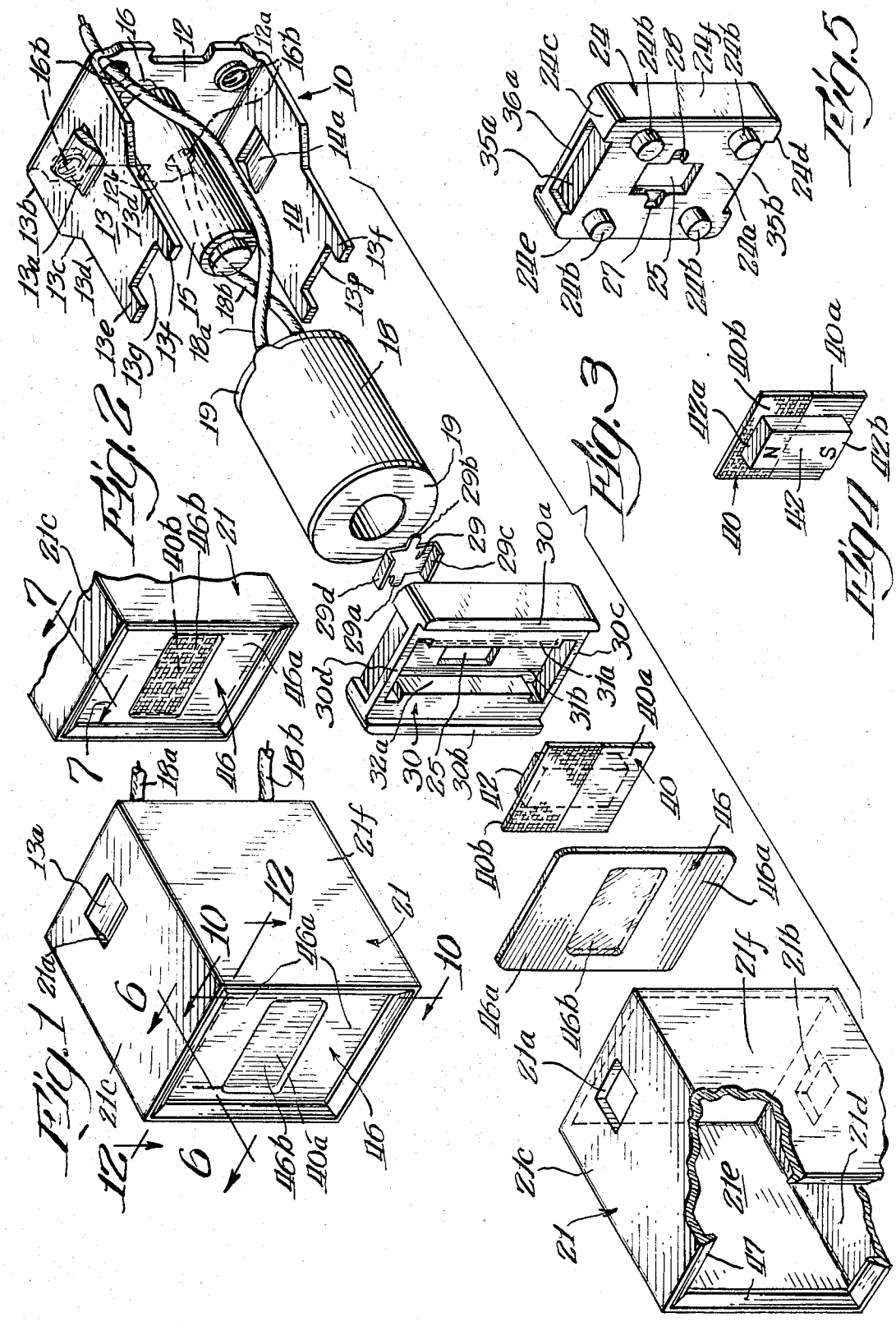
Jan. 14, 1969 J. R. BAILEY ETAL 3,422,426

