

June 4, 1968

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3,387,238

MECHANICAL LATCHING COORDINATE SWITCH

Filed Sept. 12, 1966

5 Sheets-Sheet 1

Fig. 1A

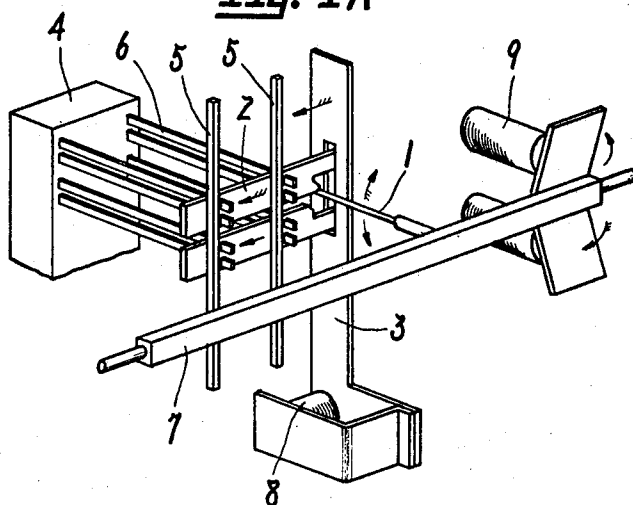
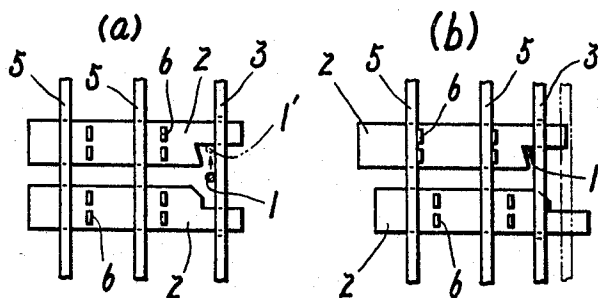


Fig. 1B



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Fig. 2A

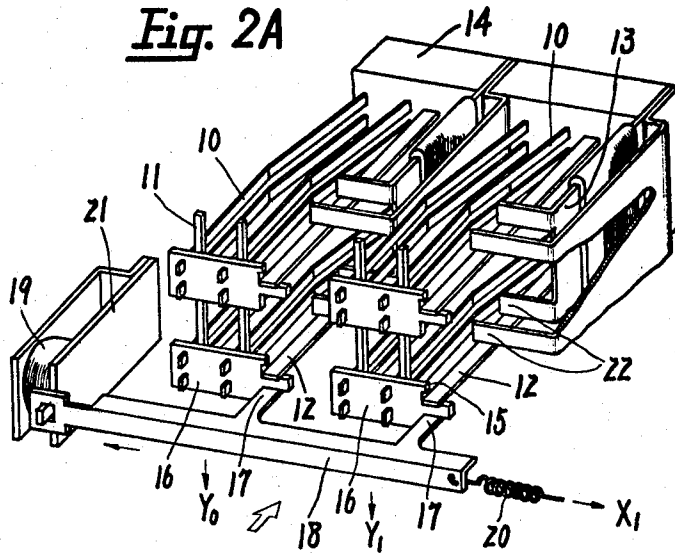
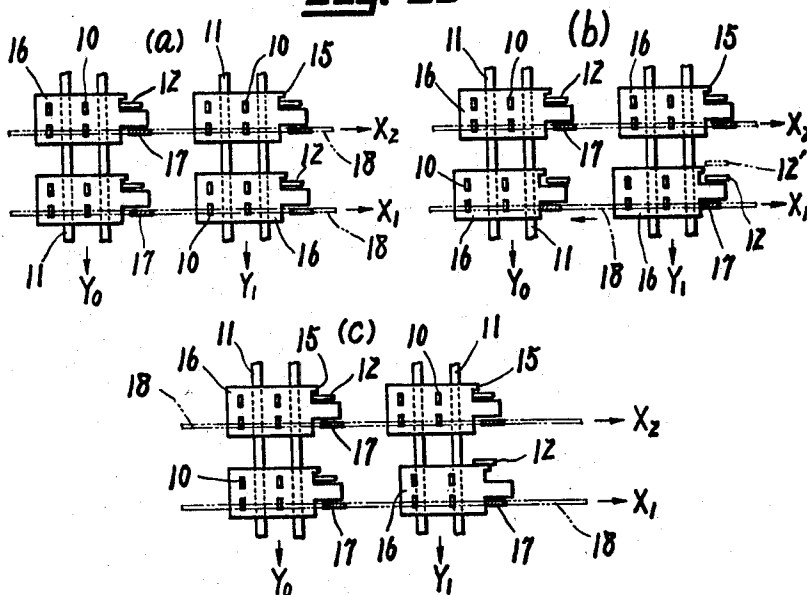


