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[54] **PUSH-BUTTON SWITCH ASSEMBLY**

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[51] **Int. Cl.** **H01h 3/12**

[58] **Field of Search** 317/136; 235/145; 340/365; 197/98, 107; 335/78, 79, 186, 11, 164, 205, 206

[56] **References Cited**

UNITED STATES PATENTS

2,971,135 2/1961 Ebert........................317/136

3,566,319 2/1971 Ohno........................335/206

3,612,241 10/1971 Bernin........................197/98

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[57] **ABSTRACT**

A push-button switch assembly that is suitable for applications requiring a relatively large number of push-button switches and in which no more than one switch is depressed at any one time. The assembly utilizes individual switches which are provided with permanent magnetic elements and a clearing coil which upon energization repels the magnets to clear any previously depressed switches as a new one is depressed. One application of the present invention is in channel selection of an electronically tuned television receiver.

13 Claims, 4 Drawing Figures

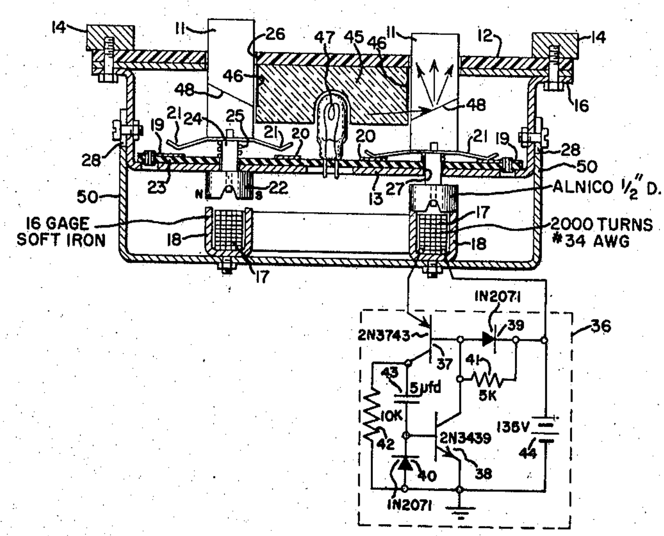

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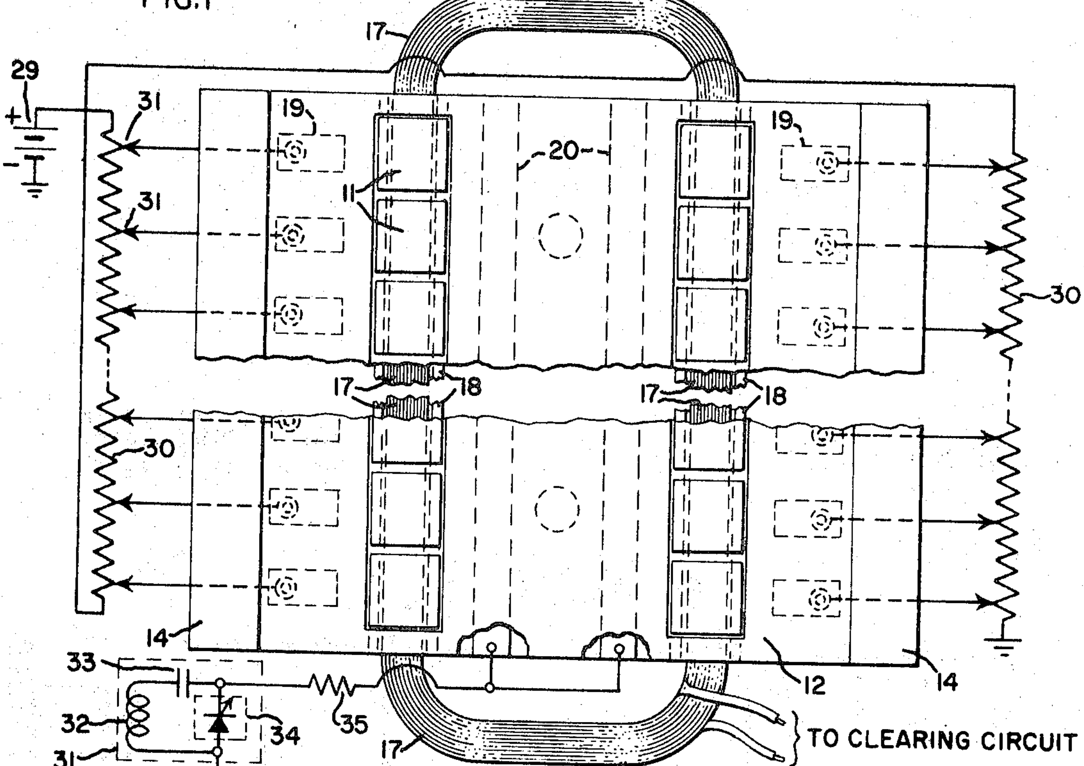
FIG. 1