ELECTROMAGNETIC SIGNAL DEVICE HAVING MOVABLE PERMANENT MAGNET

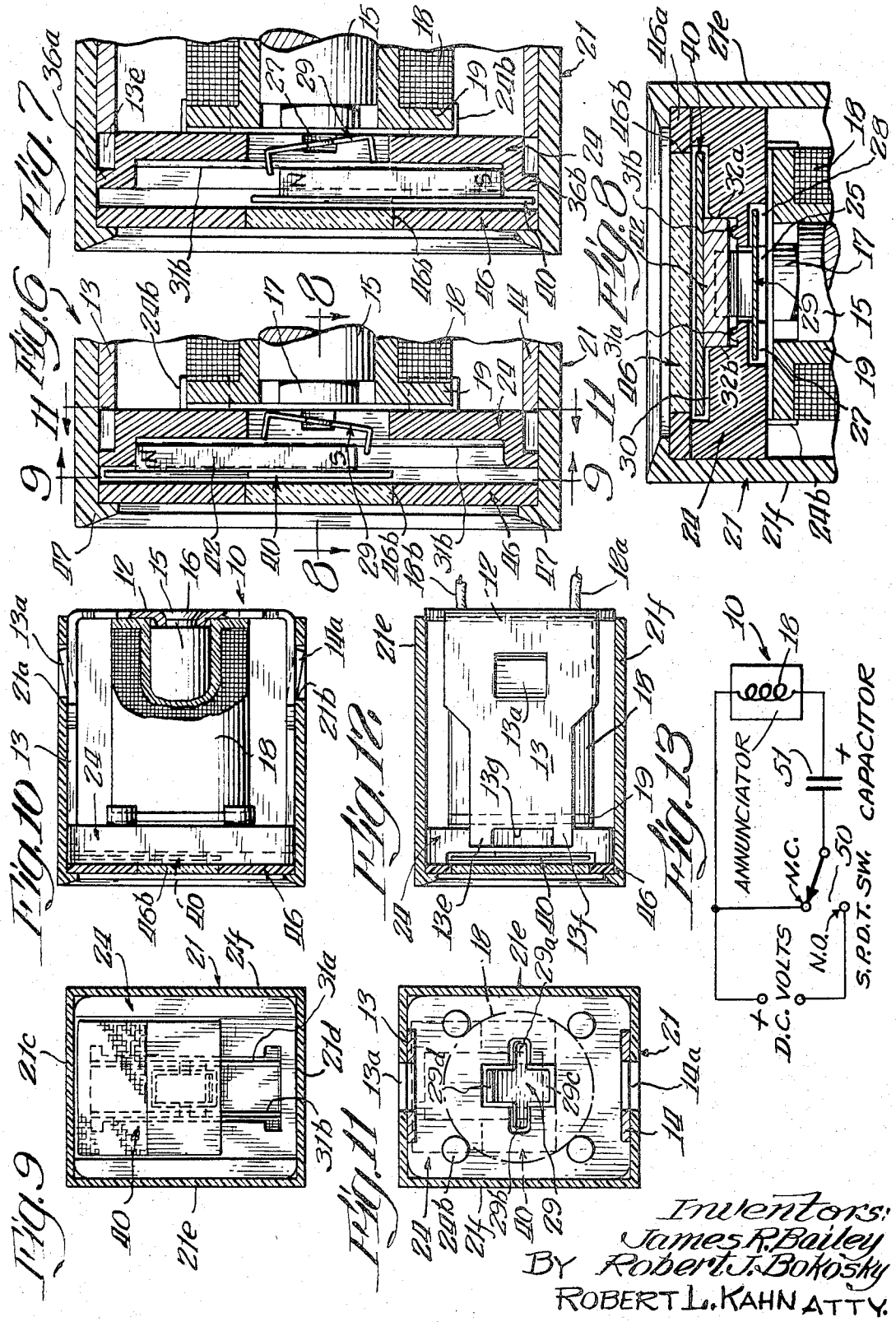
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ELECTROMAGNETIC SIGNAL DEVICE HAVING MOVABLE PERMANENT MAGNET

Filed April 10, 1967 Sheet 2 of 2



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United States Patent Office 3,422,426
Patented Jan. 14, 1969

3,422,426

ELECTROMAGNETIC SIGNAL DEVICE HAVING MOVABLE PERMANENT MAGNET

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Filed Apr. 10, 1967, Ser. No. 629,772
U.S. Cl. 340—373 11 Claims
Int. Cl. G08b 5/00; G08b 5/22; H01f 7/02

ABSTRACT OF THE DISCLOSURE

An electromagnetic signal device primarily for annunciator use has an E-shaped soft iron core with a magnetizing coil about the center leg. The E has substantial depth in a plane normal to the E. A movable flat permanent magnet attached to a signal flag is disposed so that it can cooperate magnetically with the center leg and one or the other of the end legs of the E core. The permanent magnet is guided for movement transversely across the tips of the E. Upon coil energization by current of proper polarity, each pole of the permanent magnet will be repelled and attracted by two corresponding legs of the E core, thereby moving the signal flag. A detent means for locking the permanent magnet against idle movement is provided.

