July 2, 1957 K. W. GRAYBILL ET AL 2,798,119

CROSS-BAR TYPE, IMPULSE RESPONSIVE, TELEPHONE SWITCHING APPARATUS

Filed Aug. 13, 1953 2 Sheets-Sheet 1

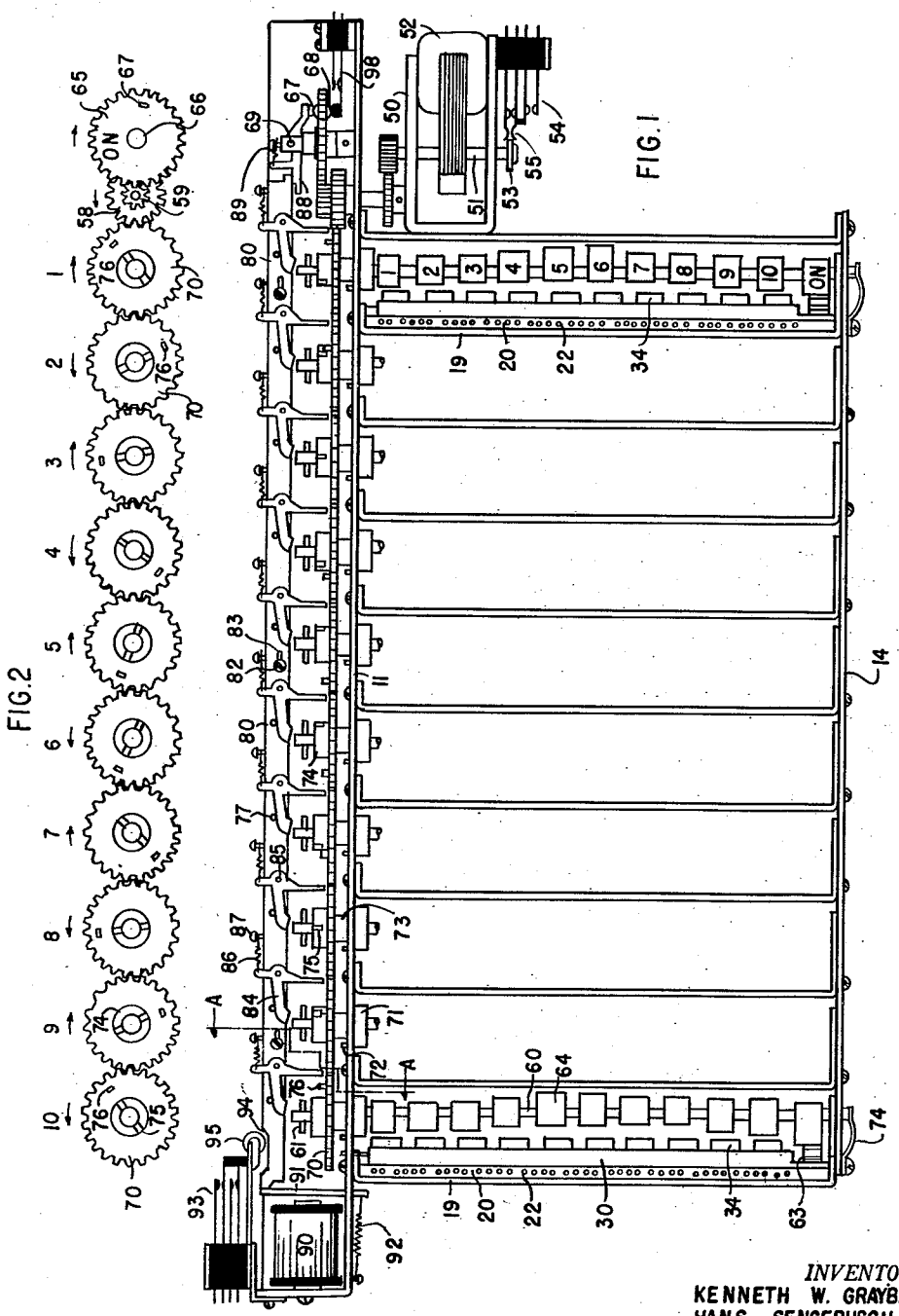


FIG. 2

FIG. 1

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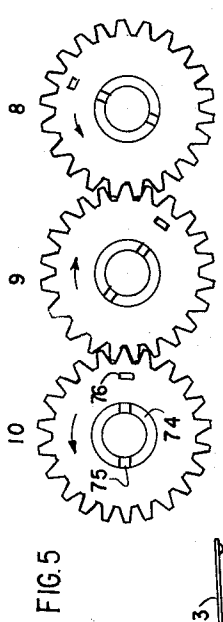