Fig. 2B



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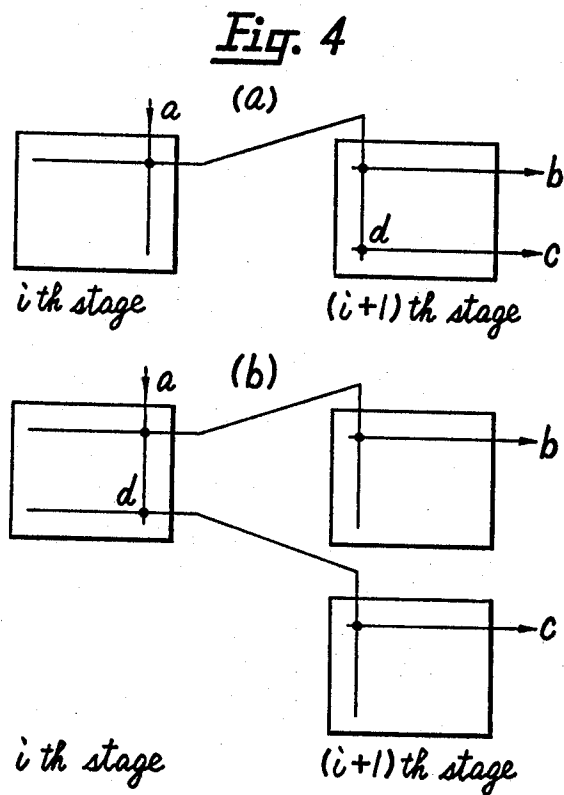
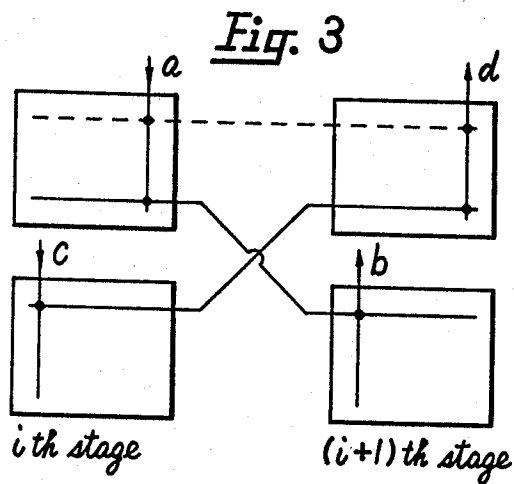
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5 Sheets-Sheet 3



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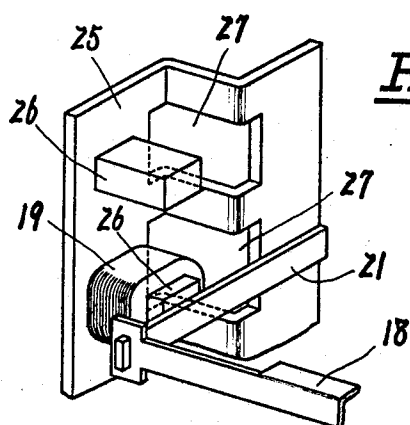


