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MAGNETIC LATCHING CROSSBAR SWITCH

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Fig. 1.

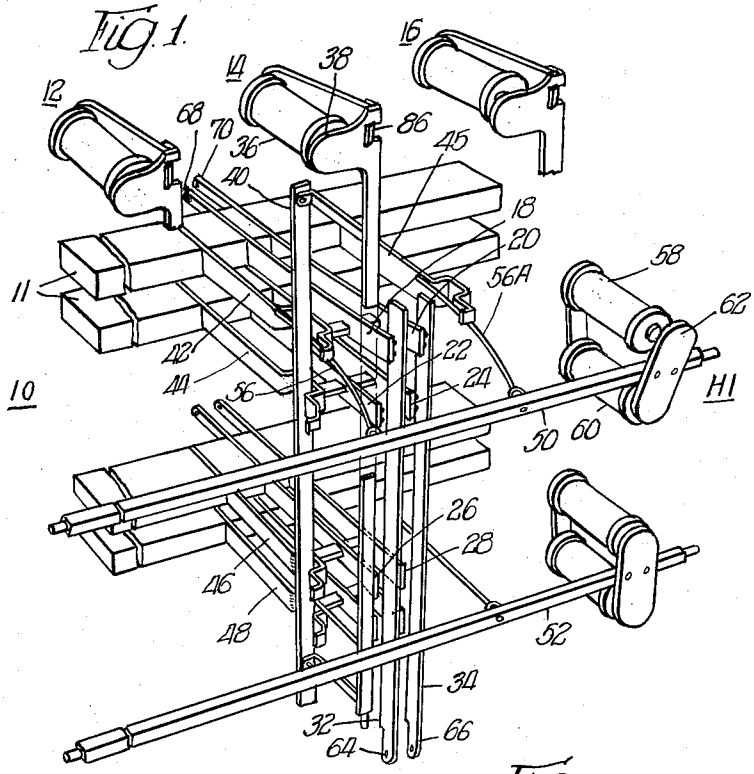


Fig. 2

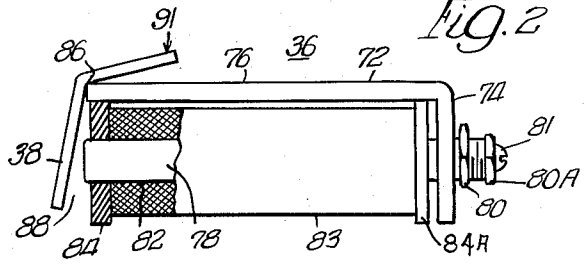
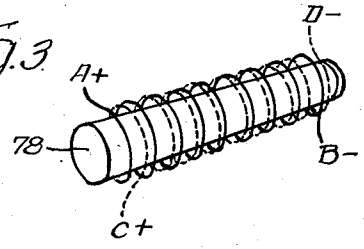


Fig. 3



ROCKWELL HARDNESS	58-60 "C
CARBON	.95%
SILICON	.30%
MANGANESE	1.20%
TUNGSTEN	.50%
CHROMIUM	.50%
VANADIUM	.20%

A-B OUTER WINDING (WOUND CLOCKWISE)
C-D INNER WINDING (WOUND COUNTER-CLOCKWISE)

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MAGNETIC LATCHING CROSSBAR SWITCH

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The present invention relates to a magnetic latching crossbar switch for use in automatic telephone systems, data transmission systems and other similar types of switching systems.

It has long been apparent that the provision of efficient, reliable service in an automatic telephone system is basically dependent upon the provision of switching equipment which is capable of extending connections in an efficient, expeditious and reliable manner. With the more recent development of additional arts and fields involving data transmission (computers, machine control equipment and the like), the need for switches of increased reliability and good quality transmission have become further apparent.