FIG. 5

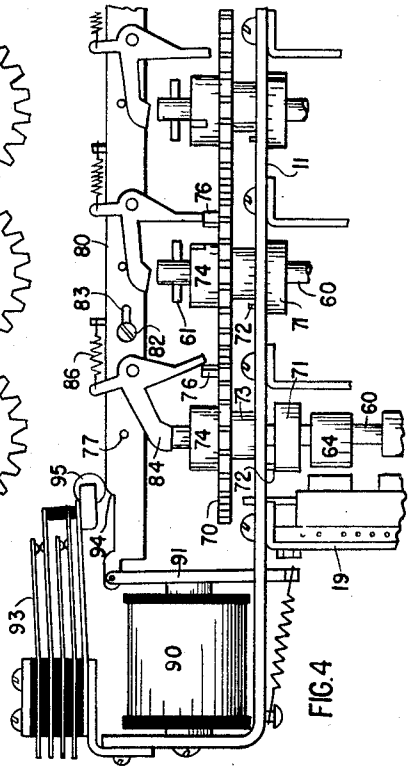


FIG. 4

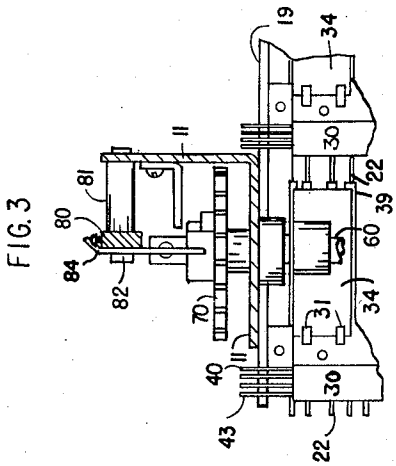


FIG. 3

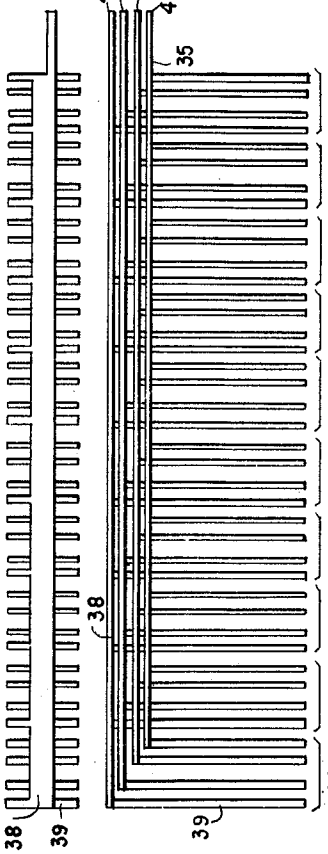


FIG. 7

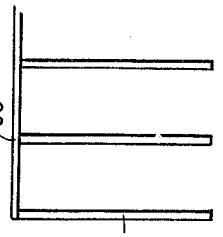


FIG. 9

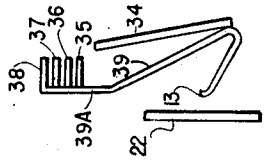


FIG. 8

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United States Patent Office 2,798,119
Patented July 2, 1957

2,798,119

CROSS-BAR TYPE, IMPULSE RESPONSIVE, TELEPHONE SWITCHING APPARATUS

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Application August 13, 1953, Serial No. 374,016

8 Claims. (Cl. 179—27.54)

The present invention relates in general to automatic telephone switching apparatus and in particular to pulse operated switches of the cross-bar type wherein a plurality of subscribers' line circuits, or trunks, associated with a multiple field of bare conductors, are made accessible through any one of a group of such switches to a local or outgoing trunk individual to the switch, for extending telephone connections. It is an improvement on the switches illustrated and described in our prior Patent 2,680,783, issued June 8, 1954.