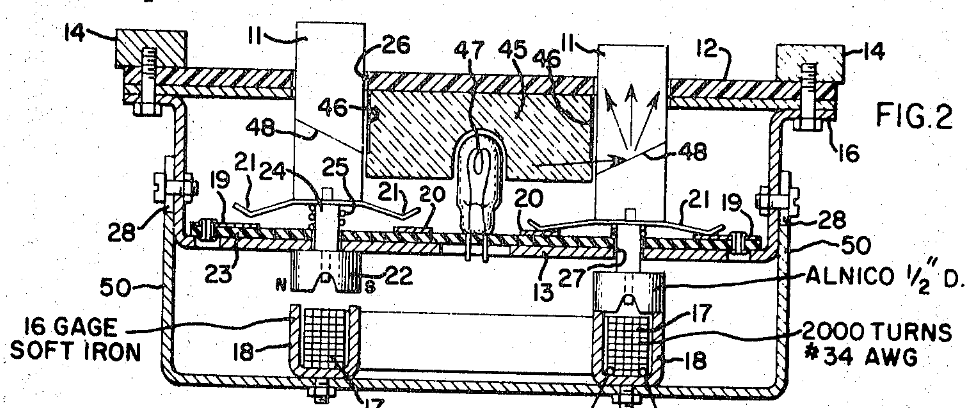


FIG. 2

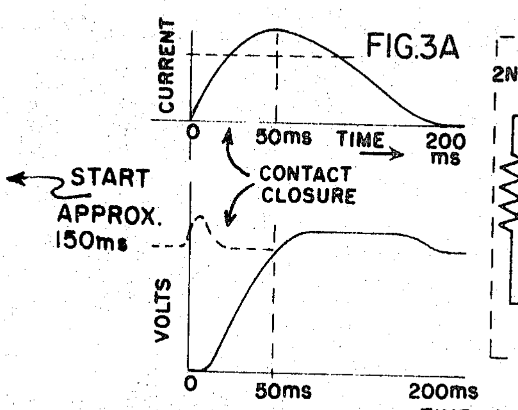
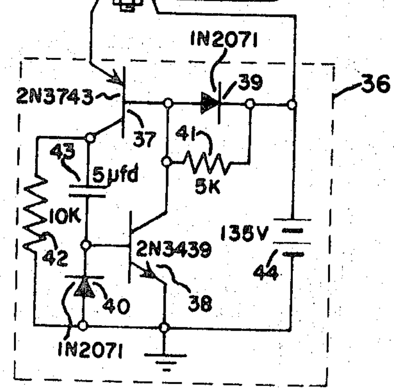


FIG. 3A

FIG. 3B



PUSH-BUTTON SWITCH ASSEMBLY

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to push-button switches and more particularly to push-button switch assemblies incorporating a plurality of individual switches and adapted to clear any previously depressed switches when a new switch is depressed.

2. Description of the Prior Art

Push-button switch assemblies of the type including a relatively large number of switches, only one of which should be in operation at any one time, have in the past required complicated mechanical linkages. One such class in use involved tandem latches, the operation of one push-button displacing a latching bar by means of a cam surface on the push-button so as to clear any previously depressed buttons prior to self-latching of the button in its final, more fully depressed position. A major problem with switches of this general nature tends to be their cost as the number of switches increase; the limited life of the latching and cam surfaces; the need for substantial numbers of springs; and, of course, the costs of fabricating these highly complicated assemblies.

To avoid some of these problems, increasing use has been made in switching assemblies of simpler magnetic elements. One such switch is the magnetic reed switch, wherein motion of a permanent magnet, typically up and down, makes or breaks contact between two flexibly supported magnetically permeable contact members. When in the magnetic field, the contacts stick together, while out of the field their resilient support forces them apart. At the same time, switching assemblies are making somewhat greater use of small electromagnetic elements. While these have been used extensively in relays for heavy duty applications, the need for compact clearing applications have provided a number of designs in which electromagnetic elements participate in operation of an assembly of switches.

In an otherwise unrelated field, the public has come to like magnetic latches which are now in common use in a growing number of closures, as for instance in the closure of cabinet doors. The doors normally must be brought to near closure by the operator or by a spring in the hinge, after which the magnet on the door sill attracts a permeable striker mounted on the door. The magnetic attraction imparts a last push to close the door tight. The magnets are capable of appreciable terminal force and the user can feel the door accelerating within his finger tips. At the same time, the impact produces a sharp audible click. These properties are ones that the user will sense and will usually like. Magnetic closure has the practical advantage of keeping the doors fully closed since the attraction of the magnet grows as the air gap shrinks to zero. A switch having magnetic latching, as herein proposed, has this same desirable touch.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an improved push-button switch assembly having a plurality of switches.

It is another object of the present invention to provide an improved push-button assembly employing a plurality of switches wherein only one switch is depressed at a time.

It is still another object of the present invention to provide a novel push-button assembly wherein permanent magnet members participate in holding and clearing functions.

It is a further object of the present invention to provide a push-button assembly having novel electromagnetic means participating in the clearing function.