Fig. 6

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MECHANICAL LATCHING COORDINATE SWITCH

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Filed Sept. 12, 1966, Ser. No. 578,733

Claims priority, application Japan, Mar. 25, 1966,
41/17,902

4 Claims. (Cl. 335—112)

ABSTRACT OF THE DISCLOSURE

A mechanical latching coordinate switch having a plurality of coordinately arranged contact groups, in each of which holding fingers and contact actuating cards are arranged in such manner that they are movable only in one direction, respectively, and the directions of their movements are perpendicular to each other, resetting bars for driving the contact actuating cards in each horizontal row, electromagnetic devices for driving said resetting bars and electromagnetic devices for simultaneously actuating the holding fingers in each vertical column, whereby the resetting bars and the holding fingers are driven by the electromagnetic devices to disengage the holding finger from the contact actuating card so as to maintain the desired cross-point connection and engage the both members so as to maintain the cross-point release.

This invention relates to coordinate switches to be used for switching networks of telephone exchange and more particularly to coordinate switches wherein mechanical latching is carried out with flat spring fingers.

Conventional non-latching cross-bar switches such as disclosed in U.S. Patent No. 2,350,464, have defects that

(1) The inertias of the selecting bar and holding arm are so large that the operating time and releasing time are long,

(2) As the electric energization of the holding electromagnet is required to hold a cross-point connection, the electric power consumption is large, and

(3) It is necessary that the selecting finger should be able to move in both vertical and horizontal directions, therefore the operation is not sure, misoperations are apt to cause and the transient vibration at the time of the operation and the release lasts long.

The conventional cross-bar switches comprises a set of contacts arranged on horizontal rows and vertical columns, bars, each of which being common to two horizontal rows, bars, each of which being common to two vertical columns, flexible linear fingers attached to the horizontal bars, operating plates with notches and an electromagnetic means for driving rollers and bars mounted on holding springs, whereby the linear finger enters into the notch of the operating plate to push or withdraw the finger and operating plate so as to operate the contacts and the roller mounted on the holding spring is fitted in the notch of the operating plate for keeping the contacts in the operation state. The conventional switch is required for maintaining the operation and operating state of the contacts to provide two entirely different kinds of the holding springs provided with the finger and roller so that the switch is complicated in its construction and becomes inevitably expensive. Furthermore, the wear caused by the sliding movement of the rollers is not negligible. For releasing the contacts which are in the operating position there requires the sequence of operation reversed to that at the time of operation by changing the sequence of operation of each element. Therefore, in the conventional switch there is the need of releasing the contact

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every time of the completion of a call, whereby the operation is not sure, malfunctions are apt to result, and the transient vibration at the time of the release lasts long, thus making the control of the switch complicated so that no high speed operation can be expected.

With the recent development of electronic exchanges, it has come to be desired to realize a switching apparatus with metallic contacts of a high speed, small electric power, small size and light weight as a switching network element. As a typical switching apparatus for electronic exchanges, the principle and embodiments of so-called "Ferreed switches" are shown in The Bell System Technical Journal, vol. XLIII, September 1964, No. 5, pages 2374-2376.

They are of a system wherein a set of reed switches and a core having a proper coercive force are arranged at a cross-point and a differential exciting winding is applied to the core so that the residual magnetization of the core may be reversed by an exciting current, the reed switches may be operated, held or released by the combination of the polarities of the residual magnetization and the contacts may be operated and released at a high speed of about 2 ms. Specifically, if the residual magnetization is reversed, the switches will operate. Therefore, it is a feature of this system that the exciting current pulse may be of a time width (of about 100 μ sec.) required for the magnetization reversal.

Further, if, in order to select and to connect one cross-point, an electric current is passed through the exciting coils of the row and column to which said cross-point belongs, said cross-point contact will be connected but all the other connected cross-points belonging to the same row and column will be released. Therefore, there is no need of releasing the cross-point upon the completion of a call and it is simple and easy to control the switching apparatus.