In the referred to prior application, each switch was provided with a primary shaft and ten secondary shafts at right angles to the primary shaft and all in the same plane. The primary shaft carried ten bevel gears mounted at regular intervals along its length, and each secondary shaft had a similar bevel gear mounted on one end thereof, adjacent to one of the gears on the primary shaft, but normally disengaged therefrom. An impulse responsive motor device was arranged to drive the primary shaft alone in a first selecting movement to select one of said secondary shafts for operation. At the end of the primary rotation, a trigger bar carrying a plurality of pivoted triggers, or bell crank levers, was pulled lengthwise by an electromagnet whereupon one of the triggers was caused to rock on its pivot, and lift the selected shaft and its bevel gear into engagement with the corresponding bevel gear of the primary shaft. A second operation of the driving motor then caused a further rotation of the primary shaft, and a corresponding rotation of the engaged secondary shaft. The rotation of the secondary shaft then caused one of a plurality of sets of flexible contact fingers to be moved into engagement with a corresponding set of bare conductors to extend a connection between the trunk individual to the switch and a particular one of the line or trunk circuits associated with said bare conductor multiple.

The main feature of the present invention is the elimination of the primary shaft and the bevel gears, and the provision instead of a simple spur gear drive of ten gears directly mounted on the secondary shafts. These gears are permanently meshed with one another and are freely rotatable about their respective shafts. Both the cost and the number of the gears is thus reduced, and the problem of meshing and unmeshing of gears is completely eliminated.

Another feature of the invention is the means whereby the secondary shaft selected by a first movement of the gear train, is positively locked to its gear, for rotation therewith.

Other features of the invention will be made apparent by the following specification and claims, when considered together with the appended drawings comprising Figures 1 to 9 inclusive.

Fig. 1 represents a top or plan view of one of the switches, with two shafts shown in full, and the others shown only in part, as they are similar to those shown.

Fig. 2 is an inverted side view of the gear train, from the trigger bar side, with all intervening and other parts

omitted, to show certain details. In this view the gear train is shown in the normal, unoperated position.

Fig. 3 is an enlarged sectional view taken along the line A—A in Fig. 1, and including a portion of a second switch assumed to be below the switch of Fig. 1.

Fig. 4 is an enlarged plan view of the upper left corner of Fig. 1, showing the left trigger bar actuated and the left shaft locked to its gear, for rotation thereby.

Fig. 5 is an enlarged side view of the left three gears of the gear train, seen as in Fig. 2, but in position to select the left shaft for operation, in accordance with Fig. 4.

Fig. 6 shows a side view in elevation of a row of flexible contact sets as assembled into the switch, but with all intervening and associated parts removed.

Fig. 7 represents a top view of the contact sets of Fig. 6.

Fig. 8 represents an end view in elevation of the contact sets of Fig. 6, to which has been added an end view of a section of the bare conductor field associated therewith, and an end view of the associated contact actuators, which urge the flexible contact sets into engagement with the corresponding bare conductors in response to the rotation of the associated shaft.

Fig. 9 is a side view in elevation of a portion of one of four parts comprising Fig. 6.

A complete assembly of switches, which may be used as linefinders, selectors, or connectors, consists of a plurality of switches such as shown in Fig. 1, mounted one above the other on an arrangement of vertical bare conductors, which are common to all of the switches of the group.

The bare conductor multiple, or field, comprises a plurality of panels **20**, mounted parallel to each other, and spaced at regular intervals to provide room for the shafts and actuators. Fig. 1 provides for a total of ten such panels, of which only the first and last have been shown completely, since they are all similar. Each panel **20** consists of a channel plate **19** mounting a number of transverse slotted insulators, not shown, one above the other, in the slots of which the required number of vertical bare conductors **22** have been inserted and locked in place in any suitable manner. One end of each channel plate is secured to a back plate **11**, and the other end to a front plate **14** in any suitable manner, as by the screws indicated.