It is a further object of the present invention to provide a push-button switch having an improved finger action.

It is another object of the present invention to provide a push-button switch assembly employing electromagnetic clearing and having improved finger action.

These and other objects of the invention are achieved in a push-button switch assembly comprising a plurality of push-button switches, each switch having a depressable button and a permanent magnet attached to each switch, the assembly further comprising a lower stop of magnetically permeable material for holding said switches in depressed position when said magnets are in contact therewith. A clearing coil associated with said lower stop means is provided which repels the magnets of any previously depressed switches and which is momentarily energized by means responsive to depression of a switch. Preferrably, the push-button is attached to the magnet, which in turn holds the push-button in a condition indicative of switch condition.

The clearing coil is energized during a period of maximum downward momentum of the push-button so that the energy available to clear the button is reduced by the kinetic energy of the button and produces a minimum finger sensation in the push-button being depressed. In its practical form, the clearing coil is wound within a U-shaped channel supported beneath the magnets of the individual switches and forming a bottom stop. Both sensing the depression of a button and clearing the previously depressed buttons may be achieved in a single winding. This arrangement for sensing button closure has the advantage of delaying motion sensing to near the bottom of the push-button stroke when the downward velocity of the button is greatest. This timing tends to avoid premature firing of the clearing pulse which might cause the button to be kicked upwardly into the finger. The general provision of a permeable core beneath the magnet and attachment of the button and switch assembly to the magnet, provides the desired tactile sensation which magnetic latches can provided, and delayed timing of the clearing stroke provides minimum interference with this sensation.

BRIEF DESCRIPTION OF THE DRAWING

The novel and distinctive features of the invention are set forth in the claims appended to the present application. The invention itself, however, together with further objects and advantages thereof may be best understood by reference to the following description, and accompanying drawings in which:

FIG. 1 is an illustration in plan view of a push-button assembly incorporating the invention and applicable to the tuning of an electronically tunable television receiver;

FIG. 2 is a side elevation of the push-button assembly illustrated in FIG. 1 and showing the electronic clearing circuit; and

FIGS. 3A and 3B are electrical waveforms illustrating operation of the clearing circuit.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIGS. 1 and 2, a push-button switch assembly suitable for an electrically tuned television tuner is illustrated, together with the associated operating circuitry.

The push-button switch assembly includes a plurality of rectangular push-buttons 11, which project through a laminated cover assembly 12 and are arranged in two parallel rows. Each push-button is arranged to operate a switch disposed beneath the push-button. The cover assembly 12 is in turn attached to an underlying channel 13 of magnetically permeable sheet metal. The attachment is achieved by means of a front panel trim member 14, which secures the edges of the panel assembly to a flange 16 on the channel 13. Completing the structural assembly is a pair of straps 50 attached to the walls of the channel member 13. The push-buttons and associated switches are generally supported upon the bottom of the channel 13 while the straps 50 support an electromagnetic winding 17 and an associated core 18 disposed immediately beneath the switch elements. The electromagnetic members 17 and 18 aid in holding and clearing the push-buttons, as will be described.

The plan view of FIG. 1 illustrates the push-buttons and associated stationary switch contacts 19 and 20. The side elevation view of FIG. 2, which is taken as a section through a pair of push-buttons, illustrates the mode of assembly of the individual push-button switches including both the moving switch contacts 21 and moving permanent magnet elements 22 which interact with the stationary members 13, 17 and 18.

Individual stationary contacts 19, which are associated with each of the switches, are disposed outwardly of and adjacent each of the push-buttons. They are mounted upon an insulating sheet 23 supported upon the upper surface of the channel member 13. Arranged inwardly of the buttons 11 are a pair of bus bars 20 also supported upon the insulating sheet 23. These bus bars are connected together and provide a common point for external connection to the switch. The other points for external connection are the individual stationary contacts 19.

An individual push-button switch, as seen in FIG. 2, comprises a push-button member 11, a cylindrical member 24 attaching the moving contact 21 and a permanent magnetic member 22 to the undersurface of the push-button, and a compression spring 25 encirculing the cylindrical member 24.

During operation, the push-buttons 11 which are of square cross-section and of a generally transparent insulating material are arranged to move in an axis perpendicular to the plane of the panel assembly 13. The push-buttons 11 move through rectangular apertures 26 in the panel assembly which prevent rotation of the button about the axis of motion. A set of circular apertures 27 in the channel member 13 and insulating layer 23 provide a sliding fit for the cylindrical member 24. Together, apertures 26 and 27 constrain the push-button to motion perpendicular to the panel 12. The spring 25 is compressed between the upper surface of the insulating layer 23 and the undersurface of the push-button 11 providing a predetermined button raising force.

