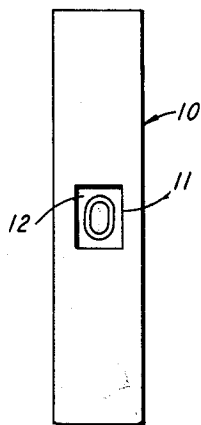
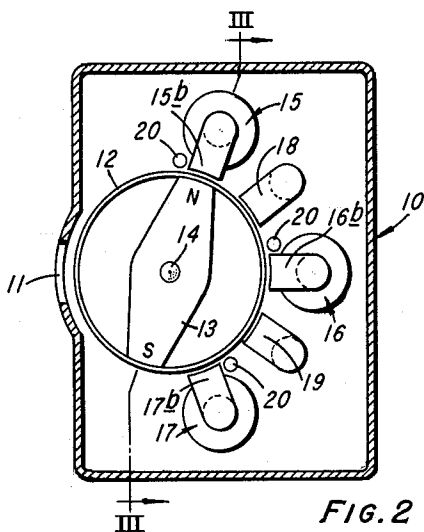
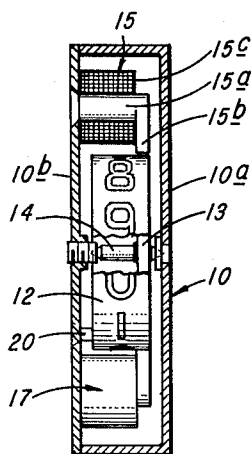
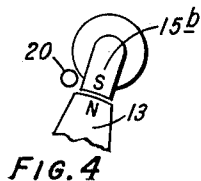
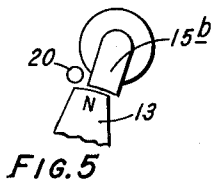


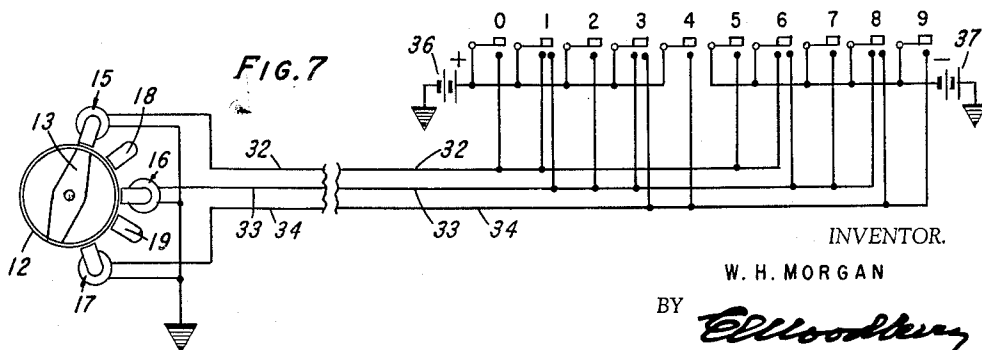
W. H. MORGAN

ELECTROMAGNETIC INDICATOR

Filed May 25, 1959



COIL	15	16	17
0	+		
1	+	+	
2		+	
3		+	+
4			+
5	-		
6	-	-	
7		-	
8		-	-
9			-



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3,089,131

ELECTROMAGNETIC INDICATOR

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This invention relates to electrically-actuated indicators for indicating any one of a plurality of discrete numbers or symbols, and is particularly useful in indicating any one of the ten decimal digits 0 to 9, inclusive.

A broad object of the invention is to provide a simple, compact and low-cost indicator.

A feature of the invention is an electromagnetic indicator capable of providing a large number of indications but requiring only about a third as many lines and electromagnets.

Another feature is a permanent magnetic holding means for retaining the indicator in any discrete position into which it has been operated.

Another feature is a magnetic indicator operable directly from one position into a diametrically opposite position by magnetic repulsion without danger of stalling on dead center in its first position.