In Fig. 1 each panel **20** is indicated as having 40 vertical bare conductors **22**, which may be assumed to represent ten sets of four conductors each, connected to line circuits or trunks as required. It will be obvious that the complete multiple will include 400 such bare conductors corresponding to 100 lines or trunks divided into ten groups of ten. It will also be obvious that more or less than four conductors per line or trunk, and more or less than forty per panel, may also be provided.

Horizontally disposed across each row of vertical bare conductors and in alignment therewith, in each switch, is a row of 40 flexible contact fingers, best seen in Figs. 6, 7, 8, 9. The complete assembly consists of four horizontal, spring-metal flat conductors **35**, **36**, **37**, **38**, mounted one above the other in a suitable insulating mounting not shown in Figs. 6–9 but indicated at **30** in Figs. 1 and 3. Depending from each horizontal conductor are ten spaced apart vertical contact fingers **39**, each such conductor and its contact fingers being stamped and formed from a single piece of metal. The vertical contact fingers of the four conductors are staggered or arranged in 1, 2, 3, 4 order, in groups of four, as best seen in Fig. 6, so as to enable the four conductors to make contact with any set of vertical bare conductors **22** in the row, by moving the corresponding set of four contact fingers against them. The four metallic parts forming this assembly are similar, but not identical.

The free ends 40—43 of each group of four horizontal conductors (Figs. 3 and 6) extend, in the final assembly, beyond the back plate 11, where they may be multipled, in any convenient manner, with the other nine groups of similar conductors of the same switch, to form a single 4-wire trunk having access to any set of vertical bare conductors associated with such switch, through the various sets of contact fingers thereof.

The formed, downwardly extending contact fingers 39 are so formed and tensioned that in the normal unoperated position, the free tips 13 (Fig. 8) are adjacent to, but clear of, the corresponding bare conductors 22. Thus when any contact finger is moved a short distance in a clockwise direction, its tip 13 will be pressed into sliding contact with the associated conductor 22, and will establish an electrical connection therewith.

Horizontally disposed across each row of contact fingers, and in contact therewith, is a row of ten contact actuators 34 (Figs. 1, 3, 8). Each such actuator consists of a rectangular insulating plate, of a width to actuate four contact fingers, and suspended loosely from an upper bracket on the frame, as by a series of lugs 31 (Fig. 3) extending through slots in the actuators. Thus when any contact actuator 34 is urged in a clockwise direction, it will move the associated four contact fingers 39 into engagement with the corresponding four vertical bare conductors 22. The contact actuators 34 may be of insulating material with vertical slots on the inner face to receive the contact fingers and prevent them from moving sideways, or they may be made of metal with a contact centering comb or nest of insulating material mounted on the inner face.

Horizontally disposed across each row of contact actuators, and in proximity thereto, is a cam shaft 60, slidably mounted in suitable bearings in the plates 11 and 14. These shafts, as shown in Fig. 1, are each provided with ten spaced cams 64 for operating the associated contact actuators, and an off-normal cam, seen at the lower end, for operating a set of off-normal contacts 63, which may be varied in number and arrangement as necessary. The single high points of the different cams are spirally distributed around the circumference of each shaft in eleven equal steps, so that the associated off-normal springs will be actuated by the last cam when the shaft is in the normal position, while the associated contact actuators will be operated in succession by the other cams at each one-eleventh of a revolution, when the shaft is rotated away from its normal position.

A spring 74, in engagement with the lower end of each shaft as seen in Fig. 1, urges the shaft upwardly. In the normal position of the shaft, a pin 72, projecting upwardly from a hub 71 secured to the shaft near its upper end just inside the back plate 11, is forced into a hole not shown, in the back plate 11, and enables the shaft to move axially in its bearings to the position shown in Fig. 1. In this position the pin 72 effectively locks the shaft against rotation.