When the push-buttons are in an undepressed position, the moving contacts 21, which are attached to the undersurface of the push-button 11, are spaced above the corresponding contact surfaces on stationary contacts 19 and 20. At the same time the magnetic member 22, which is attached to the lower portion of the cylinder 24 is in direct contact with the undersurface of the channel member 13. This undersurface is the stop for the upward motion of the push-button. The push-button tends to remain in this up position under the primary influence of the magnetic member 22, which being a permanent magnet is attracted to the undersurface of the permeable frame member 13. To a lesser degree the compression spring 25 tends to hold the push-button assembly in an up or undepressed position.

When a push-button is depressed as illustrated in the righthand portion of FIG. 2, the moving contacts 21, which are attached to the undersurface of the depressed push-button, move into contact with the facing contact surfaces of the stationary contacts 19 and 20 electrically connecting them together. In a depressed position, the magnetic member 22 comes into direct contact with the upper surface of the of the electromagnetic core member 18. Such contact is adjusted to occur when the push-button switch contacts are properly closed with the moving contact members 21 resiliently biased into contact. At this position, the moving contact members and the compression spring 25 are in a compressed condition. Thus, the core member 18 becomes the stop for downward motion of the push-buttons and as will be explained below, means for holding the button in a down position. The position of this stop is adjusted as desired by means of slotted openings 28 in core supporting straps 50 at their point to attachment to the walls of the channel 13.

As indicated above, the permanent magnet members 22, in addition to engaging the up and down stopping surfaces for limiting push-button travel, assist in holding the push-buttons in their up and down positions. The permanent magnet member 22 is provided with sufficient magnetic attraction to the upper surface of core member 18 to sustain the push-button in the "-down" position against the resilient forces of the compression springs 25 and the contact arms 21, in addition to any unsupported weight in the moving parts of the individual push-button.

In the "up" position, where the member 22 is engaged with the undersurface of panel 13, there is a smaller requirement for magnetic force. In the "up" position, any resilient bias is aiding. The magnetic force and aiding resilient force should exceed any unsupported weight in the individual button.

While several configurations and magnetizations of the permanent magnet member 22 may be employed, a convenient configuration is a slotted cylindrical arrangement (illustrated) wherein the magnetic poles are arranged in diametrically opposite positions perpendicular to the axis of the cylinder. The internal magnetization is normally U-shaped with the stronger fields on the slotted undersurface. The member 22 is then oriented with the poles arranged directly over the exposed edges of the magnetic core 18. This places the strongest external magnetic field just above the core pieces 18, and provides a positive latching of the button in the down position.

Turning away for a moment from this partial description of the magnetic details of the switch, one may at this point consider the application of the switch to push-button station selection, as for instance, in an electronically tuned television receiver.

In switching an electronically tuned television tuner, the push-button switch assembly is arranged to provide a preset control potential at each push-button to tune the television receiver to a corresponding pre-arranged channel. In performing this function, the push-button assembly is connected with a source 29 of d.c. potentials and a tapped resistance element 30. A suitable voltage sensitive tuned circuit is shown in the dotted block 31. The source 29 has the negative terminal connected to ground and the ungrounded positive terminal connected to an end terminal of the resistance element 30. The remote end terminal of the resistance element is also grounded. The resistance element 30 is provided with a plurality of individually adjustable taps 31, one tap being provided for each of the push-buttons. Thus, the taps provide a descending succession of positive voltages as one proceeds from the taps on the resistance closest to the positive terminal of the source 29 toward the taps nearer the grounded resistance terminal. Adjustment of the individual voltages at each tap is achieved by tap adjustment in conventional fashion. Adjustment of the tap provides fine tuning.

The dotted block 31, which designates the voltage sensitive tuned circuit, comprises an inductor 32, a d.c. isolating capacitor 33 connected in series with the inductor 32, and a voltage tunable capacitor 34 connected in shunt with the series circuit formed by the elements 32 and 33. The element 34 is capacitive in nature having a value which is controlled by the applied voltage. It may take several conventional forms including that of a reversely biased diode. The capacity of the element 34 resonates with the inductance 32 to establish the resonant frequency of tuned circuit 31. The resonant circuit 31 has one terminal grounded and the other terminal connected through an r.f. isolating resistance 35 to the bus bars 20 of the push-button switch assembly.

Reviewing the tuning operation, it may be seen that each push-button is arranged to connect a different pre-assigned d.c. potential through the r.f. isolation resistance 35 to the voltage variable capacitor 34 in the tuned circuit 31. Since the tuned circuit presents a high impedance at the point of connection, the isolating resistance can normally assume a value of about 50,000 ohms. The available voltages and the tuning characteristic of the voltage tuning capacitor 34 are selected to cause the resonant circuit 31 to assume the desired frequencies required for selection of specific television channels. Normally, the frequencies will include both VHF and UHF channels. A proposed number of separate push-buttons is 24.

Let us now return to the mechanical aspects of the push-button assembly. While the permanent magnets 22 participate with the magnetizable members 13 and 18 in holding individual buttons in the up and down positions, they also participate in the self-clearing operation which prevents more than one button from being down at the same time.