The listed objective is attained largely because of the first feature; namely, the small number of electromagnets required. In a ten-digit indicator, only three electromagnets energized over three lines are required. Each electromagnet, when actuated alone, provides two positions according to the polarity of the applied signal, thereby yielding six of the ten decimal positions. Joint energization of the first and third electromagnets with positive or negative pulses provides two more positions, and joint energization of the second and third electromagnets with positive or negative pulses provides two additional positions, making a total of ten in all.

The holding feature is obtained by providing two passive paramagnetic pole pieces between the pole pieces of the electromagnets, providing a total of five pole pieces, each of which holds a rotatable permanent magnet element of the indicator in either of two positions.

The anti-stalling feature is obtained by a novel magnetic structure whereby the magnetic repulsive force resulting from energization of an electromagnet is displaced from the holding force exerted when the electromagnet is not energized.

A full understanding of the invention may be had from the following description with reference to the drawing, in which:

FIG. 1 is a front elevational view of an indicator in accordance with the invention.

FIG. 2 is an elevational view looking at the right side of FIG. 1 with the right side wall removed.

FIG. 3 is a cross-section in the plane III—III of FIG. 2.

FIGS. 4 and 5 are detailed views illustrating the operation of the structure for preventing stalling of the indicator on dead center.

FIG. 6 is a table showing the mode of energization of the electromagnets to produce different indications.

FIG. 7 shows a possible circuit that may be employed to energize the indicator.

Referring to FIGS. 1, 2 and 3, an indicator in accordance with the invention may consist of a thin case 10 of generally rectangular configuration to facilitate mounting a plurality of them side by side in a row. The front wall has a window 11 through which any one of a plurality of numbers or symbols on a rotary indicating member, here shown as a drum 12, may be displayed.

The drum 12 is of nonmagnetic material and is secured to opposite ends of a diametrically extending permanent magnet 13, which is secured to a pivot shaft 14 extending

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therethrough and supported in pivot bearings in the opposite side walls 10a and 10b of the case 10.

Cooperating with the permanent magnet 13 are three identical electromagnets 15, 16 and 17 arranged in an arc closely adjacent the drum 12, and each having a paramagnetic core 15a, 16a, or 17a secured at one end to the side wall 10b of the case and having at its free end a pole piece 15b, 16b or 17b juxtaposed to the path of movement of the ends of the magnet 13 and having a winding 15c, 16c or 17c. The case 10 is preferably of nonmagnetic material.

Positioned intermediate the electromagnets 15 and 16 is a passive core 18 (having no winding), and positioned between the electromagnets 16 and 17 is a passive core 19. The passive cores 18 and 19 may be identical with the cores of the electromagnets 15, 16 and 17.

The three electromagnets 15, 16 and 17 are adapted to be selectively energized with either positive or negative current pulses.

When the electromagnet 15 is energized by a positive pulse, its pole piece 15b is magnetized south to attract the north end of the permanent magnet 13 into juxtaposed position as shown in FIG. 2, in which position the digit "0" on the drum 12 is displayed through the window 11. The drum 12 is retained in this position following the pulse by the continuing, but lesser, magnetic attraction between the permanent magnet and the pole piece.

If a positive pulse is simultaneously applied to both the electromagnets 15 and 16, the resultant magnetic force of the two pole pieces is midway therebetween, and the north end of the magnet 13 is rotated into midway position where it is aligned with the passive core 18, and is retained in alignment with the passive core 18 after the pulse has ceased. In this position of the armature 13, the drum 12 displays the digit "1" in the window 11.

In the same manner, application of a positive pulse to the electromagnet 16 alone, to the electromagnets 16 and 17 simultaneously, or to the electromagnet 17 alone, moves the north end of the magnet 13 into juxtaposed relation to the electromagnet 16, the dummy pole piece 19, or the electromagnet 17, to display one or the other of the digits "2," "3" and "4," respectively.