A spur gear 70 is loosely mounted on the upper end of each shaft, on the outer side of the back plate 11. These gears, in addition to being freely rotatable about their shafts, are permanently meshed with each other to form a gear train, as shown in Figs. 1 and 2. Each gear 70 is provided with an inner hub 73 which rides on the back plate 11, and an outer hub 74, which is provided with a slot 75 cut across the flat outer face thereof. The outer face of each gear 70 is also provided with a stud 76 near the outer periphery, and in line with the slot in the hub 74. A pin 61 is also inserted crosswise in each shaft 60 near the upper end thereof, with a portion projecting on each side of the shaft, just clear of the outer hubs 74 of the gears 70. In the normal position of the shafts, these pins all point in the same direction, lengthwise of the gear train. They provide the means for locking the shaft to its associated gear, for operation thereby, as will be shown.

Mounted lengthwise of the gear train and just beyond the pin end of the shafts, is a trigger bar 80, slidingly mounted on a back angle of back plate 11, so as to be movable longitudinally in either direction. As may be seen in Figs. 3 and 4, the trigger bar or slide bar 80 is loosely mounted on a row of posts 81 by a number of button-head screws 82 inserted through slots 83 in the trigger bar, into threaded holes in the ends of the posts 81. One end of the trigger bar 80 is loosely secured to the free end of the armature 91 of a transfer magnet 90, also mounted on the back plate 11. A restoring spring 92 on the magnet 90 normally maintains the armature 91 and the trigger bar 80 in their right hand, unoperated position shown in Fig. 1. The trigger bar 80 is also arranged to operate a set of contact springs 93, by means of the slope 94 and the roller 95, each time the electromagnet 90 is operated to pull the trigger bar to the left.

A row of ten bell crank levers or triggers 84 are mounted at regular intervals along the trigger bar 80, on pivots 85, opposite the upper end of each shaft. These triggers are normally held against the stops 77, in the position shown in Fig. 1 by the coil springs 86, which are secured at one end to a projection on the trigger, and at the other to a screw 87 on the trigger bar 80. In this position one arm of each trigger has its tip adjacent to the upper end of the associated shaft 60, while the tip of the other arm is adjacent to the outer face of the associated gear 70, near the periphery thereof, just beyond the arc of travel of the studs 76 when these rotate with their respective gears.

The impulse responsive motor which drives the gears 70, is shown at 50 on the right of Fig. 1. It may be of any desired type that will drive a shaft a given distance in a uniform direction for each complete impulse received, or that responds in a positive manner to both the make and the break of each impulse. In the illustrated embodiment, it is assumed to be of the general type shown and described in British Patent 649,427, published January 24, 1951, wherein a shaft such as 51 is rotated a quarter turn on each energization of a coil 52, and is rotated another quarter turn in the same direction on each de-energization of the coil. Upon each energization also, a cam such as the butterfly cam 53 carried by the shaft, operates a set of contacts of any desired arrangement, such as shown at 54, 55. The cam 53 also returns the contacts 54, 55 to the normal position shown on each subsequent de-energization of the coil 52.

The motor shaft 51 is arranged by means of suitable gearing to drive the gears 70 one-eleventh of a revolution for each half revolution of the shaft 51, through the intermediary of a driving gear 58 (Fig. 2). A pinion 59 on the gear 58 also serves to drive an off-normal gear 65 either one or two revolutions for each revolution of the gears 70, as desired. In the illustrated embodiment, it is assumed that the gear ratio is such that the gear 65 makes one revolution for each two revolutions of the gears 70. The gear 65, which is loosely mounted on a shaft or spindle 66 rigidly secured to the back plate 11, carries a release stud 67 on its outer face near the periphery (Figs. 1, 2), and an off-normal stud 68 (Fig. 1) on its inner face, in the same relative location. In the normal position of the gear train, these studs occupy the radial position shown for stud 67 in Fig. 2. In this position, the stud 68 is pushing apart a pair of off-normal springs 98, and the stud 67 is under one end of a latch 88, which is pivoted at 69 on an extension of the shaft 66. The left end of the latch 88 is thereby held in place directly below the right end of the trigger bar 80, against the tension of a coil spring 89 which tends to rock the latch 88 on its pivot in a clockwise direction.