Self-clearing is provided by means of the electromagnetic coil 17 and core 18 arranged beneath the individual permanent magnets 22 and the external clearing circuit 36 electrically connected to the electromagnetic coil. The coil 17 has a relatively large area central opening and the winding cross-section is compacted into a small bundle which is fitted into the U-shaped core member 18 whose width approximates the diameter of a magnet 22. The field configuration about the winding 17 in the immediate vicinity of the magnetic members 22 is roughly circular. Viewed microscopically the close-in field is approximately toroidal. Because of its intimacy with the core 18, the winding 17 is closely coupled thereto. When current flows in the coil, poles of opposing polarity are induced in the upper edges of the U, with the local field concentrated at and generally directed across the gap. The induced poles are spaced a distance approximately equal to the spacing between the poles of the magnets 22. When the clearing current flows, therefore, the outer and inner edges of the core assume mutually opposite polarities, which polarities are also the same as those of the permanent magnets 22 aligned immediately opposite. Thereupon, any permanent magnets in a down position are repelled and the corresponding buttons are cleared.

The clearing circuit 36 illustrated in FIG. 2 is arranged to sense the momentary depression of a given push-button and to thereupon create a repulsive force raising all the push-buttons to an up position except the one being momentarily depressed. The clearing circuit comprises a pair of complementary transistors 37, 38, diodes 39 and 40, resistances 41, 42, capacitor 43 and a bias source 44. Both sensing the depression of the push-button and force for clearing the nondepressed push-buttons is achieved by means of the single coil winding 17.

The clearing circuit 36 is connected as follows: The winding 17 has one terminal connected to the emitter of transistor 37. The base of the transistor 37 is connected through the diode 39, poled in the same direction as the input junction of the transistor 37, to the other terminal of the winding 17. A resistance 41 shunts the diode 39. The collector of the transistor 37 is connected through a load resistance 42 to a point of ground potential. The collector of transistor 37 is also connected through a coupling capacitor 43 to the base of complementary transistor 38. The emitter of the transistor 38 is grounded. The input junction of the transistor 38 is shunted by an oppositely poled voltage stabilizing diode 40. The collector of the transistor 38 is connected to the base of the transistor 37. Suitable operating potentials are provided by a d.c. source 44 connected between ground and the base connected terminal of the winding 17.

The clearing circuit is normally quiescent but produces a large clearing pulse when a push-button is depressed. The foregoing pair of collector to base interconnections between the transistors provides regenerative feedback and tends to force both transistors into the same state of conduction. The quiescent condition of the circuit is one in which both transistors are nonconductive, the capacitor 43 isolating the input junction of the transistor 38 from forward biasing potentials. Similarly, the low d.c. impedance path across the input junction of the transistor 37 tends to reduce the input junction potential below conduction.

Upon depression of a push-button the clearing circuit begins to function in an active manner. As the push-button is depressed, the permanent magnet **22** is thrust suddenly toward the core member **18** and its associated coil **17**. This motion induces a short unidirectional pulse illustrated in the dotted line in FIG. 3B. This pulse is applied in conduction inducing polarity across the input junction of the transistor **37** through the circuit including the diode **39** and resistance **41**. As the transistor **37** begins to conduct, capacitor **43** couples a conduction inducing pulse to the base of transistor **38**. Thus, after the button is depressed, current begins to flow in both transistors under the influence of their regenerative interconnection and both are driven toward saturation.

As the transistors begin to conduct, the current path through the inductor **17** is closed through the transistors and the voltage across the inductor is stepped from a near zero quiescent value to a maximum value, poled oppositely to the initial pulse. The voltage waveform is as illustrated in the solid line of FIG. 3B. This voltage causes a current flow in the inductor as illustrated in FIG. 3A. The resulting field in the coil is now the reverse of that created by the original pulse, and it exerts an opposing force on all of the electromagnetic members **22**, including the ones depressed. The field configuration about the winding **17** in the immediate vicinity of the magnetic members **22** is roughly circular with the outer edge of the core member **18** assuming an N polarity with the inner edge assuming an S polarity. Since these electromagnetically induced polarities are the same as the polarities of the permanent magnets **22**, the latter are repelled.

The force of repulsion produced by the energized electromagnetic core and coil should be adequate to overcome the weight of the movable mass of each button and whatever stray friction may be expected to be encountered so as to achieve positive clearing action irrespective of panel orientation. The repulsive force and available energy are set such that clearing does not interfere with closing the desired button with a light finger pressure (as will be described in greater detail below).

Continuing now with the operation of the clearing circuit **36**; transistors **37** and **38** are connected to provide positive feedback and the capacitor **43** is an element of the positive feedback path such that "one shot" operation is achieved. Under quiescent conditions the emitter base junctions of the complementary transistors **37** and **38** are back biased (or zero biased) and the entire voltage of the power supply (**44**) exists across the collector-base junctions drawing no current and providing no voltage drop across the series connected element **17** which is the winding generating the repulsive magnetic force. When triggered, the NPN-PNP switch (**37–38**) becomes a short circuit and the entire power supply voltage (**44**) is impressed across the winding **17**. As this inductive winding builds up voltage current with time ($I = 1/L \int v\, dt$), the capacitor **43** builds up voltage with time ($V = 1/C \int i\, dt$) and more of the power supply voltage exists across the PNP–NPN switch and less exists across the inductor. A maximum current exists when all the power supply voltage is impressed across the switch and none exists across the inductive winding **17**. The voltage across capacitor **43** continues to rise as the inductive winding **17** reverses polarity until the current flows through the emitter base junction of transistor **37** and diode **39** and winding **17** exclusively.

