Nov. 29, 1966 J. A. WATKINS ETAL 3,289,131

ELECTROMAGNETIC SWITCH SELECTOR

Filed Nov. 12, 1964 4 Sheets-Sheet 1

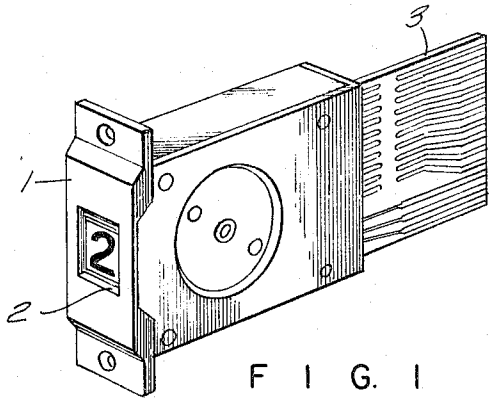



FIG. 1

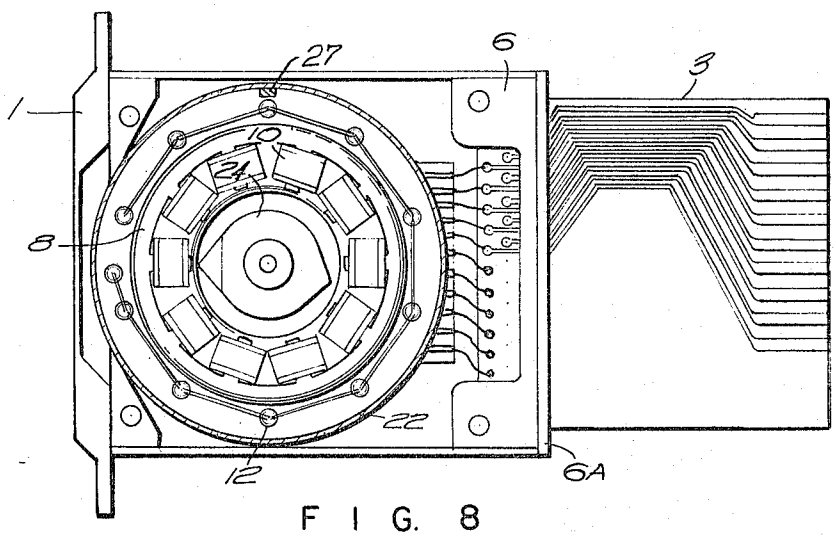



FIG. 8

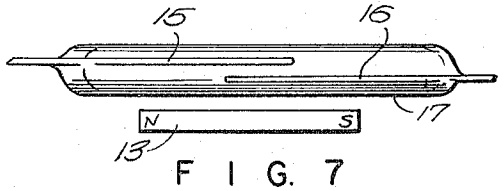



FIG. 7

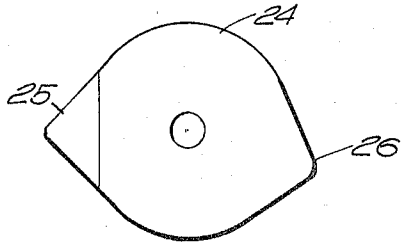



FIG. 6

INVENTORS
JOHN A. WATKINS
BY ELLIOT R. LANG
Weingarten, Oremburch & Lahive
ATTORNEYS

