March 14, 1967 J. N. PEARSE 3,308,527

METHOD OF MANUFACTURING RELAYS

Original Filed July 23, 1962 2 Sheets-Sheet 1

Fig. 1

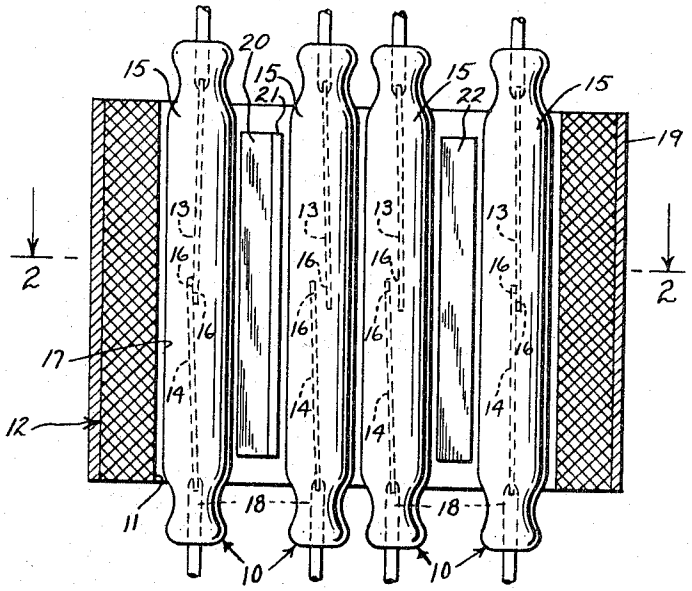
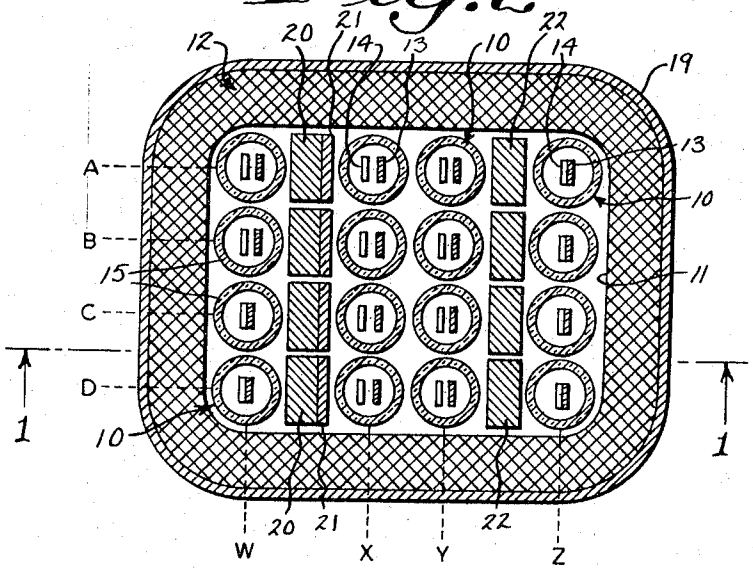