To display the digits "5," "6," "7," "8" and "9," respectively, negative pulses are applied to the electromagnet 15 alone, the electromagnets 15 and 16 simultaneously, the electromagnet 16 alone, or the electromagnets 16 and 17 simultaneously, or the electromagnet 17 alone. Under these conditions, the pole pieces of the electromagnets are magnetized north to attract the south end of the magnet 13, so that the magnet 13 and the drum 12 assume positions diametrically opposite to those when positive pulses are applied to the electromagnets. In this manner, any one of the digits "0" to "9" may be selectively displayed.

Under some conditions, the magnet 13 will be required to assume a diametrically opposite direction, that is, a movement through 180°, in response to a single operation. Thus, while the magnet 13 is positioned with its north end juxtaposed to the pole piece 15b of the electromagnet 15, the latter may be energized by a negative pulse to change the indicated digit from "0" to "5" in one operation. If the magnet 13 were exactly aligned with the pole piece 15b, the repulsive force between the north end of the magnet and the north pole piece would be exactly radial, with the result that the magnet would be on dead center and would not be rotated in either direction. This tendency to stall is aggravated by whatever frictional resistance to rotation of the drum may be present.

To obviate such stalling small bodies of paramagnetic material, here shown as iron posts 20, are provided, one

adjacent to and positioned to one side of each of the pole pieces 15b, 16b and 17b. These posts 20 are small relative to the pole pieces of the electromagnets, and produce little effect on the position of the magnet 13 at the time a pole of an electromagnet is energized by a pulse. However, prior to the application of a pulse, the post adjacent the end of the armature 13 produces a slight attractive effect thereon which diverts the adjacent end of the magnet 13 away from exact alignment with the pole piece, so that if the pole piece is next magnetized with polarity corresponding to that of the adjacent end of the magnet 13 the resultant repelling force on the magnet cannot be purely radial, but has a tangential component urging the magnet end away from the pole piece. This effect is illustrated in FIGS. 4 and 5. FIG. 4 shows the relative positions of the magnet end and the pole piece while the pole piece is magnetized south by a pulse, and is attracting the north end of the magnet 13. It will be observed that the end of the magnet is substantially symmetrically disposed relative to the pole 15b. FIG. 5 shows the condition after the energizing pulse has terminated, and the only magnetic force existent is that produced by the permanent magnet 13. Under these conditions, the attractive force between the magnet 13 and the post 20 relative to the attractive force between the magnet 13 and the pole piece 15b is greater than it was under the condition illustrated in FIG. 4, so that the magnet 13 is displaced slightly counterclockwise toward the post 20. If the pole piece 15b is now magnetized north to repel the adjacent north end of the magnet 13, it is apparent that the repulsive force between the magnet and the pole piece 15b will have a component tending to rotate the magnet 13 counterclockwise toward its diametrically opposite position.

To prevent stalling when the magnet 13 is aligned with one of the passive pole pieces 18 or 19 and the two electromagnets straddling that passive pole piece are energized to reverse the magnet, each passive pole piece is located closer to one of its straddling electromagnets than to the other. Thus passive pole piece 18 is closer to electromagnet 15 than to 16, and passive pole piece 19 is closer to electromagnet 16 than to 17.

Obviously many different circuits may be employed for selectively energizing electromagnets 15, 16 and 17 to indicate a desired digit. A simple circuit is illustrated in FIG. 7, in which ten push-buttons, respectively identified with the digits 0-9, are adapted to connect a positive source 36 or a negative source 37 to lines 32, 33 and 34 leading to the electromagnets 15, 16 and 17, respectively, in the necessary fashion to rotate the drum 12 into position to indicate the digit corresponding to the digital push-button that is depressed. Thus it will be apparent that push-buttons 0, 2 and 4 connect the positive source 36 to electromagnets 15, 16 and 17 respectively; push-button 1 connects the positive source 36 to both electromagnets 15 and 16 simultaneously; and push-button 3 connects the positive source 36 simultaneously to both electromagnets 16 and 17. It will also be apparent that push-buttons 5, 7 and 9 connect the negative source 37 to electromagnets 15, 16 and 17; push-button 6 connects the negative source 37 to electromagnets 15 and 16 simultaneously; and push-button 8 connects the negative source 37 to electromagnets 16 and 17 simultaneously.