ELECTROMAGNETIC SWITCH SELECTOR

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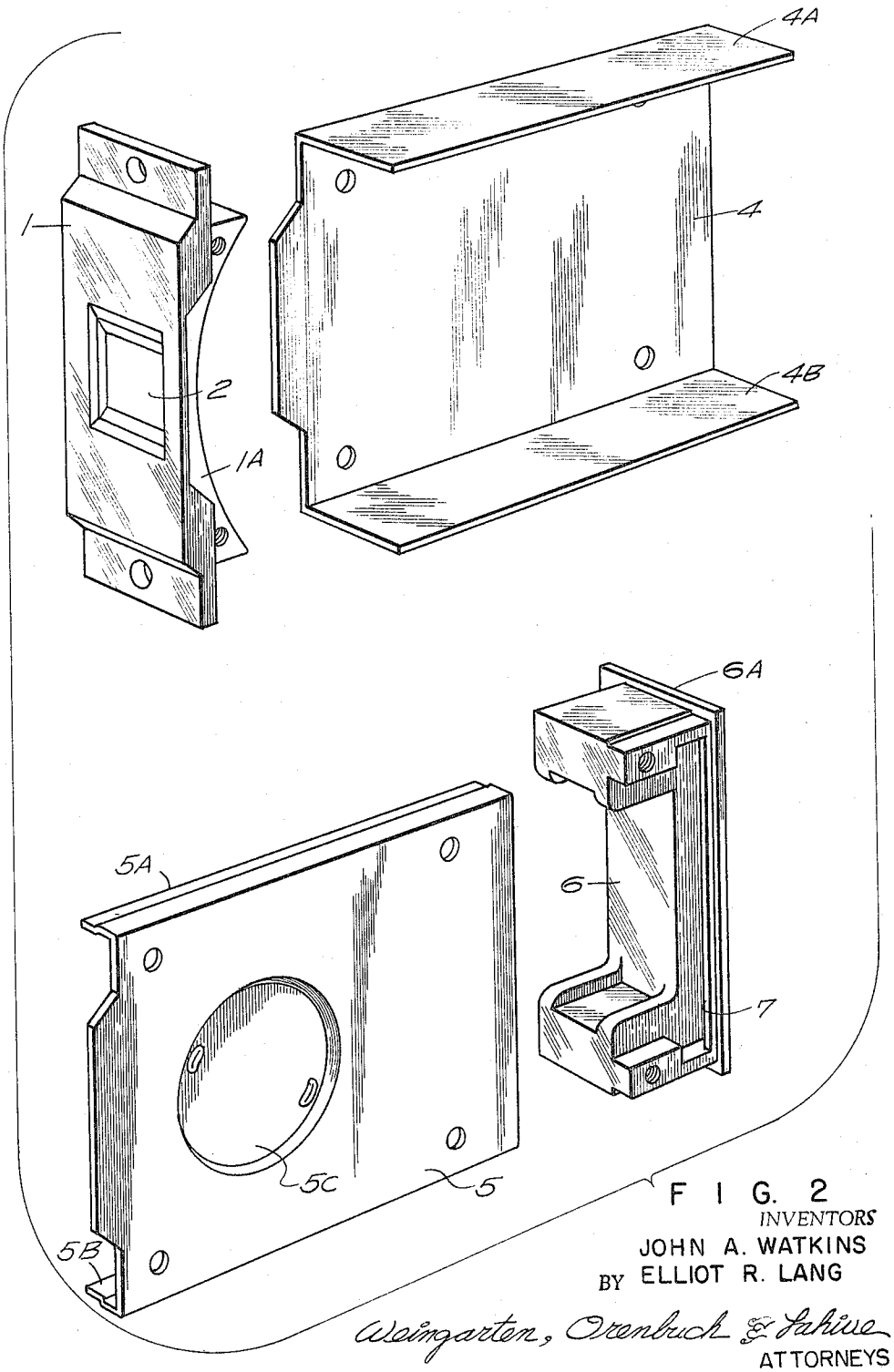



FIG. 2

INVENTORS
JOHN A. WATKINS
BY ELLIOT R. LANG
Weingarten, Orenbuch & Lahive
ATTORNEYS