At the instant the voltage at the collector of transistor **37** ceases to rise, current flow through capacitor **43** and into the base of transistor **38** is halted. At this point in time two independent events occur. The "flyback" current in winding **17** decreases to zero (essentially linearly) with its voltage clamped by the series conduction of diode **39** and transistor **37** operating as an emitter-base diode; and the voltage across capacitor **43** is discharged by resistor **42** with the discharge path completed through a now forward biased diode **40**. When both the relaxation of the current in the inductive winding **17** and the discharge of voltage in the capacitor **43** has been completed, the circuit is once again in the quiescent condition and ready to be retriggered.

The duration and timing of the clearing pulse are arranged so that the push-button clearing action exerts at most a momentary resistance to depression of the push-button under conditions when it is least likely to be sensed by the operator's finger. The period of repulsion is a few tenths of a second and normally less than the period that an operator is likely to sustain his finger pressure. The clearing impulse is of a magnitude comparable to that required to overcome the normal momentum of the descending button which exists near the bottom of the stroke. The button being depressed reaches home relatively silently and without vibration at a speed further reduced by the energy required to compress the spring **25** and flexible contactor **21**. An audible click is caused, however, as the button previously depressed clears and strikes the upper stop.

In general, the push-button operates to provide the desired subjective reaction that users would like to associate with push-button switches. During the initial portion of the push, there will be an initial resistance that the user will sense as the button is pushed away from the upper stop. Where the holding force is mostly magnetic, the force is initially quite large and falls off rapidly. Where the holding force is partly resilient and partly magnetic, as indicated in the preferred embodiment, the initial finger sensation is one of more nearly steady pressure. Then, as the button nears completion of the stroke, there will be a sensation of slightly decreasing pressure as the magnetic force increases rapidly with the narrowing gap between the magnet **22** and the lower stop **18**.

Normally, it is preferred that the clearing pulse occur towards the lower limit of button travel since at this point the button is acquiring most of its downward momentum and it will not be fully halted if the rather substantial clearing force desired to insure positive clearing operation is exerted. In this preferred mode of operation, the finger will not sense an impact that it might have experienced had the pulse occurred at the beginning of the stroke. Instead, the clearing pulse is masked and the finger senses only a perceptable lightening of pressure as the button hurries home. While the factors so far discussed are largely subjective, they appear to lead to user attractiveness of the present push-button assembly.

Electronically sensing the motion of the magnets **22** and then generating a clearing pulse tends to insure proper timing and reduces the chance for too premature clearing of the button being pushed. The pulse induced in the coil **17** from the motion of the magnet **22** tends to peak near the bottom of the push-button stroke due to the effect of the closing air gap between the magnet **22** and the core **18** (associated with the coil **17**). Thus, there is a natural delay in this configuration of at least three-fourths of the period of the full stroke.

The induced pulse is then used to turn on the clearing circuit **36**. The clearing circuit **36** has a threshold which is set above the level from noise alone and below the lowest peak that the induced pulse would reach in normal operation. Attaining the peak of the clearing pulse, after sensing the induced pulse, takes approximately 50 milliseconds in a typical configuration. Assuming the normal period for a button stroke of from 0.1 to 0.2 of a second, the clearing pulse will not peak until near a time close to the bottom of the push-button stroke. Typically, the peak will occur momentarily after the actual contact of the push-button with the core **18**. The clearing pulse will tend to decay from its peak value for a longer period, typically another 150 milliseconds (as shown in FIG. 3A). Thus, if one would sense the magnetization of the core **18**, a repulsive field would be encountered throughout the approximately **200** milliseconds duration of magnetizing current in the coil **17**. However, the magnetizing influence of the magnetic member **22** as it approaches the edges of the core **18** opposes the induced field from the coil. After contact, the magnetomotive force of the magnet exerted upon the domains of the upper elements of the core becomes large and the magnet will stick so long as it exceeds the opposing field created in the same domains by current in the coil. The magnetomotive force of the magnet in these upper elements is indicated by the dotted line in FIG. 3A.

Assuming stationary contact between the magnet and the core, there is only a brief period of perhaps 60 or 70 milliseconds about the current peak that the field from the coil will exceed that from the contacting magnet and thus tend to repel it.