Fig. 2



INVENTOR
JAMES N. PEARSE
BY
ATTORNEY

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Fig. 3

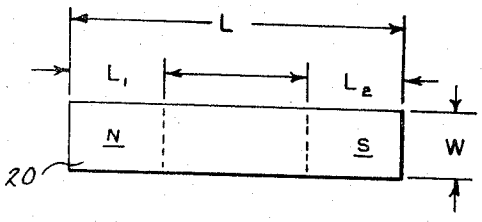


Fig. 4

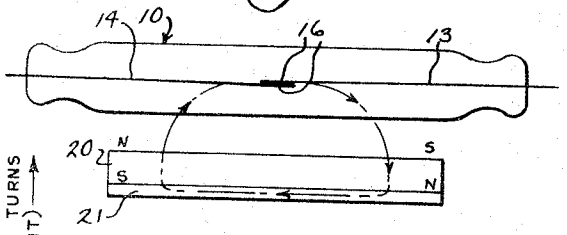


Fig. 5

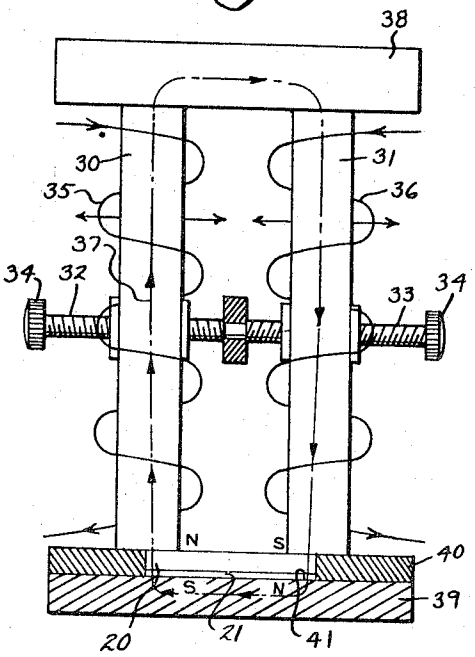


Fig. 7

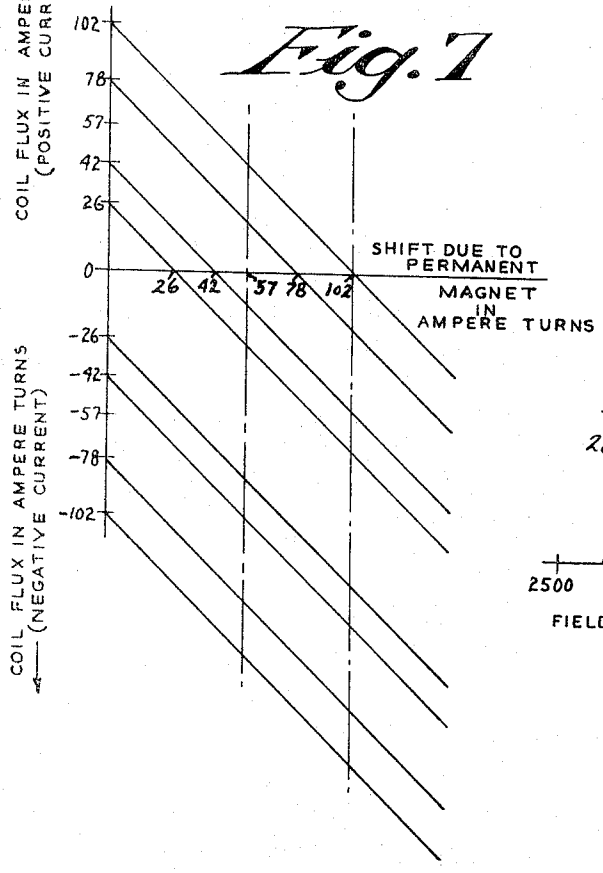
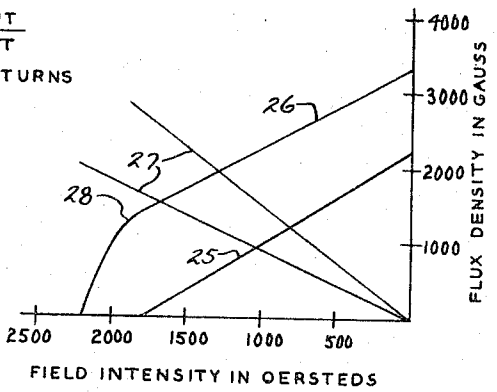


Fig. 6



INVENTOR
JAMES N. PEARSE

BY

ATTORNEY

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3,308,527

METHOD OF MANUFACTURING RELAYS

James N. Pearse, Milwaukee, Wis., assignor to Allen-Bradley Company, Milwaukee, Wis., a corporation of Wisconsin

Original application July 23, 1962, Ser. No. 211,628. Divided and this application Oct. 30, 1963, Ser. No. 324,161

3 Claims. (Cl. 29—155.5)

This is a division of an application Ser. No. 211,628, filed July 23, 1962, now Patent No. 3,239,626.

The present invention relates to relays and components thereof, and particularly to relays incorporating sealed reed switching units and to a method of manufacturing said relays.

A principal object of the present invention is to provide an electromagnetic relay including a plurality of commingled sealed reed switching units actuated by a common coil, and wherein the operating characteristics of one unit will in no manner interfere with the operating characteristics of adjacent or otherwise proximately disposed switching units, such units being selected from type having operating characteristics, such as normally-open, normally-closed, normally-closed contacts selectively responsive to (+) or (−) currents, latching contacts that latch with (+) or (−) currents and unlatch with (−) or (+) currents, respectively, and paired latching contacts having one switching member latching on (+) and unlatching on (−) current and the other member of the pair latching on (−) and unlatching on (+) current, and wherein only one biasing magnet is required for a respective pair of latching switches.