Nov. 29, 1966 J. A. WATKINS ETAL 3,289,131

# ELECTROMAGNETIC SWITCH SELECTOR

Filed Nov. 12, 1964 4 Sheets-Sheet 3

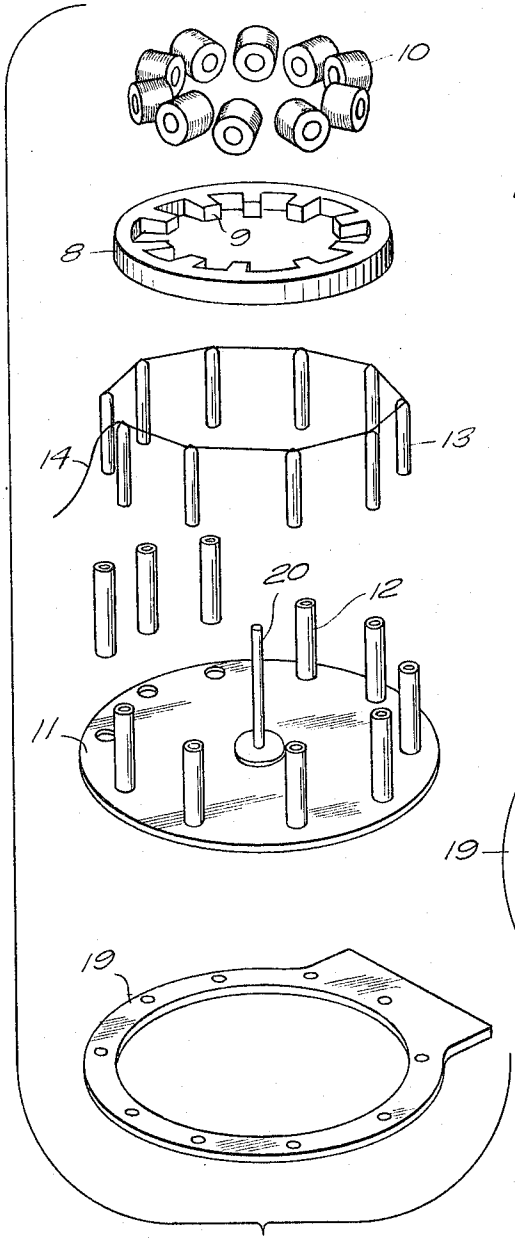



FIG. 3

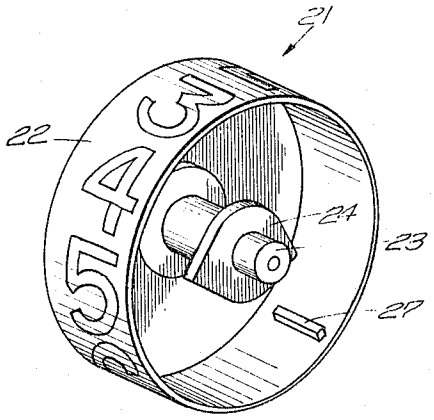



FIG. 5

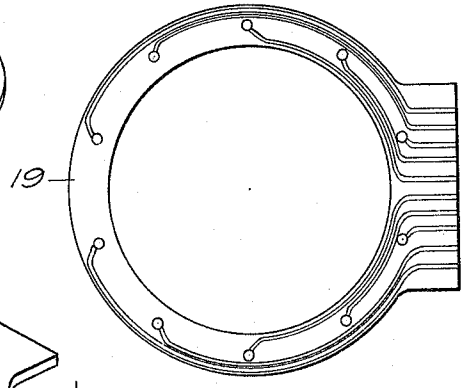



FIG. 4

INVENTORS
JOHN A. WATKINS
BY ELLIOT R. LANG
Weingarten, Oronbuch & Lahive
ATTORNEYS

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ELECTROMAGNETIC SWITCH SELECTOR

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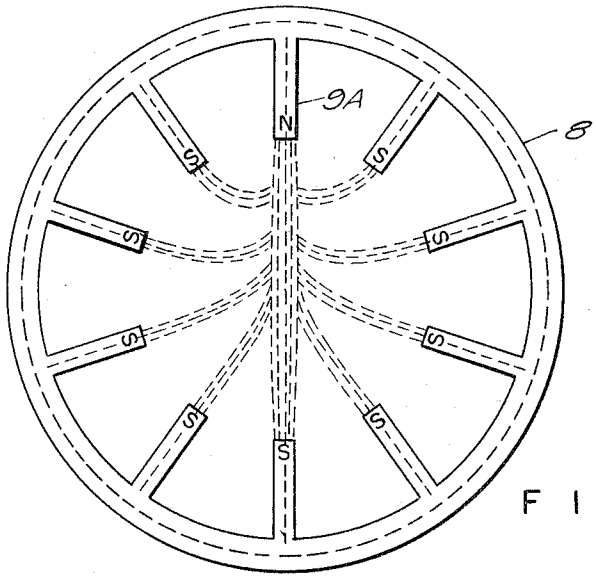