It will be observed that the circuit of FIG. 7 energizes the electromagnets 15, 16 and 17 according to the pattern shown in FIG. 6.

Although for the purpose of explaining the invention a particular embodiment thereof has been shown and described, obvious modifications will occur to a person skilled in the art, and I do not desire to be limited to the exact details shown and described.

I claim:

1. An electromagnetic indicator comprising: a rotary indicating member movable through a plurality of discrete positions; a permanent magnet on said rotary member having north and south ends respectively positioned

at points angularly displaced from each other a predetermined number of said positions; a stationary structure cooperating with said rotary member and comprising a plurality of paramagnetic pole pieces less in number than said positions and respectively juxtaposed to a consecutive group of said positions less than said predetermined number, each pole piece being magnetizable either north or south to attract either end and repel the other end of said magnet; means for individually selectively magnetizing said pole pieces either north or south, whereby said rotary indicating member can be moved directly from any of said positions into any other selected one of said positions by selectively magnetizing a selected one of said pole pieces either north or south; and a paramagnetic structure associated with each said pole piece to angularly displace the direction of the magnetic force between an end of said permanent magnet and a juxtaposed pole piece when the pole piece is not magnetized by said magnetizing means from the direction of said magnetic force when said pole piece is magnetized by said magnetizing means, whereby upon remagnetization in reverse polarity of the last magnetized pole piece said permanent magnet is off dead-center position with respect to the repellant magnetic force produced by said remagnetization and is positively moved in response thereto.

2. Apparatus according to claim 1 in which said paramagnetic structure comprises a body of paramagnetic material closely adjacent to but separate from and angularly spaced from the associated pole piece.

3. An electromagnetic indicator comprising:

a rotary indicating member movable through a plurality of discrete positions and having a permanent magnet having north and south ends respectively positioned at points angularly displaced from each other a predetermined number of said positions;

a stationary structure cooperating with said rotary member and comprising a plurality of paramagnetic pole pieces less in number than said positions and respectively juxtaposed to a group of alternate positions less than said predetermined number, each pole piece being magnetizable either north or south to attract either end and repel the other end of said magnet;

means for individually selectively magnetizing said pole pieces either north or south whereby said rotary indicating member can be moved into any selected one of said alternate positions by selectively magnetizing a selected one of said pole pieces either north or south;

a plurality of passive paramagnetic pole pieces, each approximately intermediate a consecutive pair of said first-mentioned pole pieces;

and means for selectively simultaneously magnetizing any said consecutive pair of said first-mentioned pole pieces either north or south to position said rotary member with one end of said magnet approximately juxtaposed to the passive pole piece intermediate said magnetized pair.

4. Apparatus according to claim 3 in which each said passive pole piece is slightly closer to one of its associated consecutive pair of pole pieces than the other.

5. An electromagnetic indicator comprising: a casing having a front wall member having a display window therein, a rotary indicating member within said casing movable through ten discrete positions to display any of ten different symbols through said window; a permanent magnet on said rotary member having north and south ends respectively positioned at points angularly displaced from each other a predetermined number of said positions such that while one end is traversing the first five positions, the other end is traversing the last five positions; a stationary structure cooperating with said rotary member and comprising three paramagnetic pole pieces in the first, third, and fifth positions, each pole piece

being magnetizable either north or south; and means for selectively magnetizing each pole piece either north or south and either individually or simultaneously with a next adjacent pole piece whereby said indicating member can be moved directly into any one of ten positions by magnetizing a selected pole piece or adjacent pair of pole pieces either north or south, said pole pieces being radially positioned beyond said rotary member within an arc on the side of said rotary member remote from said win-

dow whereby said rotary member can be positioned close to the window.

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