A corollary object of the present invention lies in the provision of sealed reed contacts disposed in the same relay coil in close proximity with one another, and wherein certain of said contacts are operated as magnetically biased, normally-closed contacts, and being so arranged as to not affect the operation of the normally-open or weakly biased latching switches disposed in the vicinity thereof.

It is a further object of the present invention to provide a relay construction utilizing sealed reed switching units wherein latching contacts may be provided in the same relay with normally-open and normally-closed contacts.

It is still another object of the present invention to provide means for adjusting the strength of a bias magnet used in conjunction with the normally-closed reed switching unit or with the latching switching units without altering the physical shape of the magnet or its proximity to the switch, thereby allowing means for compensating for variation in the reed switch operate characteristics and geometry within the relay coil to re-open at some bucking flux by the relay coil that is specified as a relay parameter.

It is a still further object of the present invention to provide a method of manufacturing an electro-magnetically operated relay utilizing sealed switching units, wherein the switching units are pre-selected for their individual operate and release characteristics and are thereafter arranged in a prescribed relationship to one another and to a magnetic coil to take advantage of the variations in intensity of flux induced by the coil and influencing the operation of the various switching units operated thereby, and wherein such pre-selection and arranging will further tend to permit the various switching units to operate or to release in unison.

The present invention disclosed herein finds application in relays of the type comprising a plurality of glass-sealed reed contact devices arranged co-extensively in a group with a common coil surrounding the same, which coil serves to simultaneously energize the reeds to control electrical circuits. A flux-carrying metallic casing substantially surrounds the coil as a means of directing the coil flux towards the reed switches. The reeds of such relays are also of known construction and are made of magnetic material of high electrical conductivity and may be plated with gold or other precious metal, if so desired. The contacts of each reed switch are preferably enclosed in a hermetically sealed, tubular envelope made of vitreous material such as glass. The envelope is filled with an inert gas such as helium, argon, neon or other non-corrosive gas and is sealed at each end to prevent escape of the gas and admission of foreign particles to the contact areas.

For a fuller understanding of the nature and objects of this invention, reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

FIG. 1 is a view in longitudinal section taken in the plane of lines 1—1 of FIG. 2 of a relay embodying the features of the present invention;

FIG. 2 is a cross-sectional view taken in the plane of lines 2—2 of FIG. 1;

FIG. 3 is a top plan view of a biasing magnet used with certain of the switching units which may be used with the relay of the present invention;

FIG. 4 is a view in side elevation of the biasing magnet of FIG. 3, and indicating the flux path through an adjacent normally-closed or latched contact;

FIG. 5 is a diagrammatic view, partially in section of the apparatus in magnetizing the biasing magnet of FIG. 3;

FIG. 6 is a diagram of the demagnetization curves of ferrite material useful in manufacturing the biasing magnets of FIGS. 3 and 4;

FIG. 7 is a diagram of a typical set of curves illustrating the range of ampere-turns needed to operate and to release a typical group of normally-closed switches used in conjunction with the relay of this invention.

It is to be noted that in the views of FIGS. 1, 2 and 5 that various supporting members not forming a specific part of the present invention have been omitted for the sake of clarity in drawing and description. It will be obvious that additional supporting spacer members, terminals and other necessary appurtenances will be required in the commercial application of the relay of FIGS. 1 and 2. Stationary supporting members and other means of support are also required in the magnetizing apparatus of FIG. 5, but have also been eliminated for the sake of clarity and will be readily understood by those familiar with the art.

It has been observed that in the magnetic circuit of a relay coil there is considerable variation in the usable flux density affecting operation of the various switching units actuated by the coil. That is, the magnetic field is known to be strongest at each of the corners of the rectangularly wound coil, and is somewhat lessened at leg portions intermediate these corners, whereas the magnetic field affecting the operation of switching units disposed centrally of a coil window is even of relatively lesser intensity than that of the intermediate leg portions. It will be further appreciated that normal manufacturing procedures inevitably produce some variations in the switch operating characteristics. Tolerance limitations are difficult to maintain and changes in the unit cannot be made after sealing. This will be apparent from the following description of the various switching units, designated generally by the reference numeral 10 (see FIGS. 1 and 2) and disposed in the window 11 of the coil 12. The switches 10 each comprise two elongated metal strips or reeds 13 and 14 sealed in a glass tubular enclosure 15. The strips are of ferromagnetic, electrically conducting metal, preferably of a nickel-iron alloy having a co-