This invention relates to an electromagnetic signal device and more particularly to a compact, small device for annunciator or other signalling use. The invention utilizes a "soft" ferro-magnetic E core with an energizing winding disposed about the center leg. The core E has substantial depth in a plane normal thereto. Cooperating with the leg tips is a permanent magnet flag assembly so shaped and mounted as to be movable transversely of the E legs at the ends thereof. The direction of magnetization is along the line of magnet travel and the magnet body is long enough to cooperate with only two adjacent core legs. When the winding is energized by current of proper polarity, the permanent magnet will be repelled from one position and attracted toward the other position.

Non-magnetic guide means for the permanent magnet are provided to provide desired spacing between the permanent magnet material and the ferro-magnetic core material as well as to reduce friction and maintain the permanent magnet in desired position for cooperation with the tips of the E core.

While a device embodying the present invention will remain in either end position until properly pulsed, detent means may be provided for locking the permanent magnet in position at either end of its travel range to prevent mechanical shock or vibration from moving the permanent magnet and flag from one position to another.

A construction employing the present invention is characterized by mechanical and structural simplicity, has low tooling costs and may be assembled easily and economically. In addition, the device employing the present invention is compact and is susceptible to being housed easily so that the entire device may be mounted in a panel board with minimum space requirements. An important advantage of the new construction resides in the inherent susceptibility to miniaturization, thus making possible a large array of annunciator arrangements. The annunciator employing the present invention is particularly useful in hospitals, hotels, airplanes and other locations where separate annunciator signals may be desirable or necessary. For a full description of the invention reference will now be made to the drawings wherein:

FIG. 1 is a perspective view of the new annunciator in its housing; FIG. 2 is a partial perspective of the same

annunciator showing the flag in a different position; FIG. 3 is an exploded view of the annunciator parts with the housing broken away; FIG. 4 is a perspective of the permanent magnet and flag; FIG. 5 is a perspective of the guide plate; FIGS. 6 and 7 are enlarged sections on lines 6—6 and 7—7 of FIGS. 1 and 2 respectively; FIGS. 8 and 9 are sections on lines 8—8 and 9—9 of FIG. 6; FIG. 10 is a section on line 10—10 of FIG. 1. FIG. 11 is a section on line 11—11 of FIG. 6; FIG. 12 is a section on line 12—12 of FIG. 1; FIG. 13 is an exemplary circuit for use with the new annunciator.

A device employing the invention has, as viewed in elevation, a generally E-shaped core **10** of magnetically "soft" material such as, for example, soft iron or soft steel. Core **10** has a rear frame portion **12** from which extend end leg portions **13** and **14** laterally spaced from each other and generally parallel. Frame portion **12** also has attached thereto at the center thereof central leg **15** preferably in the form of a cylindrical body having reduced ends **16** and **17**. Reduced end **16** of the center leg is staked to a countersunk frame part so that the outer frame face away from the legs has no projections and provides a smooth mounting face. Frame portion **12** has a number of extrusion apertures **16***b* therethrough for mounting the device and/or for accommodating lead wires therethrough. As illustrated, frame portion **12**, when viewed in rear elevation, is roughly rectangular and has apertures **16***b* disposed at four corner regions. If desired, two apertures may be tapped for mounting screws and the remaining two apertures be finished to remove burrs for accommodating leads **18***a* and **18***b* of energizing winding **18** disposed about center leg **15**. Winding **18** is disposed on a suitable plastic bobbin **19** which is disposed over center leg **15** with the ends of bobbin **19** extending against the inner face of frame portion **12** and about reduced pole portion **17** of center leg **15**.

Core end legs **13** and **14** are generally flat in plan view and are provided with laterally disposed locking fingers **13***a* and **14***a* facing frame portion **12**. These fingers can cooperate for locking with slots **21***a* and **21***b* in top and bottom walls **21***c* and **21***d* of non-magnetic shell **21** for housing the structure. Top and bottom are used for reference purposes only. The device can be operated in any position. Non-magnetic shell **21** is preferably of plastic, has a rectangular shape as seen from either open end and is adapted to have core legs **13** and **14** lie close to the inner surfaces of the shell top and bottom walls. The rear end of shell **21** can only come up to frame portion **12** and not overlap the edges. This permits springing shell side walls **21***e* and **21***f* inwardly toward each other. This causes top and bottom shell walls **21***c* and **21***d* to spring outwardly and clear locking fingers **13***a* and **14***a*.