FIG. 9

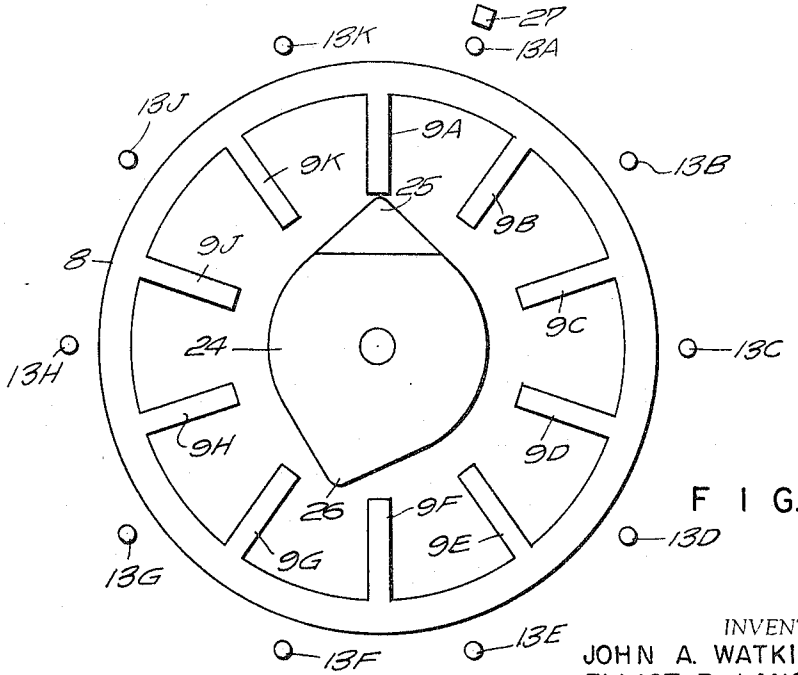



FIG. 10

INVENTORS
JOHN A. WATKINS
BY ELLIOT R. LANG

Weingarten, Oxenbruch & Lahive
ATTORNEYS

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3,289,131

# ELECTROMAGNETIC SWITCH SELECTOR

John A. Watkins, Cheshire, and Elliot R. Lang, Hamden, Conn., assignors to The Patent Button Company, Waterbury, Conn., a corporation of Connecticut

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2 Claims. (Cl. 335—162)

This invention relates generally to switching apparatus of the type having a plurality of switches arranged to permit any switch to be selected for operation in response to an electrical command. More particularly, the invention pertains to an electromagnetically actuated device permitting rapid and reliable selection among a multitude of switches in response to electrical signals.

The invention is an improvement upon data indicators of the type utilizing an electromagnetic stator that is capable, when appropriately energized, of establishing any one of a plurality of discretely oriented magnetic fields. Indicators of this type employ a panel or housing having a window in which symbols, such as alpha-numeric characters, are displayed. The symbols are carried upon a drum that is part of a rotor located in the housing. Usually, the symbols are arranged upon the drum so that only one symbol at a time can be fully displayed in the window. A permanent magnet is part of the rotor. When the stator is energized, the magnet causes the rotor to turn to a position at which the magnet is aligned with the magnetic field established by the stator. The symbol appearing in the indicator's window is, thus, determined by the position of the rotor which, in turn, is determined by the magnetic field established by the stator. By selecting the magnetic field established by the rotor, any symbol on the drum can be made to appear in the window.

In some situations where data indicators are used, it is desirable to have an electrical output in addition to the visual display of the selected character. For example, such data indicators may be employed in a system where the indicator must generate a feedback signal to assure that the correct symbol is being displayed. In other systems, the data indicators may be required to generate electrical signals to operate "slave indicators" or to operate other apparatus when certain symbols are displayed.

The invention resides in a switch arrangement that is controlled by the position of the indicator's rotor. This arrangement permits an electrical signal to be generated corresponding to the character present in the window of the indicator.

More specifically, the invention comprises a stator having an annular ferromagnetic core carrying a plurality of inwardly extending radial poles. Surrounding each pole is a winding that can be electrically energized to cause a discretely oriented magnetic field to be established. A circular array of reed switches is positioned externally of the annular core and in close proximity to it. A permanent magnet is attached to the drum of the rotor in a location where the magnet sweeps a path close to the positions of the reed switches. The reed switches are disposed so that for each position where a symbol is fully displayed in the indicator's window, the magnet on the drum is in close proximity to a different reed switch and controls the state of the adjacent switch.