efficient of expansion approximately equal to that of the glass enclosure **15**, and terminate in overlapping contact surfaces **16**. The contact surfaces **16** may be coated with gold or other precious metal, if so desired. The interior **17** of the glass enclosure **15** is preferably filled with an inert gas to minimize contact contamination and deterioration through corrosion, etc. The space between the contacts **16** is quite minute and may be between 2 and 3 millimeters. Each metallic reed **13**, **14** is anchored in the glass enclosure at **18**. The switching units **10** are manufactured as normally-open contacts, as shown in the units of the columns designated X and Y of the view of FIG. 2. Application of a magnetic field from the coil **12** causes the reeds to assume a position parallel with the magnetic lines of force, thereby contacting each other.

A metallic-flux-carrying casing **19** surrounds the coil **12**. The casing **19** being of low reluctance, prevents the loss of flux through other undesired paths and hence substantially all of the coil flux is directed to, and concentrated at the gaps between the overlapped portions of the reeds **13** and **14**.

It is often desirable, however, to provide normally-closed contacts or biased closed latching contacts as shown in the switching unit **10** of the columns designated by the reference character W of FIG. 2. Here a biasing magnet, indicated generally by the reference numeral **20**, is provided to maintain the contacts in the normally-closed position. In the case of latching contacts AW and BW (see FIG. 2), these contacts are normally open, as shown, but remain latched upon the first pulse of current of the proper direction in the coil **12**, as will be later explained. The magnet **20** is provided with a keeper **21** of magnetic material. The magnet **20** and its manufacture form a part of the present invention which will be hereinafter described.

It is also often desirable to provide paired latching contacts composed of adjacent switches, indicated as swtiching unit **10** of rows Y and Z of FIG. 2. In this case a magnet **22**, without keeper is disposed between a pair of switching units **10**, as may be found in rows designated by the reference characters A, B, C, D of columns Y and Z of FIG. 2.

In the present embodiment, as aforementioned, there may be single and paired latching contacts. The action of the relay with respect to the latching contacts, in general, can be visualized by considering the directions of the magnetic fields produced by the permanent magnets **20** or **22**, respectively, in conjunction with the coil **12**. An otherwise normally-open switch, such as the switches AW and BW, is subject to the influence of an adjacently disposed permanent magnet, but the force of the magnet is maintained at a level not high enough to close the switch contacts. If, however, a pulse of current is sent through the coil **12**, which sets up a flux in the same direction as the flux from the permanent magnet, the contacts will close. The permanent magnet then keeps them closed with no further current required in the coil. To open the contacts, a second pulse of current is sent through the coil in the opposite direction and it produces a flux that opposes and overcomes the permanent magnet flux, thus releasing the reeds.

In the case of the paired latching contacts, such as those of columns Y and Z of FIG. 2, the switching units **10** are alternatively operated relative to one another, and are illustrated in a "normal" or initial position with the contacts AY, BY, CY and DY open and the other respective pairs AZ, BZ, CZ and DZ in latched closed position. Thus, for instance, upon supplying the coil **12** with a charge of (+) current the contacts AZ, BZ, CZ and DZ will unlatch and their paired contacts AY, BY, CY and DY will latch closed. Reversal of supply current to (−) current will return the contacts to the respective "normal" positions illustrated.

Having now outlined and described the various components which may be used to make up a relay, it will be apparent that heretofore a commingling of switching units has been next to impossible to provide in one coil, and only then where provision was made for considerable spacing between each of the switching units to avoid the problem of having the operation of one unit affect the operation of a unit of differing magnetic characteristics. The present invention contemplates and overcomes these problems, and further provides a relay construction which, at the same time, meets rigid industrial specifications, requiring that each of the switching units of the relay operate at 80% of nominal voltage at its highest expected operating temperature. For example, under these conditions, all switches are expected to operate or release at or below a given voltage at minimum coil power. For instance, the 80% value of a 24 volt coil; i.e., 19.2 volts, will be reduced, for commercial application to a value of under 15 volts at a operating maximum temperature of 90° C. Heretofore, in order to manufacture each of the switches to meet such severe requirements, rigid tolerances were maintained, leading to considerable scrapping of switches. The problems will become particularly apparent when one realizes that there is no means possible for adjustment after the reeds **13** and **14** have once been sealed in the tubes **15**. However, the present invention contemplates the fact that coils vary in flux density at certain areas of the coil configuration, and takes advantage of this fact in providing a relay wherein each contact is disposed in optimum operating position relative to the field intensity of the coil.

