leg of said core intermediate said separate legs, a permanent magnet embedded in those core portions which connect said third leg with the leg upon which said output coil is wound for maintaining those core portions normally saturated and causing the alternating flux to traverse a path including said third leg and means for saturating said third leg and for opposing the flux set up by said permanent magnets whereby the alternating flux is caused to traverse a path including the core leg upon which said output coil is wound.

3. In combination, a closed saturable magnetic core having two outer legs and an intermediate leg interconnected by bridge pieces, an input coil on one of said outer legs, an output coil on the other of said outer legs, means including said input coil for generating an alternating flux and means comprising a permanent magnet embedded in each of the bridge pieces interconnecting the intermediate leg with the other of said outer legs for saturating said bridge pieces with a steady flux whereby the alternating flux generated by said generating means is diverted from the other of said legs and shunted through said intermediate leg to maintain said input and output coils in uncoupled relation.

4. In combination, a closed saturable magnetic core having a pair of outer legs and an intermediate leg, an input coil on one of said outer legs, an output coil on the other of said outer legs, means including said inuput coil for generating an alternating flux, means normally saturating those portions of the magnetic circuit which connect the intermediate leg with the other of said outer legs whereby the alternating flux generated by said generating means traverses a path including said intermediate leg and excluding the other of said outer legs and means for saturating said intermediate leg and neutralizing the saturation effected by said first saturating means whereby said alternating flux is caused to traverse a path including the other of said outer legs.

5. An electrical control device comprising a closed saturable magnetic core having an input leg, a shunt leg and a plurality of output legs, said shunt leg having a portion corresponding to each of said output legs, bridge pieces connecting each of said output legs with its corresponding portion of said shunt leg, means normally saturating said bridge pieces whereby said output legs are magnetically isolated from said shunt leg, means including a coil wound on said input leg for generating an alternating flux which normally traverses said shunt leg and means for selectively saturating portions of the shunt leg and desaturating the corresponding bridge pieces whereby the alternating flux is diverted from the saturated portions of said shunt leg and caused to traverse a path including the corresponding output legs.

6. An electrical control device comprising a closed saturable magnetic core having an input leg, a shunt leg and a plurality of output legs, said shunt leg having a section corresponding to each of said output legs, bridge pieces connecting each of said output legs with its corresponding section of said shunt leg, a permanent magnet embedded in each of said bridge pieces for normally saturating said bridge pieces whereby said output legs are magnetically isolated from said shunt leg, means including a coil wound on said input leg for generating an alternating flux which normally traverses said shunt leg and means for selectively saturating sections of said shunt leg with a steady flux which opposes the flux set up by the permanent magnets of corresponding bridge pieces whereby the alternating flux is diverted from the saturated sections of said shunt leg and caused to traverse a path including the corresponding output legs.

7. An electrical control device comprising a closed saturable magnetic core, an input coil wound on one leg of said core, an output coil wound on another leg of said core, means including said input coil for generating an alternating flux in said core, and means for diverting the generated flux from the leg upon which said output coil is wound comprising permanent magnets embedded in said core at points intermediate the legs upon which said input and output coils are wound.

8. An electrical control device comprising a closed saturable magnetic core, input and output coils wound on separate legs of said core, means including said input coil for generating an alternating flux, parallel paths for said flux, one of said paths including the leg upon which said output coil is wound and having permanent magnets included therein for normally diverting said flux therefrom, and means for diverting the flux from the other of said parallel paths and for nullifying the flux diverting effect of said permanent magnets to cause the flux to traverse the path including the core leg upon which said output coil is wound.

FRANCIS A. HUBBARD.