The invention, both as to its construction and mode of operation, can be better understood from a study of the following exposition which is intended to be read in connection with the accompanying drawing in which:

FIG. 1 is a perspective view of the assembled invention;

FIG. 2 depicts the housing employed in the invention;

FIG. 3 is an exploded view showing the parts comprising the stator;



FIG. 4 shows a printed circuit board used in the stator;

FIG. 5 depicts the rotor of the indicator;

FIG. 6 shows the shape of the rotor's permanent magnet;

FIG. 7 illustrates the manner in which a reed switch is actuated;

FIG. 8 is a view having parts broken away to show the internal arrangement of the indicator;

FIG. 9 illustrates the magnetic field pattern established by energizing one of the stator windings; and

FIG. 10 depicts the position assumed by the salient pole magnet upon decay of the magnet field.

The indicator depicted in FIG. 1 of the drawings employs a housing having a front panel **1** in which there is a window **2** for displaying symbols selected by applying electrical signals to the terminals on a printed circuit board **3**. The housing, shown disjointed in FIG. 2, in addition to the front panel, includes a pair of interlocking members **4**, **5** and a rear panel **6**. The four parts fit together to form an enclosure in which the stator and rotor of the indicator are contained. Preferably, members **4** and **5** are constructed of steel or some other ferromagnetic material so as to shield the interior parts from external stray magnetic fields. Rear panel **6** is provided with a slot **7** through which the printed circuit board **3** is enabled to extend into the interior of the housing, as depicted in FIG. 8.

Cover plate **5** is provided with flanges **5A** and **5B** that fit within the arms **4A** and **4B** of housing body **4** so that the two members, in effect, form a hollow rectangular metallic tube. Front panel **1** has an arcuate portion **1A** that fits within the front of the tube, the arcuate portion having threaded holes. The rear of the tube is closed by rear panel **6** which except for the flange **6A**, fits within the tube. The rear panel **6** is also provided with threaded holes. The housing body **4** and cover plate **5** are secured to the panels **1** and **6** by screws which engage the threaded holes in the panels.

The cover plate **5** has an indented circular portion **5C** which provides a conforming protrusion of the wall on the opposite side of the plate. The stator of the indicator is secured to the disc-like protrusion of cover plate **5**.

The stator of the indicator, shown in FIG. 3, utilizes an annular ferromagnetic core **8** having a number of inwardly extending radial poles **9**. Preferably the core consists of a number of soft iron laminates, as in a transformer core, and the poles are uniformly spaced around the circle of the core. Upon each pole is mounted a winding having leads permitting the winding to be individually excited by an impressed electrical signal. For clarity, the windings **10** in FIG. 3 are shown dismounted from their poles. The core and the windings constitute an electromagnetic structure that is mounted upon a circular plate **11** of a non-magnetic structure material such as bakelite or brass. Adjacent the edge of plate **11** is a circular array of tubes **12**, each tube being mounted in an aperture in the plate. The tubes are of a non-magnetic material and within each tube is housed a reed switch. Preferably, the reed switches **13** are connected, as indicated in FIG. 3, to have a common electrical connection **14**.

A reed switch, as is well known, is a device employing a pair of contacts formed by the overlapping ends of a pair of cantilevered resilient arms or reeds of ferromagnetic material which are hermetically sealed in a glass tube. As depicted in FIG. 7, electrically conductive cantilever reeds **15** and **16** extend through the ends of glass tube **17** so that the external part of the reeds provide electrical connections to the internal contacts constituted by the overlapping ends of the reeds. The reeds are made of a ferromagnetic material so that when

a magnet, such as bar magnet 18, is placed adjacent the reeds, magnetic induction causes the reeds to be attracted toward each other and close the contacts. When the magnetic force is reduced sufficiently, as by removing the bar magnet, the resilience of the reeds causes the contacts to spring apart. The interior of the glass tube may be evacuated or it may be filled with a dry inert gas.