In accordance with this discovery, each of the switching units **10** are made in accordance with the best known manufacturing techniques, within relatively broad and reasonable tolerances. The switches are then sorted, selected and placed into groupings according to the number of ampere-turns required to operate the contacts to closed positions and to release the contacts to open position. That is, a standard test coil is provided for sorting purposes (not shown). This test coil consists of 10,000 turns of No. 36 wire and is 1¾ inches long. Thus, for instance, each of the switching units **10** may be taken from the manufacturing line and placed in the standard coil for measurement of its "operate" and "release" characteristics. Thereafter, the switches **10** are sorted into containers for proper selection. The switching units **10**, designated by column and rows AW, DW, AZ and DZ of FIG. 2, are disposed in areas of relatively high flux density. For instance, a typical 24 volt relay may be built to comprise switching units sorted into a range of 94–101 ampere-turns to "operate" the contacts from normally-open to closed position, whereas "release" of the contacts will fall within a range of 38–43 ampere-turns for the same switch. The intermediately disposed switching units of column-rows AX, AY, DX, DY, BW, CW, BZ and CZ requiring greater amounts of flux, may be selected from those sorted into an "operate" ampere-turn range of 86–93 and "release" ampere-turn range of 32–37. The more remotely disposed switching units **10** of column-rows BX, BY, CX and CY would be chosen to "operate" at 78–85 ampere-turns and to "release" at 26–31 ampere-turns.

Thus, the relative sensitivity of each of these switches will be disposed in positions of higher flux density of the coil and the relay will end up with all of its switching units **10** operating and releasing at within an approximate 15 volt range at minimum coil power, and thereby fit within the industrial specifications in one commingled unit. In addition, another major advantage in providing the present construction lies in the fact that all switching units affected by the coil **12** will operate substantially in unison. It will be apparent that the disposition of the switching units in accordance with a preselected operating range is of a considerable meritorious contribution when one considers the relative difficulty in manufacturing the

present type of switching units and the rigid tolerances that have been required previously.

Another important feature of the present invention resides in the novel biasing magnets **20** and **22** used in the normally-closed switching units C and D of column W of FIG. 2, and in the latching switching units of A and B of column W, and the paired latching units of columns Y and Z of FIG. 2.

Although it is possible to use other magnets, it has been found to be preferable to provide a ceramic magnet of barium ferrite for biasing the reeds **13** and **14** into closed position or for use as a magnetic latch. The characteristics of this ceramic permanent magnet material is that its retentivity is high, and if subjected to a demagnetizing field, it will substantially regain its original magnetic characteristics when the demagnetizing field disappears. The permeability of the ceramic permanent magnet material is very close to unity. Therefore, it is like air and cannot be saturated. In addition, one very important feature is that its field is directional in nature. The magnet **20** is illustrated in the views of FIGS. 3 and 4, and is further provided with a keeper **21** which insures the directional characteristics in the case of normally-closed or latched switches of column W of FIG. 2. The magnet **22** is used without a keeper for latching purposes, when one magnet is intended to affect the "operate" or "release" characteristics of paired latching switches, such as those of columns Y and Z of FIG. 2. Magnets of the ceramic, barium ferrite type also exhibit a high coercive force, as shown by the demagnetization curve **25** of the second quadrant of the B–H hysteresis loop of FIG. 6, as well as a low residual induction. The preferred ceramic magnet is of the non-oriented type, but it is within the province of the present invention to utilize oriented barium ferrite magnets, provided that the field influencing the magnet is maintained so that the induction B is above the knee of the curve **26** of FIG. 6. The advantage of using the non-oriented material will be apparent from the second quadrant curve of the hysteresis loop, wherein the demagnetization characteristics are clearly shown. The main criterion and good design practice governing the use of the oriented material, such as that exhibiting the curve **26** is that the effect of the demagnetizing field must not act to force the shearing line **27** below the knee **28** of the curve **26**.