Experience in the different fields has indicated that in many of these applications the so-called crossbar switch appears to be most successful in providing the high degree of service and reliability required in expeditiously establishing paths for both speech and data transmission. Among other reasons the simple setting of one bar magnet and one vertical unit magnet to complete a desired path over the switch in some tens of milliseconds constitutes both an expeditious and reliable type selecting operation. Additional paths may then be established over the same switch, the total number of paths being as large as the number of vertical magnets on the switch, whereby a reduced number of switching units is required to establish a given number of connections. Further the pressure contacts (which are similar to relay contacts) of the switch operate with an insignificant amount of wear, and the operation of a contact set obviously does not establish path disturbing vibrations of the type which are frequently experienced with the well known rotary type selector switches, and increased reliability in operation may therefore be expected.

As a result of these and other advantages, the usefulness and desirability of crossbar switches in establishing speech and data transmission paths has become well known in the field. A novel type crossbar switch has now been discovered which provides even further advantages in its use in a switching network. That is, a novel crossbar switch has now been provided which includes means operative to latch the operated magnets of a crossbar switch with residual magnetic energy whereby the associated contacts controlled by the magnet will be maintained closed subsequent to interruption of the energizing circuit for the magnet. The latched magnet may be restored to interrupt the connection established over its associated contacts, as desired, by coupling a momentary current pulse of given polarity to the latching magnet.

In the establishment of a connection over an automatic telephone system, as many as ten or twelve hold magnets may be maintained in the operated position. It is apparent that in a large metropolitan exchange in which hundreds of connections are established during the same period of time, the operating current required to maintain such connection is of a substantial order, and the use of magnetic latching magnets will result in a large reduction in the power requirement. Further, the reduction of power requirements for the switch makes possible the use of such type equipment in a large number of areas in which power supply restrictions have previously prevented such use. These and other features including the ability

to store data for long periods of time without drawing power from an energizing source, and retaining connections and stored information indefinitely in the event of power failure, constitute definite advantages which are achieved by such structure.

It is an object of the present invention therefore to provide a novel crossbar switch for use in automatic telephone systems which includes latching means operative to maintain transmission paths completed subsequent to the interruption of the original energizing circuit for such magnet means.

In the provision of a crossbar switch which includes means for maintaining transmission paths without further power drain subsequent to the initial operation thereof, it is important that the operation be both expeditious and reliable. It has been the experience of the field that the use of a mechanical locking device for such purpose is not particularly satisfactory in achieving such manner of operation. It is a specific object of the present invention therefore to provide a crossbar switch which includes a novel magnetic latching relay having operating characteristics of a value to operate an associated set of contacts in a crossbar switch responsive to coupling of a pulse of a predetermined value thereto, to maintain the contacts operated subsequent to the termination of the energizing pulse to the latching relay, and to effect the release of the contact sets responsive to the receipt of a release pulse of a further predetermined value.

In the provision of a crossbar switch including a magnetic latching type relay which is operative in such manner a number of difficulties are encountered. That is, the range of the load on the magnet will vary with the contact spring assemblies controlled thereby, and further with the nature of the particular switching operation being performed by the crossbar switch magnet. Ratios of 10:1 for maximum and minimum loads on a magnet are not uncommon in such type switches. Further the electrical pulses available for operating and releasing the magnet must be maintained within certain limited values, and the magnet must operate, latch and release responsive to the application of pulses of such values thereto even though these variable load conditions occur. As a result it has been determined that the response characteristics of a magnetic latching relay which is operative in such environment is of an extremely demanding and critical nature, and the provision of a core material of a new and novel magnetic characteristic is essential to the accomplishment of a latching relay which is operative in such manner.

It is a further specific object of the present invention, therefore, to provide a magnetic latching relay for use in a crossbar system which has a structure including a magnetic core which is of a material which provides operating forces of a value sufficient to effect attraction of the armature associated therewith under the extremely large variation in load conditions experienced in such use; to provide a holding force sufficient to hold the magnet as the energizing circuit is interrupted and to prevent release of the armature during such latching period even with the occurrence of environmental vibrational forces; and of a value to effect release of the magnet responsive to receipt of a momentary release pulse of the low values commonly used in such systems.