While the Ferreed switches have the following demerit that, the exciting current therein is so large (about 10 amperes) that the selecting circuit of the exciting coil terminals cannot be composed of such element of high speed operation as a semiconductor device or reed relay, a large electromagnetic relay slow in the operation must be used. Consequently, the time required for the final connection of a cross-point after a control signal which identify the exciting coil has been received, cannot be reduced.

Further, the Ferreed switches are comparatively so large in the occupying volume and weight that, in the case of forming an electronic exchange apparatus the occupied space of the switching devices in the telephone office building is very large.

Therefore, an object of the present invention is to provide a switching apparatus operated at a high speed by eliminating the various defects of conventional switching apparatus.

A further object of the present invention is to provide a switching apparatus of a small electric power consumption, a small size, light weight and low price.

A still further object of the present invention is to economically realize a telephone exchange system with high serviceability.

In the accompanying drawings,

FIG. 1A is a perspective view showing the operating principle of a conventional non-self-latching cross-bar switch;

FIG. 1B is a view showing a cross-point connection in a conventional non-self-latching cross-bar switch;

FIG. 2A is a perspective view showing the operating principle of a mechanically latching cross-bar switch of the present invention;

FIGS. 2B(a), 2B(b) and 2B(c) are elevations of FIG.

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2A showing cross-point connections in the mechanically latching cross-bar switch of the present invention looking in the direction of the arrow;

FIG. 3 is a view showing an inter-stage wiring to be forbidden when a mechanical latching cross-bar switch of the present invention is used;

FIG. 4 is a view showing an offering connection when a cross-bar switch of the present invention is used;

FIG. 5 is a partly sectioned elevation of a mechanically latching cross-bar switch of the present invention;

FIG. 6 is a perspective view illustrating the structure of a yoke of a resetting electromagnet to be used for the cross-bar switch of the present invention.

The explanation of the operating principle of a non-self-latching cross-bar switch usually used for a conventional common control exchange is shown in FIG. 1A and the explanation of the selecting operation of a cross-point contact is shown in FIG. 1B. Both drawings show a pair of cross-points belonging to one vertical column among cross-points arranged in a matrix. The case of selecting and connecting the cross-point on the upper side shall be explained in the following.

In FIGS. 1A and 1B, 1 is a selecting finger, 2 is a contact actuating card, 3 is a holding arm, 4 is a vertical unit frame, 5 is a vertical multiple contact rod, 6 is a cross-point movable contact spring, 7 is a selecting bar for actuating the selecting finger, 8 is a holding magnet for driving the holding arm and 9 is a pair of selecting magnets for driving the selecting bar.

In FIG. 1A, when the selecting magnet 9 of lower side is electrically energized to actuate upwardly the selecting finger 1 and select a horizontal row, the selecting finger 1 will be shifted into an operating clearance formed by the contact actuating card 2 and holding arm 3 as shown by 1' in FIG. 1B(a). Then, if the holding magnet 8 in FIG. 1A is electrically energized to horizontally move the holding arm 3 belonging to a desired vertical column as in FIG. 1B(b), the contact actuating card 2 (on the upper side of the drawing) will be pushed through the finger 1 so that the cross-point movable contact spring 6 and the vertical multiple contact rod 5 may be electrically connected.

When a desired cross-point is selected as in the above, the electrical energization of the selecting magnet 9 will be interrupted but the electrical energization of the holding magnet 8 for driving the holding arm 3 will be continued in order to maintain the cross-point connection.

Now, the fundamental principle of the mechanically latching coordinate switch of the present invention shall be explained with reference to the drawings.

FIG. 2A is a perspective view for explaining the operating principle of the mechanically latching coordinate switch of the present invention. FIG. 2B is a view for explaining a cross-point connection. Both drawings show four cross-points belonging to two horizontal rows and two vertical columns among cross-points arranged in a matrix. The case of selecting and connecting the cross-points on the lower side shall be explained in the following.