As stated previously, the curve **25** of FIG. 6 shows the approximate demagnetization characteristic of the preferred material, which is non-oriented barium ferrite. This curve dictates that an efficient magnet will have a low magnetic length-to-area ratio. Since the characteristic is a straight line, special keepers are not necessary for magnetizing the magnet because the so-called shearing line will always dictate operation of the demagnetization curve shown. The bias strength of the magnet may be varied by magnetizing only that length L_1, as shown in FIG. 3 by means of the magnetizing fixture illustrated in FIG. 5. Thus, standard size magnets may be used and may be substituted in a fixed geometry to obtain varying "operate" and "release" characteristics. In a ceramic magnet of the present type, the field is very directional and substantially normal to the longitudinal axis of the magnet **20**. Therefore, certain area sections of the magnet, such as those defined by the areas L_1w and L_2w, may be magnetized independently of one another, as indicated in FIG. 3. The area L_1w has its north pole at the upper surface with relation to FIG. 4, and the poles of the area L_2w is magnetized with its south pole at the upper surface and the north pole adjacent the keeper **21**. Another favorable characteristic of this ceramic permanent magnet material is that its retentivity is high, and if subjected to a demagnetizing field, it will regain substantially its original magnetic characteristics when the demagnetizing field disappears. The coercive force of the preferred ceramic magnet is high as indicated by the demagnetization curve **25**, and therefore, the magnet will be effective in the short lengths L_1 and L_2. Thus, the coercive force will be high even with low length-to-area ratios.

Accordingly, the present invention further contemplates a method and apparatus for magnetizing the magnets **20** in the discrete sections defined by the areas L_1w and L_2w. The fixture (see FIG. 5) used in magnetizing the magnets **20** or **22**, in general, comprises two armatures or cores **30** and **31**, which are movable laterally relative to one another by means of a simple adjustment means, such as individual worm screws **32** and **33** terminating in knobs **34**. The details of the worm screws and the support for the armatures should be obvious to those skilled in the art, and are not herein shown in detail. Each of the armatures **30** and **31** are provided with separate coils **35** and **36**, respectively. Thus, D.C. current of, for instance, a value sufficient to produce a magnetizing field of 10,000 gauss in the air gaps, is applied to the armature through its respective coils **35** or **36** and will provide a flux path, as shown at **37**, through a block of iron or pole piece **38** and a supporting block of iron or pole piece **39**. Armatures **30** and **31** are movable relative to the stationary blocks **38** and **39**. A brass, or other non-magnetic, plate **40** is disposed at the upper surface of the base magnetic block **39** and is recessed to receive the magnets **20** or **22**.

As shown in FIG. 5, the coils **35** and **36** are wound in such manner as to provide a flux path **37** as to magnetize discrete areas L_1w and L_2w with the north pole of area L_1w being at the top surface of the magnet **20** viewed at the left of FIG. 5, and the south pole of the top surface of the area L_2w, as viewed at the right of FIG. 5. In this manner, the areas L_1w and L_2w may be enlarged or decreased as desired without requiring a change in magnet size or shaving of surfaces to provide variations in cross-section or other means of varying the flux of the magnet. These areas are merely changed by moving the armatures **30** or **31** inwardly or outwardly relative to one another by turning the respective knobs **34** and their respective worm screws **32** and **33**.

The magnet **20** and its keeper **21** are removed and placed adjacent a respective switching unit **10** to provide the desired biasing effect. The magnet is magnetized so as to operate the reed contacts **13** and **14** for normally-closed or latched position as shown at positions CW, DW, AZ, BZ, CZ and DZ of FIG. 2, in order that they will operate within a specified ampere-turn range. Obviously, the degree of magnetization for latching contacts of positions AW, BW and those of columns Y and Z will be less than that required for normally-closed contacts CW and DW. The field is very directional and will affect only the particular reeds in question, and will not affect an adjacent normally-open contact, such as those of column X of FIG. 2 when the keeper **21** is used. Nor will the switches of column X be affected by the biasing action of the magnets **22** for the latching pairs of columns Y and Z.

Thus, current in the coil **12** will provide a flux path in opposition to the magnets **20**, so as to open the normally-closed contacts of the columns W and Z and to close the normally-open contacts of the columns X and Y. In the case of the latching contacts of columns Y and Z, the respective contacts will remain in the position other than the normal position upon cessation of the current supplied to the coil **12**. Obviously, the present invention permits rearrangement of the switching units as desired, just as long as the magnets affecting all contacts of a particular column are of like structure.