Referring again to FIG. 3, a circular printed circuit board 19, is shown having electrical leads printed upon its underside. The board 19 is secured to plate 11 in a manner permitting each reed switch to have its lowermost external contact connected to a different lead on the board and permitting the common lead 14 to be connected to yet another separate lead on the board. The arrangement of the leads printed upon that board is shown in FIG. 4.

When the stator is assembled, the electromagnetic structure is fitted upon plate 11 where it is concentric with and disposed within the circular array of reed switches housed in the tubes. Electrical connections to the reed switches are made through terminals on printed circuit board 3 which are, in turn, connected to terminals on board 19.

In the assembled indicator, the plate 11 is secured by screws to the protrusion 5C in cover plate 5. The disc-like protrusion fits within the central aperture in printed circuit board 19 and causes the remainder of the cover plate to be spaced from the leads on that board a sufficient distance to prevent their being short-circuited.

The plate 11, FIG. 3, is provided with a shaft 20 which is centrally disposed with respect to the annular ferromagnetic core 8. Upon the shaft 20 is mounted the rotor 21 of the indicator. As illustrated in FIG. 5, the rotor is constituted by a drum 22 having symbols inscribed upon its periphery. The drum is essentially a hollow cylinder that is closed at one end by a wall upon which is secured a spindle 23. A permanent magnet 24 is keyed or otherwise fastened upon the spindle so that the magnet, spindle, and drum turn as a unit. Permanent magnet 24, is, preferably, of the shape depicted in FIG. 6. That is, magnet 24 is a disc having a circular configuration interrupted by two salient poles 25 and 26. Pole 26 is shorter than the other salient pole and is not diametrically opposite pole 25. On the interior of the drum is secured a bar magnet 27, which when juxtaposed to a reed switch, acts in the manner of bar magnet 18 of FIG. 7.

The spindle of the rotor has a central bore which permits the rotor to be mounted upon shaft 20 of the stator. When thus mounted, the drum 22, as depicted in FIG. 8, surrounds the circular array of reed switches. Upon rotation of the rotor, bar magnet 27 is swept around a path that closely envelopes the circular array of reed switches. The drum is made of a thin light-weight non-magnetic material, such as aluminum, to minmize the inertia of the rotor. The salient pole magnet 24, in the assembled indicator, is encircled by core 8 and its array of windings 10. The windings are connected to terminals on printed circuit board 3 in a manner permitting the windings to be individually energized by applying electrical signals to appropriate terminals.

Upon energizing one of the windings of the stator, a magnetic field is established which acts upon the salient pole magnet 24 and causes that magnet to assume a position where it is, essentially, aligned with the magnetic field. Referring to FIG. 9 which shows the ferromagnetic core 8 with the windings omitted from the poles, it can be appreciated that where the winding on pole 9A is energized by an electrical signal causing that pole to be a North magnetic pole, every other pole on the core becomes a South magnetic pole. A magnetic field is thus established having the flux pattern illustrated by the stippling in FIG. 9. It should be observed that the circular ferromagnetic core is of sufficient permeability to avoid its being saturated by the magnetic flux. The magnetic flux, therefore, is prevented from extending beyond the core into the space occupied by the reed switches. The ferromagnetic core, hence effectively shields the reed switches from the magnetic field established by the stator.

The magnetic field orientation depicted in FIG. 9 causes salient pole magnet 24 to turn the rotor until the magnet is substantially in alignment with the magnetic field established by the stator. Assuming the longer of the salient poles to be a South magnetic pole, magnet 24 aligns itself so that pole 25 is closely adjacent pole 9A and shorter pole 26 is between poles 9G and 9F. When the magnetic field established by the stator decays upon de-energization of the windings on radial pole 9A, the salient pole magnet is held in the position where salient pole 25 is aligned with radial pole 9A and salient pole 26 is midway between radial poles 9F and 9G. The salient pole magnet remains in that position until the stator is again energized by an electrical signal applied to one of the windings. The rotor, therefore, is fixed in position in the interval between consecutive stator energizing electrical signals. When thus fixed in position, one of the characters on the drum is fully presented in the indicator's window and, as illustrated in FIG. 10, bar magnet 27 is juxtaposed to one of the reed switches, causing that reed switch to close. It is evident from FIG. 10 that when salient pole 25 is aligned with radial pole 9A, the bar magnet closes reed switch 13A; when salient pole 25 is aligned with radial pole 9B, the bar magnet closes reed switch 13B; when salient pole 25 is aligned with radial pole 9C, the bar magnet closes reed switch 13C; and so on.