It is still another object of the invention to provide a novel magnetic latching relay for use in switching systems such as automatic telephone systems, which has a magnetic core comprised of a high carbon steel material having a hardness in the range of 58–60 Rockwell "C" to provide the required operating and release characteristics necessary for operation with the loads and operating pulses which occur in such type switching system.

These and other objects of the invention will be ap-

parent with reference to the following specification, claims and drawings, in which:

FIGURE 1 is a schematic illustration of the novel crossbar switch including the component parts for magnetically completing and maintaining a transmission path thereover;

FIGURE 2 is a side-elevational view of the novel magnetic latching relay utilized in the crossbar switch of FIGURE 1; and

FIGURE 3 is a schematic perspective view of the coil and windings used in the magnetic latching relay of FIGURE 2.

SPECIFIC DESCRIPTION

The novel crossbar switch **10**, as schematically shown in FIGURE 1, consists of a welded steel frame, partially shown at **11**, on which are mounted ten vertical groups of contacts, such as the illustrated vertical groups **12, 14, 16**, the contacts of each vertical group being arranged in horizontal rows or levels, each of which horizontal rows contains two or more contacts, such as illustrated contacts **18, 20; 22, 24; 26, 28**; etc.

Each vertical group, such as **14**, includes two or more vertical contact strips, such as **32, 34**, which are common to the vertical row of horizontal contacts **18, 20; 22, 24**; etc., and supported in vertical spaced relation therewith. Each vertical group, such as **14**, is further equipped with a vertical electromagnet, such as **36**, for controlling operation of an armature such as **38**, which is in turn coupled to a vertical hold bar, such as **40**, to move same in an arcuate path about a vertical axis.

A contact actuating spring, such as **42**, is supported by the frame **11** in cantilever fashion between the vertical hold bar **40** and one of its associated contact sets such as **18, 20**, and locates a U-shaped channel disposed in the path of movement of the vertical hold bar **40**. A similar contact actuating spring **44, 46, 48**, etc., is located between the vertical hold bar **40** and each set of horizontal contacts **22, 24**, etc., which is controlled thereby.

The switch assembly further includes six horizontal selection bars, such as **50**, located adjacent associated ones of the horizontal contact sets such as **18, 20; 22, 24** of the different vertical groups **12, 14, 16**, etc. A pair of horizontal magnets, such as **58, 60**, control operation of a pivotally mounted armature **62** (which is connected to selector bar **50**) from the normal position to two alternate operating positions (which are readily apparent in FIGURE 1) to thereby tilt the horizontal bar upwardly or downwardly in an arcuate manner to the alternate operated positions.

Each selector bar, such as **50**, supports a plurality of selection spring fingers such as **56**, each of which fingers is located to cooperate with a corresponding pair of horizontal contact sets, such as **18, 20; 22, 24**, in a vertical group such as **14**. With the horizontal bar **50** in its normal position, each spring finger, such as **56**, lies between its two horizontal sets of contacts, such as **18, 20; 22, 24** of its associated vertical group, such as **14**.

With operation of the horizontal bar **50** from the normal position to one of the two operation positions, the flexible spring finger, such as **56**, attached thereto is displaced upwardly into position adjacent the U-shaped channel on contact actuating spring **42** or downwardly into position adjacent the U-shaped channel on contact actuating spring **44**.

Terminal portions **68, 70** on horizontal contacts **18, 20** and terminal portions **64, 66** on vertical contacts **32, 34** may be used for connecting the crosspoints to external circuits. Closure of the crosspoints is effected by completing an operating circuit for the lower winding **60** of horizontal selected magnet H1 to effect attraction of armature **62** adjacent thereto, and the resultant tilting of the horizontal bar **50** upwardly to the position shown in FIGURE 1 to thereby move the spring-mounted selection fingers **56, 56A**, etc., into spanning position relative to the U-shaped channels on the contact actuating springs, such as **42, 45** which are associated with such level of the horizontal contacts. With the operation of the vertical magnet **36** and the attraction of the armature **38** adjacent thereto, the vertical hold bar **40** presses against the selection finger **56** which spans the channel of spring **42** to cause the spring finger **56** and contact actuating spring **42** to move the ends of horizontal contacts **18, 20** into registration with the vertical contact strips **32, 34** to thereby close the crosspoints and complete a path from terminals **64, 66** to terminals **68, 70**.