Considering again the gear train for the cam shafts as shown in Fig. 2, the seemingly aimless arrangement of the studs 76 on the gears 70, is due to the fact that each gear revolves in a direction opposite to that of its immediately neighboring gear or gears. The gears 70, like

the gear 65, are shown in the normal position, and for convenience, have been numbered 1 to 10, from right to left. With reference to the various arrows indicating the direction of rotation, it will be apparent that after the gears 70 have made one-eleventh part of a complete revolution, gear number 1 on the right will have rotated one step or one-eleventh revolution in a clockwise direction. In this position of the gear train, the stud 76 of gear number 1 will be directly on the center line of the gear train on the right side of gear number 1, and no other stud 76 will be in a corresponding position. Similarly, after two-elevenths of a revolution, gear number 2 will have rotated two steps in an anti-clockwise direction, and will have moved its stud 76 to the center line of the gear train on the right side of gear number 2. No other stud 76 will then be in a corresponding position, gear number 1 having of course moved its stud beyond the center line on the second step. Each gear will similarly align its stud 76 in turn on successive steps, to select the corresponding shaft for operation, only one stud being on the center line at any given time, with none in line when the gear train is in the normal position. On the first step of the gear train also, the off-normal cam 65 rotates the stud 67 in a clockwise direction clear of the right end of the latch 88. The left end of the latch 88 is thereupon pulled up against the bottom of the right end of trigger bar 80, by the coil spring 89. At the same time, the stud 68 of cam 65 is moved away from the off-normal springs 98 which thereupon close. It will be understood that a larger number of off-normal contacts may be employed, if necessary, in any desired arrangement.

Proceeding now to the operation of the switch, let it be assumed that two series of ten impulses each are received by the motor 50, with a short pause between the two series. In response to the first series of ten impulses, the motor 50 drives the gears 70 ten steps, or ten-elevenths of a complete revolution. Stud 76 of gear number 10 is accordingly moved ten steps in an anti-clockwise direction as indicated by the arrow, and is thereby placed in the selecting position on the right side of the gear along the center line of the gear train. See Fig. 5. In this position the stud 76 of gear number 10 is directly in the path of the lower arm of the associated trigger 84, and the slot 75 of the same gear is aligned with the pin 61 of the corresponding shaft. None of the other slots 75 or studs 76 are so aligned.

During the pause following the first series of impulses, the transfer magnet 90 is energized, in any convenient manner, and attracts its armature 91. See Fig. 4. Trigger bar 80 is thereby drawn to the left, whereupon the tip of the lower arm of the left trigger 84 strikes against the aligned stud 76 of gear number 10. The said trigger 84 is thereby rocked in an anti-clockwise direction, forcing the upper arm down against the end of the number 10 shaft 60. This shaft is accordingly moved longitudinally, and the pin 61 of this shaft is pushed down into the aligned slot 75. At the same time, the pin 72 of the shaft hub 71 is moved downward out of the associated hole, not shown, in back plate 11, and is moved into a position just clearing the inner surface of back plate 11. The selected shaft is now locked to its gear for rotation thereby, and is also unlocked from the frame of the switch, to permit such rotation. The leftward movement of the trigger bar also causes the roller 95 to ride up on the shoulder 94 of the trigger bar, which in turn causes the operation of the contact springs 93, which like the other contacts, may vary in number and arrangement as required.

Upon the first movement of the gear train, the right hand gear 65 (Fig. 1) releases the gear train off-normal contacts 98 and the latch 88, as previously described. When therefore, trigger bar 80 is pulled to the left, the latch 88 is rocked in a clockwise direction and the step in the left end of the latch is pulled up into place against the right end of the trigger bar by the latch spring 89, thus effectively locking the trigger bar and the magnet armature 91 in the operated position. The subsequent deenergization of the magnet 90 is consequently without effect.