As far as the magnetization of the magnet is concerned, it will be appreciated that individual magnets **20** or **22** must at least match the ampere-turns of the coil necessary to operate a particular switch **10** from its normally-closed position, or to hold the contacts of a particular switch in latched position when current is interrupted in the coil.

Referring to the diagram of FIG. 7, it will be observed that a switch (for purposes of illustration, the switch hav-

ing characteristics wherein, it will open within a range or band of 78–102 ampere-turns and will close within a band of 26–42 ampere-turns) has certain "operate" and "release" characteristics which are affected by the combined flux of the biasing magnet and the coil. The switch exhibits four sensitivity points of operation, as indicated at the zero ordinate, where no magnet is used, as in the case of a switch with a normally-open contact. The band defined by +78 and +102 ampere-turns, for example, defines a range which insures the operation of the contacts to contact-closed position, whereas the band defined by +26 and +42 ampere-turns indicates a range which insures that the contacts will be open. That is, if one follows the zero ordinate vertically from the zero abscissa, it will be observed that the normally-open contacts of the present preselected assortment will begin to close as the coil flux is increased in a positive direction to the value of +78 ampere-turns, and all will be closed when current is supplied in an amount equal to +102 ampere-turns. As the positive current is decreased, the contacts will begin to release at +42 ampere-turns and will all be open at +26 ampere-turns.

A mirror image of the action takes place in the negative area below the zero abscissa, and as negative current is supplied to the coil, the normally-open coils will remain open until a coil flux value of −78 ampere-turns is reached and will all be closed when a value of −102 ampere-turns has been supplied thereto. Decrease of negative current supplied to the coil will permit the contacts to open between −42 and −26 ampere-turns.

In the case of providing a biasing magnet for holding contacts in normally-closed position, such as those indicated at CW and DW of FIG. 2, it will be apparent that the biasing magnet must be magnetized in areas L_1w and L_2w with a flux equivalent to 102 ampere-turns or in excess of this amount when positive current is supplied. It will be necessary to provide the coil with negative current before the contacts will open.

In the matter of providing a biasing magnet for latching type contacts, such as those indicated at AW and BW and the paired switches AY, BY, CY, DY, AX, BX, CX, and DX of FIG. 2, the magnets **20** and **22**, respectively, are magnetized in areas L_1w and L_2w to provide a flux equivalent to ampere-turns that fall within the "operate" and "release" range, such as +78 and +102 and +26 and +42, respectively, in the case of the preselected contact assortment under present discussion. Similar selection would be true for other switch operating characteristics. The present biasing magnet will then act to shift the sensitivity values to the right of the diagram of FIG. 7, and in the present case to intersect with the vertical line indicated by the dot-dash line drawn at an arbitrarily selected magnet flux value of 57 ampere-turns. This value is preferably chosen to lie intermediate the "operate" and "release" bands. Thus, it will be observed that the magnet will shift the coil flux necessary to open the contacts from the 78–102 ampere turns positive current band to a lesser value of approximately 22–46 positive current ampere-turn band. This shift is due to the fact that the permanent magnet acts in combination with the coil to supply the total flux necessary to operate the contacts.

It will be further observed that the contact open, or "release" band has been shifted by the magnet to negative values of approximately −12 to −28 ampere-turns. The negative contact open "release" band is also shifted, as is the negative contact closed or "operate" band, but to higher negative values of approximately −82 to −98 ampere-turns and −135 to −159 ampere-turns, respectively. Referring to the vertical dot-dash line at 57 ampere-turns of magnet flux, it will be apparent that as positive current is supplied to the coil, the contacts will close between a value of approximately +22 and +46 ampere-turns, and remain closed, or latched, even after the current is interrupted. It will take a negative current to release the contacts and of approximately −12 to −28 ampere-turns. It is of interest to note that the contacts will then remain open until a value of approximately −135 ampere-turns is reached. Here, there will be no latching effect upon interruption of current, as the contacts will again open as the negative current is released to the band of approximately 82–98 ampere-turns. However, the magnet may be magnetized in such manner as to latch within the negative coil flux "operate" band by simply reversing the magnet with respect to the reeds **13**, **14** or to reverse the input to the coil **12**.