It will be apparent that as the horizontal magnet **60** operated to tilt the horizontal selection bar **50**, a number of the spring fingers **56, 56A**, etc., were placed in position adjacent their respective contact actuating spring such as **42**. However, since a circuit is completed for only one of the vertical magnets (**36** in the present example) only the horizontal contacts **18, 20** which are in the vertical group **14** controlled by magnet **36** are closed.

After the connection is completed, the horizontal magnet **60** is de-energized and selector bar **50** is restored to its normal position to move the spring fingers, such as **56A**, to the normal position between the two horizontal contact sets (not shown) associated therewith, and finger **56** is held between vertical hold bar **40** and contact actuating spring **42**. It is apparent that the same horizontal magnets **58, 60** may now be used to complete connection over other crosspoints in the other vertical groups, such as **12** and **16**.

It is also noted that as the vertical magnet, such as **36** for vertical unit **14** was operated to move the associated hold bar **40** to engage finger **56** and operate contact actuator spring **42** and contacts **18, 20**, the vertical hold bar **40** was received by the U-shaped channels of the contact actuating springs, such as **44, 46, 48** without effecting operation of the horizontal contacts associated therewith by reason of the fact that the spring fingers, such as **56**, were not moved across the channel of the contact actuating springs, such as **44**, to intercept the vertical hold bar **40** in its movement.

Although the horizontal magnet, such as **60**, which was used in the establishment of the connection, is now released for use in the establishment of further calls over the other vertical contact units in the crossbar switch, the vertical magnet **36** is maintained operated for the period that a connection is to be completed over contacts in the established path between terminals **64, 66; 68, 70**.

According to a feature of the present invention, the novel crossbar switch includes vertical magnets such as **36**, which are of the magnetic latching type, such as shown in FIGURE 2. The latching relays there illustrated are operable, as energized, to operate the vertical hold bars, such as **40**, to complete the desired one of the transmission paths over the switch; are operable subsequent to the interruption of the energizing current to the relay to maintain the vertical hold bar **40** in its path completing position; and are operable responsive to the momentary coupling of a current pulse of a given polarity thereto to release the vertical hold bar **40**, and interrupt the path which extends over the contacts previously closed thereby.

As shown in FIGURE 2, the magnetic latching relay **36** basically comprises an L-shaped pole piece **72** having a first or shorter leg **74** extending perpendicular to a second or longer leg **76**. A core member **78** having a threaded shank at one end thereof is secured to the shorter leg **74** by means including positioning means **80A**, locknut **80** and screw means **81**, the longitudinal axis of the core being disposed in parallel spaced relation with the elongated pole piece leg **76** in such mounting. Positioning means **80A** threadingly engage the shorter leg **74** of the pole piece and are locked in a desired position by locknut **80**. Screw means **81** extend through the positioning means **80A** and into the threaded shank of core member **78**, whereby ad-

justment of the positioning means 80A and screw means 81 permits longitudinal adjustment of the core 78 for a purpose disclosed more fully hereinafter.

An operating winding A, B, and a release winding C, D, are wound about core 78 in the manner shown in FIGURE 3, a wrapping of insulation 82 being wound about core 78 and insulation members 84, 84A being attached at either end of the core to form a spool-like portion upon which the coils A, B; C, D are readily wound. A wrapping 83 of suitable insulating material is wound about the outer periphery of the coil windings as completed.