The motor 50, in response to the second series of ten impulses, now drives the gear train an additional ten steps. The selected shaft number 10 is also driven ten steps or ten-elevenths of a revolution, by the locked-on gear number 10. Upon the initial movement of the shaft, the pin 72 of the shaft hub 71 is rotated away from the associated hole in back plate 11, and rides on the inner surface of the back plate 11. Upon the initial movement of the shaft also, the stud 76 of the associated gear is moved clear of the trigger 84, which is thereupon pulled back into the upright position against the stop 77 by the trigger spring 87. The selected shaft number 10 however, is now maintained in its downward locked position by the pin 72 riding on the plate 11.

Upon the first step of the locked shaft, the off-normal cam at the lower end of the shaft releases the off-normal springs, and the first cam at the upper end of the shaft engages the associated contact actuator and causes the latter to move the associated four contact fingers into engagement with the corresponding vertical bare conductors. Upon the second step of the shaft, the second cam will operate its contact actuator and the first cam will release its contact actuator, which will be returned to the normal position by the back tension of the associated contact fingers. The other contact actuators will be operated in succession in similar manner, so that upon the completion of the series of ten impulses, the tenth contact actuator and the associated contact fingers will be operated, and all of the others will be normal. A connection is thereby extended to the "00" line or trunk, or the tenth line or trunk in the tenth group of ten lines or trunks. It will be obvious from the foregoing that any shaft or group may be selected, depending on the number of impulses in the first series received by the motor 50, and that any line or trunk in the chosen group may be selected, depending on the number of impulses in the second series received by the motor.

Release of the switch may be effected by closing a circuit to the motor in any convenient manner, through the gear train off-normal contacts 98 and the motor interrupter contacts 55 in series. When this circuit is closed, the motor is energized and advances the gear train. It also causes cam 53 to open the interrupter contacts 55, and the motor is accordingly de-energized to again advance the gear train. Cam 53 then allows interrupter contacts 55 to re-close, and this action continues until the gear train has been returned to its normal position, when off-normal springs 98 are opened by stud 68 to stop the rotation. At the same time, stud 67 lifts up the right end of latch 88. This drops the left end of latch 88, which disengages itself from the right end of the trigger bar 80. Since the magnet 90 is de-energized at this time, coil spring 92 then moves armature 91 and trigger bar 80 to the right, back to their normal position as shown in Fig. 1.

Since it has been assumed that the off-normal gear 65 makes one revolution for each two revolutions of the gears 70, it will be obvious that any operated shaft 60 will reach its normal position before the gear 65 will have been returned to its normal position. When the operated shaft completes its rotation, its pin 72 is pressed into the associated hole in back plate 11, and the shaft is moved into its upper position, by the pressure of spring 74, disengaging the pin 61 from the slot 75. The shaft is now once again locked in the normal position, free of its associated gear, and the shaft off-normal contacts 63 are again operated. The gear train will then continue its rotation free of the shafts, and restore the trigger bar and the switch to normal, as described in the preceding paragraph.

A modification of the release operation may be provided if desired, by changing the gear ratio of gear **65** so that it completes its rotation in the same time as the gears **70**, and by connecting off-normal contacts **98** in multiple with a pair of similar off-normal contacts on each shaft. With such a gear arrangement, the gear train would reach its home position first, whenever the sum of the two series of received impulses did not exceed eleven. In such case, the arrival of the gear train at the home position, would cause stud **67** to trip latch **88**, and enable trigger bar **80** to resume its right hand position. Since no studs **76** would be aligned at this time, this movement would be unimpeded. The operated shaft would likewise be uneffected, as its pin **72** continues to hold it in the gear-locked position. Contacts **98** would also open, but without effect, as these contacts would still be shunted by the still closed shaft-off-normal contacts. The gear train would thus continue to rotate and proceed to make a second revolution. The restoration and disengagement of the operated shaft would be completed during the second rotation of the gear train. And when off-normal contacts **98** subsequently opened again, at the completion of this second rotation, the gear train would simply stop. If however, the sum of the two series of received impulses were greater than 11, the operated shaft would reach its home position first, in which case the release would be as in the preceding paragraphs, except that there would be no second rotation of the gear train.