The static rules for repulsion however do not govern the dynamic situation. When a push-button is moving down, the electrical energy available to kick the button into an upper position is reduced by whatever kinetic energy has to be expended to bring the button to a stop. Thus, if the timing of the clearing pulse occurs at a time when the button being depressed is moving downward with maximum velocity, it will take appreciably more electrical energy to clear that button than if it had been stationery. In the dynamic situation, the departure of the button up from the lower stop will be delayed until energy has been supplied from the pulse to offset this kinetic energy. In practice, the available energy in the clearing pulse, is set (by adjustment of the parameters of **36**) to be adequate to clear any stationary buttons, but inadequate to clear a button which is moving downward with appreciable velocity.

Ideally therefore, the clearing pulse occurs at a time of maximum downward kinetic energy of the push-button and toward the end of the push-button stroke for maximum absorption of the electrical energy by the available kinetic energy. Assuming some departure from optimum conditions, as by use of too strong a clearing pulse, or timing that does not permit most of the energy of the clearing pulse to be absorbed in dissipating the downward kinetic energy of the button, the penalty is one of increasing finger reaction in the button being depressed. The mass of the finger is normally large in relation to that of the button and voluntary movement is relatively slow so that the operator will not experience any difficulty in closing the push-button although experiencing increased finger reaction to the clearing pulse. With the ideal adjustment, however, the button being depressed will stay depressed with negligible continuing finger pressure. At the same time, finger sensation of the clearing pulse will be minimum and substantially masked by the earlier overriding magnetically induced closure acceleration.

A further aspect of the practical embodiment is the mode of illumination of the depressed push-button. The elements **45** through **48** participate in this illumination. As best seen in FIG. **2**, a block **45** of light conductive plastic is attached to the undersurface of the panel **12**, having its lateral surfaces in close proximity to the inner lateral surfaces of the buttons **11** and having one or two central cavities for the insertion of a corresponding number of lamps **47**. The upper portion of the sides of the block **45** are provided with darkened or screened surface **46** to prevent light from exiting. At the same time, each button **11** is provided with an obliquely oriented frosted reflective surface as shown at **48**. This frosted surface is located just above the lower margin of the screen **46**, so that when the button is in an up position illumination from the light source **47** is prevented. The angle of obliquity is set to achieve maximum forward illumination. When a button is depressed, as shown in the right-hand portion of FIG. **2**, the reflective surface **48** slides below the screen **46** and into the path of illumination from the lamp **47**. The light from the lamp accordingly now enters the button above the reflective frosted surface **48**. Its reflection off the oblique surface produces a general forward illumination of the depressed button.

As previously indicated, the magnetic member **22** contacts the undersurface of the permeable panel **13** in the "up" position and the edges of the core member **18** in the "down" position. Thus, in the illustrative embodiment, the magnet itself comes in contact with both stops. In addition, since these surfaces are permeable, the magnetic attraction toward them serves to hold the button in the "up" or the "down" position.

In the "down" position, it is particularly desirable that the magnet **22** make actual contact with the core member **18**. Actual contact with both edges of the core is usually possible in the face of the usual mechanical tolerances by allowing the button assembly to fit loosely in the apertures **26** and **27**. As an alternative, the magnetic member **22** may be loosely attached to the button so as to permit freedom of movement with respect to the button and alignment of the undersurfaces of the magnet **22** with the core edges. Minimum air gaps are particularly desired in a "down" position to insure both positive operation of the electrical contacts and, at the moment of clearing, to achieve an optimum repulsive force for a given current input.

In the "up" position, in the illustrative embodiment, the magnet **22** stops against the undersurface of the permeable channel **13**. Thus, in the "up" position the magnet attracts the button upwardly. At the same time, the cylindrical spring **22** provides an additional upward force. One may achieve the stopping and holding functions by eliminating the spring **25** and insuring that the magnetic force on **22** is adequate to hold the button in the "up" position. Similarly, one may utilize a magnet which has little or no attractive force on the upper surface and resort exclusively to the biasing force of the spring **25** to hold the button up. In this latter event, where the resilient bias is used for holding the button in an "up" position, a projection on the lateral surfaces of the button **11** (which would contact the undersurface of the panel assembly **12**) could contact the upper stop were the upper surface of the magnet not already conveniently available.

While a detached push-button may be used, it is normally desirable for the push-button of each push-button switch to add to the inertia of the lower switch assembly and to assume a position indicative of the switch condition. Thus, simple attachment, permitting some tipping of the magnet on the axis of the button, but little axial lost motion achieves these objectives quite simply and is normally to be preferred.

The clearing circuit **36**, which has been illustrated in FIG. 2, is one of a large number that may be used with equal facility. Its printicpal advantages are in its simplicity, its lack of need for a sensing winding separate from the clearing winding and the ease with which the output pulse may be controlled in time and in energy content. One can, of course, employ other circuits which operate with a single winding combining these two functions. As earlier implied, separate sensing and clearing windings may also be employed.

The button depression sensing function can be performed in a number of alternate ways. One such way is by momentary electrical contact made as individual buttons are in downward passage. In that event, a mechanical motion sensor closes an electrical switch and momentarily energizes the clearing coil. This provision would be instead of an electromagnetic sensing coil.