Although the coils are shown as being wound in opposing directions, it will be appreciated that the coils may also be wound in the same direction and the polarity of the operating and release circuits applied to the terminals in a correspondingly different manner. Armature 38 is mounted for pivotal movement at 86 about a knife edge pivot formed at the one end of the leg 72, the armature being attracted by the magnetic path as established over core 78, air gap 88, armature 38, and pole piece 72 to core 78 whenever the operating coil A, B is energized momentarily by an electrical pulse of a predetermined polarity and value.

Subsequent to movement of the armature 38 adjacent to and in contacting relation with core 78 and the termination of the pulse, the residual magnetism of the core extends over the path including core 78, armature 38 and pole piece 72 to maintain the armature 38 in the operated position. It is important that the armature 38 engage the end of core 78 with the faces of the two members as flat as possible, and positioning means 80, 80A and screw means 81 are provided to permit lateral adjustment of core 38 to accomplish such end.

As a release pulse of a predetermined value and the polarity indicated in FIGURE 3 is coupled to release winding C, D, spring means associated with the load (and schematically shown as 91 in FIGURE 2) urge the armature 38 away from the end of core 78, and hold bar 40 effects the opening of the contact set which was previously maintained closed thereby.

In the provision of a crossbar switch including a magnetic latching relay 36 which is capable of maintaining the contacts of a crossbar switch in the operated position subsequent to interruption of the power thereto, it has been found that a special core material must be utilized to provide the necessary forces (*a*) for operating the armature reliably under load conditions which vary over a large range, (*b*) for holding the armature latched under such load for indeterminate periods of time even with the possible application of external forces to the crossbar switch or its support frame, and (*c*) for releasing the armature responsive to the momentary application of a pulse to the winding.

It has been discovered that a magnetic latching relay which is operable in crossbar switches used in telephone exchanges may be provided by using a material consisting of oil hardened drill rod having a composition of carbon—.95%, silicon—.30%, manganese—1.20%, tungsten—.50%, chromium—.50%, vanadium—.20%, and hardening such material to a hardness of a minimum of 58 Rockwell "C." The hardness of the material has been found to be directly related to the operating and latching characteristic of the core.

In one preferred embodiment the hardening process comprises the steps of heating the furnace to a value not in excess of 1300° F. After attaining furnace heat the cores are introduced and the temperature is advanced at such a rate that thin sections or small turnings will not heat more rapidly than thick sections. After the furnace has attained 1450° F. the work is "soaked" or held at such temperature for ten to twenty minutes before quenching in oil. The cores are then double tempered at 425° F. for one and one-half hours to provide a hardness of 58–60 Rockwell "C."

It was discovered that the physical hardness produced by such heat treatment was related to the magnetic latching properties of the device, and that by hardening the high carbon steel to a 58–60 Rockwell "C" it is possible to produce a core for a magnetic latching relay which has the proper operating characteristics for successful use as a vertical magnet in a crossbar switch which not uncommonly has loads of 600 grams for a magnet having a 1:1.2 lever ratio.

In one preferred embodiment of the magnetic latching relay which was operative in a crossbar switch of the type shown in FIGURE 1 having ten horizontal makes and nine off-normal springs, the magnetic relay core and coil structures were built to the following specifications:

OPERATING WINDING

Turns	Wire Size	Resistance	50 v. D.C.
8,000	34	334	149 milli-amperes. 1,190 ampere-turns.

RELEASE WINDING

3,500	40	900	53 milli-amperes. 188 ampere-turns.

In such arrangements under severe combinations of loads and conditions, it was found that the crossbar switch magnets operated successfully with an average operate pulse of 27 milli-seconds to hold and an approximately 6 milli-seconds pulse to release.

The use of the novel crossbar switch including the magnetic latching relays having the core material of the disclosure are capable of providing automatic telephone exchanges and data switching networks which are capable of providing reliable switching with a minimum of power. Further, the nature of the novel crossbar switch is such that the construction used to provide the desired results does not incorporate any mechanical latches or critical circuitry which would entail additional maintenance problems or expense. As a result, large savings in the cost of exchange operation are effected, and an increased use and application of crossbar switching equipment is made possible in locations where available power is a problem.