In the embodiment depicted in the drawings ten radial poles are employed, permitting the rotor to assume ten different fixed positions. In each of those fixed positions a different character may be presented in the window and a different one of the reed switches is closed by the adjacent bar magnet 27. The number of radial poles and switches may, of course, be increased or diminished as desired. Further, more than one bar magnet may be carried by the drum in order to operate a number of switches for each fixed position of the rotor. Those changes are obvious and do not depart from the essence of the invention.

Referring to FIG. 8, it can be seen that the array of reed switches is disposed in an annular space between the drum 22 and the ferromagnetic core 8. The reed switches are shielded from external magnetic fields by the end plates 4 and 5 of the housing. If desired, the entire housing may be constructed of a ferromagnetic material to better shield the reed switches from external magnetic fields. Ferromagnetic core 8 confines the magnetic field of salient pole magnet 24 and the magnetic field established by the stator and thereby shields the reed switches from internal magnetic fields. Only the magnetic field of bar magnet 27 is, therefore, permitted to affect the reed switches.

As the reed switches are sensitive to magnetic fields, bar magnet 27 causes the intervening switches to close when the rotor turns to a new position. Where the closure of those switches is objectionable, the electrical output of the switches can be blocked during the time that an electrical signal is applied to the stator. For example, each reed switch may have a diode in its output circuit that is arranged to be reversely biased when a signal is applied to any winding of the stator so as to block the reed switch output. By this arrangement, the outputs of the reed switches are blocked during the time that the rotor turns and are unblocked when the rotor has assumed its fixed position.

As the invention can be embodied in a multitude of differing structures, it is not intended that the scope of the invention be restricted to the precise embodiment illustrated in the drawings. Rather, it is intended that the

scope of the invention be delimited by the appended claims and to include such structures as do not in essence fairly depart from the invention there defined.

What is claimed is:

**1.** Switching apparatus comprising:

(1) a panel having a window for displaying symbols;

(2) a stator having a ferromagnetic annular core for establishing any one of a plurality of discretely oriented magnetic fields, the core having a plurality of inwardly protruding radial poles, and a plurality of windings, each winding being mounted upon a different radial pole and being connected to permit the winding to be separately energized by an electrical signal;

(3) a plurality of switches disposed outside the annular core and fixed in an array that closely encircles the annular core, the switches being of the type operative by magnetic induction; and

(4) a rotor having a magnet mounted to turn within the enclosure of the annular core the magnet having salient poles of opposite magnetic polarity whereby the magnet is constrained to rotate into substantial alignment with the magnetic field established by the stator, the rotor further including a drum bearing the symbols to be displayed in the window, the drum having a second magnet attached to it in a position where rotation of the drum carries the second magnet about a circular path outside the annular core and closely adjacent to the circular array of switches.

**2.** Switching apparatus comprising:

(1) a housing having a window for displaying symbols;

(2) a stator disposed in the housing, the stator having a ferromagnetic annular core for establishing any one of a plurality of discretely oriented magnetic fields, the core having a plurality of inwardly protruding radial poles spaced uniformly around the annulus and a plurality of windings, each winding being mounted upon a different radial pole and being connected to permit the winding to be separately energized by an electrical signal;

(3) a plurality of switches disposed outside the annular core and fixed in an array closely encircling that core, the switches being of the type operative by magnetic induction;

(4) a rotor having a magnet mounted to turn within the enclosure of the annular core, the magnet having salient poles of opposite magnetic polarity whereby the magnet is constrained to rotate into substantial alignment with the magnetic field established by the stator, the rotor further including a drum having symbols on its periphery, the drum being positioned to cause the symbols to appear in the window of the housing in the aligned position of the salient pole magnet, the drum carrying a second magnet in a position where rotation of the drum carries the second magnet about a circular path outside the annular core and where the second magnet is juxtaposed to a different switch in the array for each different aligned position of the salient pole magnet.




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BERNARD A. GILHEANY, *Primary Examiner.*

J. J. BAKER, *Assistant Examiner.*