Another alternative may be employed when only a single pair of switching buttons are required, as for instance, in the event that one desires a matching pair of on-off push-buttons to turn the equipment on and off. In this alternative, one may provide each push-button with an extra pair of normally open contacts for the clearing circuit. These extra contacts, which would normally be arranged orthogonal to the normal contacts are then connected in series with the clearing winding and their source of current. Thus, when one button is depressed and both buttons are momentarily down, the clearing circuit through the two extra contact pairs is closed and the undepressed button is thrust up by current supplied by the source.

A further alternative for sensing depression of the button takes into account the particulars of the television receiver into which the tuner is installed. In a television receiver to which the present invention is applicable, the push-button assembly acts to tune the tuned circuit **31** as a function of the voltage applied to the variable capacitor **34**. At the moment that a second button is depressed there will be a momentary transient upon the variable capacitor signalling the presence of a new voltage on the variable capacitor and signalling the need for retuning to a new operating frequency. The automatic frequency control circuit of a television receiver, which is required to hold the tuner in precise tuning to the selected channel will thus sense detuning and go into the acquisition mode. This will create a transient condition on the a.f.c. bus which can be used to trigger the clearing pulse.

From the above, it may be seen that the invention may take a number of practical forms. It may also be widely used in applications requiring both a small number of buttons, as in the last example, and a relatively larger number of buttons. In general, an advantage of the invention is the ease with which a large number of buttons may be cleared. Such applications as adding machine and typewriter keyboards are among those requiring a large number of keys. In the adding machine application, the clearing function can be controlled as desired to clear all buttons or to reduce the chance that more than one button is depressed at a time in a single decimal rank, and like functions. In a typewriter, the invention would have application to preventing double strikes when the key finger accidentally hits two keys.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A push-button switch assembly comprising:

a. a plurality of push-button switches,
   1. each switch having a depressable push-button, said switch being in one or another conductive state dependent on whether it is in an undepressed or depressed position, and
   2. a permanent magnet attached to each switch,

b. an upper stop for establishing a predetermined undepressed position for each of said switches,

c. means for holding each switch in contact with said upper stop when said switch is elevated,

d. lower stop means of magnetizable material for holding said switches in a predetermined depressed position when said magnets are in contact therewith,

e. a clearing coil associated with said lower stop means, which upon energization repels the magnets of any previously depressed switches to elevate said switches to undepressed position, and

f. means responsive to depression of a switch for momentarily energizing said clearing coil.

2. A push-button switch assembly as set forth in claim **1** wherein said permanent magnet of each switch is attached to the corresponding push-button to cause push-button position to correspond with switch position.

3. A push-button assembly as set forth in claim **2** wherein said clearing coil is energized by said energizing means during a period of approximately maximum kinetic energy of downward motion to reduce the available clearing energy thereby and to reduce the finger sensation resulting from clearing to a minimum.

4. A push-button switch assembly as set forth in claim **3** wherein said energizing means provides energy adequate to clear buttons in a stationary depressed state, but inadequate to clear buttons having appreciable kinetic energy of downward motion.

5. A push-button switch assembly as set forth in claim **4** wherein said energizing means responds to depression of the push-button by sensing motion of said magnet, said motion sensing elements comprising a coil associated with said lower magnetizable stop which produces a pulse peaking when said magnet is in close proximity to said stop and near the point of maximum kinetic energy of said push-button.

6. A push-button switch assembly as set forth in claim 5 wherein said energizing means is responsive to said pulse exceeding a predetermined threshold and initiates a clearing pulse prior to completion of the button downward stroke.

7. A push-button assembly as set forth in claim 1 wherein said clearing coil magnetizes said magnetizable stop means and creates a magnetization therein repelling said permanent magnets.

8. A push-button switch assembly as set forth in claim 6 wherein said clearing coil is a loop with a relatively large central opening whose windings are compacted into a small bundle so as to create a generally toroidal close-in field, said magnetizable stop means lying within said toroidal field.

9. A push-button switch assembly as set forth in claim 8 wherein the poles of each of said magnets lie in a plane perpendicular to the direction of motion of the associated switch and wherein said magnetizable stop means are of a U-shaped configuration to permit formation of opposing poles at the edges thereof in general alignment with the poles of said magnets.

10. A push-button assembly as set forth in claim 1 wherein said upper stop is of a magnetizable material and said holding means is magnetic.

11. A push-button switch assembly as set forth in claim 1 wherein said upper stop is of a magnetizable material and said holding means is in part magnetic and in part resilient in nature.

12. The combination set forth in claim 1 wherein said energizing means comprises a sensing coil disposed in proximity to said magnets for sensing downward motion of said magnet and producing a corresponding pulse, and means responsive to said sensing pulse for energizing said clearing coil.

13. The combination set forth in claim 12 wherein said clearing coil and said sensing coil are common, said clearing coil producing a sensing pulse of one polarity and said means responsive to said sensing pulse applying a pulse of opposite polarity to said coil.

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