In FIGS. 2A and 2B, a resilient contact spring 10 made of an electric conductor and provided with a contact, a vertical multiple contact rod 11 made of an electrical conductor, a holding finger 12 and a finger driving magnet 13 are fixed to a frame 14 made of an electrical insulator so as to form a vertical unit. A contact actuating card 16 made of an electrical insulator and provided with a projection 15 to engage with the holding finger is fitted to the tip of the contact spring 10.

The holding finger 12 is in the form of a flat spring and is made of a magnetic material high in tensile strength or is made by securing a magnetic material to a resilient spring material and is formed so that all the holding fingers mounted on the vertical unit may be directly electromagnetically and simultaneously attracted by the finger driving magnet 12 and two or more holding fingers are driven by one driving coil. As this holding finger is

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flat-shaped, it can move only vertically in FIG. 2A but does not move horizontally due to its rigidity.

A required number of the above described vertical units are arranged and as many resetting bars 18, which are provided with projections 17 to engage with the contact actuating cards 16 corresponding to the respective cross-points of the horizontal rows as the horizontal rows are arranged. Each resetting bar is mounted to an armature 21 of a resetting magnet 19 at one end and is tensioned with a restoring spring 20 at the other end. Therefore, if the resetting magnet 19 is electrically energized, the resetting bar 18 belonging to said magnet will be pulled longitudinally and the contact actuating cards 16 in the same horizontal row engaging with the resetting bar 18 at the projection 17 thereof will move together with the resetting bar 18.

FIGS. 2A and 2B(a) show a state in which the projection 15 of the contact actuating card 16 is engaged with the holding finger 12 and the cross-point is released.

In FIGS. 2A and 2B, in the case of connecting the cross-points of the row X_1 and column Y_1 , when the resetting magnet 19 of the row X_1 in FIG. 2A is electrically energized by a control signal, the armature 21 will be attracted and the resetting bar 18 will move in the direction indicated by the arrow. At this time, the contact actuating cards 16 of all the cross-points belonging to the row X_1 will be pushed in the same direction as of the resetting bar by the projections 17 of the resetting bar and, as shown in FIG. 2B(b) the finger 12 will separate from the projection 15 of the contact actuating card 16 and will be disengaged.

Then, if the finger driving magnet 13 of the column Y_1 is electrically energized by a control signal in FIG. 2A, an attraction will act on all the holding fingers 12 of the column Y_1 but only the finger 12 of the row X_1 and column Y_1 disengaged with the contact actuating card 16 will be able to move toward the magnetic pole 22 and, as in FIG. 2B(b), the holding finger will move to the position represented by 12' and will be completely separated from the projection 15 of the contact actuating card 16. But, as the holding finger belonging to the column Y_1 except at the cross-point of the row X_1 and column Y_1 is subjected to the action of the attraction but is locked not to move by the projection 15 of the contact actuating card 16, the holding finger and the contact actuating card remain engaged as they are. In this state, in FIG. 2A, if the electrical energization of the resetting magnet 19 is interrupted, the resetting bar 18 will return due to the restoring spring 20. At this time, the contact actuating card 16 pushed and moved by the projection 17 of the resetting bar 18 will also return to the original position due to the restoring force of the contact spring 10 or the like and will again engage with the holding finger. But, only the contact actuating card 16 at the cross-point of the row X_1 and column Y_1 at which the holding finger 12 is separated from the contact actuating card 16 will move together with the resetting bar 18 without being locked by the finger 12 and the contact will be connected. Then, if the electrical energization of the finger driving magnet 13 is interrupted, the cross-point will remain connected as in FIG. 2B(c) in a state of making no current flow to the electromagnet.

In releasing the connected cross-point, if the resetting bar 18 is operated as in FIG. 2B(b), the holding finger 12 will return from the position 12' to the position 12 due to its own resiliency and then, if the resetting bar 18 is released, the state shown in FIG. 2B(a) will be restored. The operation of releasing the cross-point of this resetting bar 18 will be carried similarly to the case of connecting the cross-point. Therefore, if one cross-point connection is made, at least all the other cross-points in the horizontal row belonging to said cross-point will be released.