Although only a particular embodiment of the invention has been shown and described, it is apparent that modifications and alterations may be made therein, and it is intended in the appended claims to cover all such modifications and alterations as may fall within the true spirit and scope of the invention.

What is claimed is:

1. A mechanical crossbar switch comprising at least one set of horizontal contacts and at least one set of vertical contacts supported in spaced aligned relation with each other, selector means supported adjacent said contact sets for completing a circuit connection over said contact sets, a magnetic latching magnet supported on said switch comprising at least one winding on a core consisting of high carbon steel material having a hardness in the range of at least 58 Rockwell "C" and an armature member supported for movement adjacent to said core responsive to energization of said winding, the residual magnetism provided by said core subsequent to removal of the energizing force retaining the armature in such position, and operating means connected to said armature member operative responsive to energization of said magnet winding to operate said selector means in the completion of a circuit over said horizontal and vertical contact sets.

2. A mechanical crossbar switch comprising at least one set of horizontal contacts and at least one set of vertical contacts supported in spaced aligned relation with each

other, selector means supported adjacent said contact sets for completing a circuit connection over said contact sets, a magnetic latching magnet supported on said switch comprising at least one winding on a core consisting of high carbon steel material in the order of 1% carbon and having a hardness in the range of 58–60 Rockwell "C" and an armature member supported for movement adjacent to said core responsive to energization of said winding, the residual magnetism provided by said core subsequent to removal of the energizing force retaining the armature in such position, and operating means connected to said armature member operative responsive to energization of said magnet winding to operate said selector means in the completion of a circuit over said horizontal and vertical contact sets.

3. A mechanical crossbar switch comprising at least one set of horizontal contacts and at least one set of vertical contacts supported in spaced aligned relation with each other, selector means supported adjacent said contact sets to control the extension of circuit paths thereover, a magnetic latching magnet supported on said switch having at least one winding on a core consisting of high carbon steel material comprised of .95% carbon, .30% silicon, 1.20% manganese, .50% tungsten, .50% chromium, and .20% vanadium, said core having a hardness in the range of 58–60 Rockwell "C" and an armature member supported for movement adjacent to said core responsive to energization of said winding, the residual magnetism provided by said core subsequent to removal of the energizing force retaining the armature in such position, and operating means connected to said armature operative responsive to energization of said magnet to operate said selector means in the completion of a circuit over said horizontal and vertical contact sets.

4. A mechanical crossbar switch for use in an automatic telephone exchange comprising at least one set of horizontal contacts and at least one set of vertical contacts supported in spaced aligned relation with each other, selector means supported adjacent said contact sets for controlling said contact sets in the completion of circuit paths thereover, a magnetic latching magnet supported on said switch including a first and a second winding wound on a core consisting of high carbon steel material having a hardness in the range of 58–60 Rockwell "C," said first winding having a number of turns sufficient as energized to provide in the order of 1190 ampere turns and said second winding having a number of turns sufficient to provide in the order of 188 ampere turns for release purposes responsive to the energization thereof, and an armature member supported for movement adjacent to said core responsive to energization of said first winding, the residual magnetism provided by the core subsequent to the removal of the energizing force retaining the armature in such position and operating means connected to said armature member operative responsive to energization of said first winding on said magnet to operate said selector means in the completion of a circuit over said horizontal and vertical contact sets and operative responsive to energization of said second winding on said magnet to interrupt said circuit.

5. An electromagnetic relay device for use in a crossbar switch for an automatic telephone exchange comprised of at least one winding on a core consisting of high carbon steel material having .95% carbon, .30% silicon, 1.20% manganese, .50% tungsten, .50% chromium and .20% vanadium, and having a hardness in the range of 58–60 Rockewll "C," terminal means for coupling an energizing potential to said winding, and an armature member operatively controlled responsive to energization of said magnet coil to move to a position adjacent one end of said core for retention by the residual magnetism of the core subsequent to termination of the coupling of the energizing potential to said magnet coil.

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