Core legs **13** and **14** are similar insofar as shape is concerned. Thus, referring to core leg **13**, for example, base part **13***b* extending immediately from frame portion **12** tapers at **13***c* to leg portion **13***d*. Leg **13** has end fingers **13***e* and **13***f* between which undercut portion **13***g* is provided. The dimensions across the side edges of the legs (parallel to frame sides **12***a* and **12***b*) may be considered as the depth of the E core. The particular shape of the end of leg **13** is for convenience in mounting a plastic guide plate to be described and fingers and undercut portions function as pole ends. This shape may be varied to suit mechanical and magnetic requirements.

Guide plate **24** is of non-magnetic material and is preferably of molded plastic. This guide plate has rear face **24***a* facing rear frame **12** and is generally flat. Rear face **24***a* has four guide bosses **24***b* so dimensioned and located as to be tangent to and be disposed about the end of bobbin **19**. Guide plate **24** has top and bottom edges **24***c* and **24***d*. Side edges **24***e* and **24***f* complete the gen-

erally rectangular shape of the guide plate. Preferably all corners are rounded as illustrated. Extending completely through guide plate **24** is aperture **25** having a generally rectangular shape. Aperture **25** is symmetrically located with respect to the four edges of guide plate **24** and can accommodate a magnet locking mechanism. Rear face **24***a* of guide plate **24** has two aligned recesses **27** and **28** extending from opposite sides of aperture **25**. The axis of recesses **27** and **28** is parallel to edges **24***c* and **24***d* of the plate and the recesses accommodate pivot portions **29***a* and **29***b* of ferro-magnetic rocker **29** having hooked ends **29***c* and **29***d* extending forwardly of the guide plate. Rocker **29** is of magnetically "soft" material. The hook portions are so dimensioned and the mounting for pin portions **29***a* and **29***b* are deep enough so that rocker **29** and both hook portions may be moved bodily toward pole end **17** of the center leg to locate the rocker and hooks within the confines of aperture **25**. This occurs when winding **18** is energized.

Guide plate **24** has front face **30** bordered along edges **24***e* and **24***f* by shoulders **30***a* and **30***b*. Face **30** extends the entire length of plate **24** along edges **24***e* and **24***f*. Aperture **25** of guide plate **24** has adjacent its long sides guide rails **31***a* and **31***b* shaped to provide a convex bearing support oriented toward the front of the plate.

Referring again to rear face **24***a* of guide plate **24**, top and bottom edges **24***c* and **24***d* have undercut portions **35***a* and **35***b* to leave thin stop ribs **36***a* and **36***b*. The arrangement and dimensioning of undercut portions **35***a* and **35***b* is such that fingers **13***e* and **13***f* for leg **13** and the corresponding fingers for leg **14** of the core can fit to hold the guide plate between them, and limit the guide plate overlap, the spring of the core legs maintaining the guide plate in position.

Slidably disposed against front face **30** of guide plate **24** is a magnet-flag sub-assembly. The sub-assembly comprises thin self supporting flag portion **40** of plastic or any desired non-magnetic material. Flag portion **40** is wide enough to extend between shoulders **30***a* and **30***b* at front face **30** of guide plate **24** and carries at front face **40***a* of the flag plate suitable indicia. Inasmuch as flag plate **40** will be moved along the length of guide plate **24**, parallel to sides **24***e* and **24***f*, the indicia on face **40***a* should be divided into two portions along a line perpendicular to the direction of flag travel. Thus, flag plate **40** may have one-half of face **40***a* colored red and the other half of face **40***a* colored black, each colored portion extending between shoulder portions **30***a* and **30***b*. Flag plate **40** has cemented thereto at its rear face **40***b* flat permanent magnet **42**. Permanent magnet **42** is dimensioned to fit between side walls **32***a* and **32***b* in the guide plate and rest upon guide rails **31***a* and **31***b* for movement along the length of these guide rails. The direction of magnetization of magnet **42** is along the line of travel of the magnet so that end **42***a*, for example, may be a north pole and end **42***b* may be a south pole. Front face **30** of the guide plate continues across the guide plate at **30***c* and **30***d* and provides magnet stops. Magnet **42** may be of any suitable material and preferably may be a ceramic ferrite. Such a magnet material has a high coercive force and is powerful for its weight. The length of magnet **42** (along the line of magnet travel) is such that in either magnet position, the permanent magnet can extend from near pole portion **17** of the central leg to adjacent the ends of leg **13** or leg **14**, depending upon the magnet position.