As evident from the above explanation, the mechanically latching coordinate switch has a self-latching function by using such magnetic material low in coercive force as pure iron for the electromagnet core and yoke so that,

with the operation of one cross-point connection, all the other operated cross-points belonging to the same horizontal row will be released. This is different from the Ferreed switches wherein, with the operation of a cross-point connection, all the other operated cross-points belonging to the same horizontal row and vertical column will be released. In the mechanically latching coordinate switch, in the case of a cross-point connection, only the other operated cross-points belonging to the same horizontal row will be released but the other operated cross-points in the vertical column will not change its state.

Such cross-point selecting method as in the Ferreed switches has no need of releasing and controlling the switch upon the completion of a call and gives a convenience in the case of forming an exchanging system but has a defect that no offering connection can be made therein.

However, there has been suggested a system wherein, in the case of forming switching network by the mechanically latching coordinate switches, the formation and control of speech paths will be simple and an offering connection by the operator will be done easily.

Needless to say, with the completion of the call, the resetting bar is operated to release the cross-point, there will be no problem on a subsequent network connection. Aside from it, instead of the operation of the resetting bar upon completion of a call, the following restricting conditions may be applied to the inter-stage wiring of the switching network.

FIG. 3 is a view showing an inter-stage wiring to be forbidden when a coordinate switch according to the present invention is used. Such wiring as makes each row of the switch in one stage (i th) an outlet and makes each row of the switch in the next stage ($i+1$ th) an inlet as shown in FIG. 3 has a possibility of producing such cross-talk loop as is shown by the broken line for the connecting paths of $a-b$ and $c-d$ when the switch is not released upon the completion of a call and is therefore forbidden. However, if such inter-stage wiring as from column to row or from row to column or from column to column is made, no cross-talk loop will be produced. Such restriction will not be so disadvantageous, especially, in the case of constructing a switching network by the square matrix switch, because the row and column are quite symmetrical with each other.

Further, in the case of making a so-called offering connection of connecting another call to one call being made, with the Ferreed switch, when one cross-point in the switch is connected, the other cross-points belonging to the same row and column will always release and therefore it is impossible to make an offering connection within the switch. But, in the mechanically latching coordinate switch according to the present invention, in the case of connecting a cross-point, the other cross-points in the same row as of it will be released but the cross-points in the same column will not be influenced at all and therefore, by utilizing this fact, an offering connection can be made.

FIG. 4 is a view showing an offering connection when the mechanically latching coordinate switch of the present invention is used. As shown in the drawing, it is possible to form a connecting path with c by connecting a contact d further to a connecting path connecting a and b .

As explained above, in the mechanically latching coordinate switch according to the present invention, the resetting bar 18 in the horizontal row will be subjected mostly to a tensile stress and can be made very light and, as the holding finger 12 is driven directly with the electromagnet, the mass of its moving part is very small. Further, in the mechanically latching coordinate switch, during a call, no electric current is required to electrically energize the electromagnet, merely a pulse current may be impressed in the case of the connecting operation, therefore the temperature rise of the exciting coil will be very small, thus the amount of copper required for the exciting coil may be small, the time constant of the exciting coil

will become smaller and the operating time of the switch will be reduced very much.

Further, as the holding finger is flat-shaped as different from the known conventional selecting finger and its moving direction is limited to one, its operation will be sure. Further, as in the mechanically latching coordinate switch according to the present invention the holding finger and the finger driving magnet are mounted on a vertical unit and an electromagnetic attraction may act simultaneously on all fingers of column, so the structure of the finger driving magnet can be simplified and the relative positions of the holding finger, contact actuating card and finger driving magnet with one another can be realized accurately.