It will be apparent that since the preferred ceramic magnets of the present invention lend themselves to magnetization of discrete areas and are very directional in nature, that it is within the scope of this invention to supply magnets (not shown) which are of equivalent size as the areas L_1w and L_2w, but which are independent from one another and separately fastened to opposite ends of a keeper (such as keeper **21**). The keeper would be of ferromagnetic material for use with switches, such as those of columns Y and Z of FIG. 2, a non-magnetic supporting bar would be used with the ceramic magnetic slugs being fastened by cement to other means to extend from opposite ends thereof (not shown).

Another important aspect of the present invention results from the use of ferrite biasing magnets, which permit automatic temperature compensation of the biased contacts. Since the coil flux is produced by the coil ampere-turns, and since an increase in temperature causes the coil resistance to increase, the coil flux in terms of ampere-turns will be less for a given coil voltage at a relatively higher temperature. This was the reason for specifying 15 volts as a minimum "cold" operating voltage, corresponding to a measurement on a cold coil for 80% of voltage operation at highest specified operating temperature. This is true for all normally open contacts.

In the case of biased normally closed contacts, however, the present relay takes advantage of the decrease in bias flux provided by a ferrite magnet as temperature is increased. This decrease in magnet bias flux is therefore matched with the decrease in coil ampere-turns as the operating temperature increases due to increase in coil resistance. Thus, the coil operating voltage will not vary appreciably with changes in temperature. This effect is only apparent in the biased contacts of the switching units.

While this invention has been herein described by reference to specific embodiments of the same, it is intended that the protection of Letters Patent to be afforded hereby be not unnecessarily limited by such description, the intention being that such protection extend to the full limit of the inventive advance disclosed herein as defined by the claims hereto appended.

I claim:

1. In the manufacture of a relay comprising a plurality of sealed switching units having individual operating characteristics and a common energizing coil defining a window and which coil when energized produces a variable magnetic field within the window, said field varying from a maximum at the periphery of the window to a minimum at the center point of the window; the improved manufacturing procedure of individually subjecting a plurality of switching units of unknown operating characteristics to the magnetizing field of a standard coil of preselected dimension and coil flux, sorting said switching units into groups in accordance with the amount of coil flux required to operate the units by said standard coil, and positioning said switching units within the window, a number of said switching units being positioned adjacent to the periphery of the window and at least one of said switching units being positioned remote from the periphery of the window and intermediate switching units positioned adjacent the periphery of the window, each switching unit being positioned in a predetermined area of

the variable magnetic field of said common energizing coil corresponding with the amount of flux needed to operate the respective sorted switching unit.

2. In the manufacture of a relay comprising a plurality of sealed switching units having individual operating characteristics and a common energizing coil defining a window and which coil when energized produces a variable magnetic field within the window, said field varying from a maximum at the periphery of the window to a minimum at the center point of the window and wherein it is desired to operate said units substantially in unison or in a desired sequence; the improved manufacturing procedure of individually subjecting a plurality of switching units of unknown operating characteristics to the magnetizing field of a standard coil of preselected dimension and coil flux, sorting said switching units into groups in accordance with the amount of coil flux required to operate the units by said standard coil, and positioning said switching units within the window, a number of said switching units being positioned adjacent to the periphery of the window at least one of said switching units being positioned remote from the periphery of the window and intermediate switching units positioned adjacent to the periphery of the window, each switching unit being positioned in a predetermined area of the variable magnetic field of said common energizing coil corresponding with the amount of flux needed to operate the respective sorted switching unit in substantially simultaneous operation with the others of said units or in a desired sequence of operation therewith.

3. In the manufacture of a relay comprising a plurality of sealed switching units having individual operating characteristics and a common energizing coil of rectangular configuration and defining a window therein for receiving said switching units, said coil producing a magnetic field within the window through said switching units when energized, said field varying from a maximum at the periphery of the window to a minimum at the center point of the window; the improved manufacturing procedure of individually subjecting a plurality of switching units of unknown operating characteristics to the magnetizing field of a standard coil of preselected dimension and coil flux, sorting said switching units into groups in accordance with the amount of coil flux required to operate the units by said standard coil, and positioning said switching units in said coil window, a number of said switching units being positioned adjacent to the periphery of the window and at least one of said switching units being positioned remote from the periphery of the window and intermediate switching units positioned adjacent the periphery of the window, each switching unit positioned in a predetermined area of the variable magnetic field of said common energizing coil corresponding with the amount of flux needed to operate the respective sorted switching unit.

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JOHN F. CAMPBELL, *Primary Examiner.*

J. M. ROMANCHIK, *Assistant Examiner.*