What is claimed is:

1. In an automatic switch, a plurality of rows of parallel bare wire conductors, a row of sets of contact fingers for each row of conductors, a shaft for each said row of contact sets, cams along said shafts for operating the sets of contact fingers of the row successively into engagement with the corresponding conductors in response to rotation of said shaft, a gear train comprising a gear mounted on each shaft, said gears being permanently meshed together and freely rotatable about their respective shafts, a motor for rotating all of said gears in a first movement, selecting means positioned in response to said first movement of said gear train to select any one of said group shafts for operation, a coupling means, a magnet for operating said coupling means, means operated responsive to said operation of said coupling means for moving the selected shaft axially, and means responsive to said axial movement for locking said selected shaft to its associated gear to enable said selected shaft to be rotated in response to a second movement of said gear train by said motor for operating any one of the associated sets of contact fingers.

2. An automatic switch as in claim 1 including, a normally disengaged key and keyway for each said shaft and gear, and said keys and keyways so located radially as to cause the engagement of the associated key and keyway, responsive to said axial movement of said selected shaft, to enable the associated gear to rotate said selected shaft.

3. In an automatic switch as in claim 1, a frame for said switch, a first lug for each shaft normally engaged by said frame, a second normally disengaged lug for each shaft, and openings in said frame and said gears so disposed as to enable disengagement of said first lug from said frame and engagement of said second lug with the associated gear responsive to said axial movement of the selected shaft, to enable rotation of said shaft by said associated gear.

4. In a cross-bar switch, a plurality of parallel rows of parallel bank conductors, a row of sets of contact fingers across each said row of conductors, a shaft across each said row of contact fingers, a spur gear mounted on and freely rotatable about the end of each said shaft, each said gear permanently meshed with the next, a motor for driving said gears in response to received impulses, a movable bar overlaying one end of said shafts, a pivoted trigger on said bar overlaying the same end of each shaft, a stud on each gear so located that one of said studs will be aligned with one of said triggers to select one of said shafts for operation in accordance with the value of a first series of received impulses, an electromagnet for moving said bar and said triggers following said selection to cause said aligned stud to rock said one trigger against the end of said selected shaft to move said shaft axially, locking means operated responsive to said axial movement for locking said selected shaft to its gear to enable said motor to rotate said shaft responsive to a second series of received impulses, and cams on said shaft for operating any one of the associated sets of contact fingers into engagement with the corresponding bank conductors, in accordance with the value of said second series of impulses.

5. In a cross-bar switch as in claim 4, a cross-pin for each shaft, a hub for each gear, and a groove in each hub in such a location as to be aligned with the associated shaft pin when the stud of said gear is aligned with the associated trigger, to enable said pin to engage said slot when said shaft is moved axially by said trigger.

6. In a cross-bar switch as in claim 4, a pin inserted transversely in each shaft near the end thereof, a hub for each said gear, a groove across said hub on the side facing said pin, and said pin and groove so located with respect to the associated stud of said gear as to cause engagement of the pin of the selected shaft in its associated groove whenever said shaft is moved axially through the co-operation of the associated stud and trigger bar.

7. In a cross-bar switch as in claim 4, a pin crosswise through the end of each shaft and normally in alignment with said triggers, a hub for each gear, and a slot across said hub in alignment with the stud of said gear for receiving said pin responsive to said axial movement of said shaft to rotatively couple said shaft with said gear.

8. In an automatic switch, a plurality of parallel rows of parallel bare conductors, a row of movable contact sets facing each said row of conductors, a shaft facing each said row of contact sets, means for moving the associated contact sets into contact with the associated conductors responsive to rotation of said shafts, a gear loosely mounted on each shaft near one end, said gears being permanently in mesh to form a gear train, a motor for rotating said gears in response to a first series of received impulses, means responsive to said gear rotation for selecting one of said shafts for rotation, a slide bar, a magnet for moving said slide bar lengthwise, means responsive to said movement of said slide bar for moving said selected shaft axially under control of said selecting means, normally misaligned locking means for said selected shaft and its associated gear rotated into alignment responsive to said first rotation of said gears, and said aligned locking means engaged responsive to said lengthwise movement of said selected shaft for rotatively connecting said selected shaft to said associated gear for rotation thereby responsive to a subsequent series of received impulses.

No references cited.