In the connecting operation of the mechanically latching coordinate switch, it is necessary to delay the movement of the holding finger 12 from the movement of the resetting bar 18 a little. However, if the operation is a little delayed by applying a copper sleeve or a bare copper winding to the finger driving magnet 13 or connecting an inductance and capacitance to the coil, the resetting magnet 19 and finger driving magnet 13 will be able to be electrically energized simultaneously with the same current pulse and the control of the switch will become easy.

FIG. 5 is an elevation of the embodiment of the present invention shown in FIG. 2A. As the vertical units Y_4 and Y_5 are used for pre-selection, it shows substantially a mechanically latching coordinate switch of 2 wires, 8 rows and 8 columns.

FIG. 5 shows an arrangement of the contacts 10, holding fingers 12 and resetting bars 18. As explained with reference to FIG. 2A, the contacts 10 and holding fingers 12 in the same vertical columns (Y_0, Y_1-Y_5) are secured to the unit frame 14 made of a synthetic resin by injection molding, together with the finger driving magnet 13 so as to form one unit.

Now, in arranging any required number of such vertical units, if all the vertical units are fixed by being fastened with bolts 24 passing through the upper ends and lower ends of the vertical units on the right side of a fixing plate 23 having the resetting magnets 19 fixed on the left side, a formation of switches of X rows and Y columns will be made. Thus, it is easy to form an optional number of vertical units and the assembly can be made very light.

In FIG. 5, the contacts in each of the columns Y_0 to Y_3 are arranged in two columns, a horizontal multiple connection is made on the back surface of switch and the fixed contact is in the form of a vertical multiple contact rod. In each of the vertical units of the columns Y_4 and Y_5 , the contacts are arranged in one column only backwardly. The fixed contact and movable contact of each contact pair in the columns Y_4 and Y_5 are both electrically insulated in the vertical column and are independent of each other and an electric terminal comes out on the rear side of the switch so as to make a unit for pre-selection. The left side contact spring terminals and the right side contact spring terminals of the vertical units Y_0 to Y_3 are horizontally multiple-wired with the movable contact spring terminals of the vertical unit Y_4 and the movable contact spring terminals of the vertical unit Y_5 , respectively. The fixed contacts in the same horizontal row of the vertical units Y_4 and Y_5 are connected with each other. Therefore, in the case of connecting the cross-point, if the holding finger 12 belonging to one of the vertical units Y_0 to Y_3 and either one of Y_4 and Y_5 and resetting bar 18 in the desired row are operated, a so-called pre-selective connection will be made.

The structure shown in FIGURE 5 provides a set of two units for pre-selection but a preselective function can be obtained by one unit. That is, each contacts group of the unit for pre-selection comprises two pairs of make-break contacts, wherein the movable contact which is opened when the holding finger 12 is engaged with the contacting actuating card 16, is horizontally multiple-wired with the

left side contact of the vertical units Y_0 to Y_3 , while the movable contact respectively which is closed respectively is horizontally multiple-wired with the right side contact of the vertical units Y_0 to Y_3 . Further, in the unit for pre-selection, the fixed contact is independent of each contacts and its terminal comes out on the rear side of the switch. In case of connecting the cross-point, if the holding finger belonging to one of the vertical units Y_0 to Y_3 are operated, a pre-selective connection will be made, according to the location of the holding finger of the unit for pre-selection.

Thus, the pre-selective connecting function can also be provided by only addition of a pair of units for pre-selection and the number of the cross-points contained in the horizontal row can be selectively varied with the increase of the vertical units so that the switch can easily be constructed and is universal and can be mass-produced.

Now, though the resetting magnets are fixed on one side of the fixing frame 23 to which the vertical units are fixed, the yokes of these electromagnets can be made in a body and used commonly as a path of magnetic flux so that they may be easy to make and may be made light in the weight and high in the speed.

FIG. 6 is a perspective view showing the structure of a yoke of a resetting magnet of a coordinate switch of the present invention. As shown in FIG. 6, the yoke 25 is bent by press working, has a core 26 arranged on one edge and is provided with an opening 27 in the part of the yoke 25 opposed to the core 26. This opening is effective to reduce the leaking magnetic flux between the core and the yoke and is useful for the high speed operation. Further, the required cross-sectional area of the yoke will be sufficient if it is such that, when one resetting magnet is electrically energized, no magnetic saturation will occur. The amount of iron will be remarkably reduced to be smaller than in the case of providing individual resetting magnets with independent yokes. Thus, it is useful to reduce the weight of the switch. Further, as these resetting magnets are arranged in one column, it is easy to make integral the hinge lug and back stop of the resetting armature or the restoring springs 20 of the resetting bar 18 (ref. FIG. 2A) also arranged in one column respectively. Therefore, it is very effective to the reduction of the number of parts and the reduction of the price of the switch.

The features of the mechanically latching coordinate switch of the present invention explained above are

(1) That it consists of vertical units on which cross-point contacts, holding fingers and finger driving magnets are mounted, horizontal resetting bars and resetting magnets, that the mass of the movable parts is so small that a high speed operation can be made,

(2) That is a self-latching switch wherein, in the case of a cross-point connection, the other operated cross-points in the same row will be automatically released, that the connection and control of a speech path are simple and an offering connection is possible,

(3) That the vertical unit frame and other parts are made of light materials, no switch frame is required and therefore it is light and small, that as it is formed by making various parts integrally, the number of component parts is reduced and, as it is of a structure in which the accuracy of the assembly is obtained easily, the price is low,

(4) That, as it is formed by piling up and bolting a required number of vertical units, in increasing the number of vertical columns, only the resetting bars may be changed and, if units for pre-selection are added, it will be

a switch for pre-selection and that thus it is very universal. It is well adapted to switching apparatus for electronic exchanges. Indeed, the switch realized according to this invention is much smaller and lighter than any conventional switch of this kind. Each of its horizontal and vertical energizing electric powers is about 50 w. Its exciting current is so small that it is possible to use the reed relay driven with the semi-conductor device in the selecting circuit of the exciting coil terminal. Therefore, though the exciting current pulse width of the switch is about 4 ms., the time which is required for the excitation of the switch driving magnet after the control signal is received, will be greatly reduced, and the controlling apparatus will be saved, moreover the switching apparatus will be made small, light and cheap and thus the telephone exchange system can be economically constructed.

What is claimed is:

1. A mechanical latching coordinate switch comprising a plurality of cross-point contact units having a plurality of contact groups provided with contact actuating cards having parts engaging with holding fingers and aligned in a vertical column, a plurality of holding fingers provided for respective contact groups and movable only in one direction perpendicular to the direction of movement of the contact actuating cards and electro-magnetic devices for simultaneously acting on said holding fingers; a plurality of resetting bars arranged perpendicularly to said cross-point contact units so as to operate the contact actuating cards of the contact groups belonged to each horizontal row of said cross-point contact units; and resetting bar driving units provided with a plurality of electromagnetic devices driving individually said resetting bars in a vertical column and in the same surface of said cross-point contact units, whereby the electromagnetic devices drive the resetting bar and the holding finger, respectively, the holding finger disengages from the contact actuating card and then when the resetting bar is released, the contacts remain connected and the holding finger is prevented from its return, while when only the resetting bar is driven, the holding finger returns to engage with the contact actuating card and the contacts remain released.

2. The mechanical latching coordinate switch claimed in claim 1, wherein a plurality of units for pre-selection is added, said units having the same construction as of the cross-point contact units except that the contacts of each contact group are separately and independently formed.

3. The mechanical coordinate switch claimed in claim 1, wherein the individual electromagnetic devices of the resetting bar driving unit are formed for such common yoke as has an opening in the part opposed to the side of each core.

4. The mechanical latching coordinate switch claimed in claim 1, wherein the electromagnetic devices provided with a driving coil which is common to more than two holding fingers in each cross-point contact unit is provided.

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