In the assembled condition of the various parts within shell **21**, thin, flat screen member **46** of plastic or other non-magnetic material rests on shoulders **30***a* and **30***b* of guide plate **24** and is retained in position by inwardly extending lips **47** at the front edge of shell **21**. Flat screen **46** has opaque portion **46***a* at one part thereof and transparent part **46***b* disposed and dimensioned so that only one part of flag plate **40** is visible. The long dimension of transparent part **46***b* is perpendicular to the line of movement of the flag plate and magnet while the remaining dimension will be great enough so that only a portion of the flag plate is visible in either position of the flag plate.

Rail portions **31***a* and **31***b*, the sides and bottom of magnet **42** are smooth to permit the magnet and flag sub-assembly to slide easily. The opposing surfaces of flag plate **40** are screen **46** are also smooth to permit the flag plate to travel easily. Furthermore screen **46** and flag plate **40** should have some clearance therebetween. Such clearance prevents binding and permits magnet **42** and flag plate **40** to move slightly toward screen **46** during magnet repulsion and to get started toward a new position when the annunciator is energized by an electric pulse of proper polarity and intensity. No current is required to maintain the annunciator in either magnet position. The clearances in the drawing are exaggerated for illustration.

If the clearance between the pole tips of core leg **13** or **14** on the one hand and the pole face of the permanent magnet is very small in either end position of the magnet, the force of attraction between the permanent magnet and the pole tips of core **10** may be so powerful that a correspondingly powerful electromagnetic action when winding **18** is energized must be provided to create a strong repelling action for moving the permanent magnet from one position to another. This may require a large number of ampere turns for winding **18**. In the structure illustrated and in order to avoid excessively powerful magnet attractive forces for keeping the permanent magnet in either stable position, undercut portions **13***g* are provided. By controlling the shape and thickness of iron at the pole portions for core **10** at legs **13** and **14**, the force of attraction between the adjacent pole tip of the permanent magnet and the size of the permanent magnet can be made to provide a desired holding force in relation to turns and operating current for winding **18**.

While the permanent magnet length relative to E core dimensions is not critical, good engineering will guide to good dimensional relationship. Thus width, thickness of magnet **42**, density and magnetic strength of magnet material, E core dimensions will all have a bearing upon an engineering design. Generally if magnet **42** is too long relatively, magnet travel is reduced and flag display characteristics undesirably affected. If magnet **42** is relatively too short, system dynamics may be adversely affected to an extreme where no magnet travel may take place. Good engineering practice will provide for generally satisfactory performance over quite a range of dimensions and materials.

With all parts assembled, a momentary electrical pulse of proper polarity and magnitude fed to winding **18** will create, as an example, a north pole at pole portion **17** and south poles at the ends of legs **13** and **14**. Assuming that permanent magnet **42** has its south pole **42***b* disposed close to the tip of core leg **14** which is momentarily magnetized to be south, there will be a repelling force between like poles tending to repel the permanent magnet from the leg ends and initiate travel toward the other magnet position. The detent mechanism may be omitted and for the moment will be disregarded.

The new signal mechanism is normally stable in either end magnet position and only requires a momentary current pulse for operation. If desired, the magnet and flag system may have a preferred normal stable position and be automatically returned to such normal position after momentary actuation. This may be accomplished by the energizing circuit illustrated in FIG. 13.

This energizing circuit includes a two position switch and capacitor **51**. For annunciator operation switch **50** is closed against the N.O. contact. A direct current charging circuit for capacitor **51** is established through annunciator winding **18**. By having capacitor **51** of substantial value, a sufficiently heavy charging current at a low voltage can be provided to move the flag and magnet from an assumed stable normal position to a temporary

stable off-normal position. When switch **50** is operated to engage the N.C. contact, a discharge circuit for capacitor **51** through winding **18** is established. The discharge current is in the form of a pulse of polarity opposite to the charging current and thus operates the annunciator signal to return the flag and magnet to the assumed normal position.

The time constant of such a charging or discharging circuit may be quite short, say of the order of about 1/25 of a second. It is possible to have switch **50** of the type which is biased normally to the N.C. contact. By operating such a switch, the mechanism can keep the switch against the N.O. contact for a required period of time after which it returns to the N.C. position shown where capacitor **51** can discharge through winding **18**. Since the parts making up the annunciator are small and particularly since the permanent magnet and signal flag assembly can be very light, rapid response to the annunciator to charge or discharge currents can be provided. It is understood that other current reversing arrangements for the annunciator winding may be used.

While the annunciator mechanism works efficiently without any detent, vibration or mechanical shock of the annunciator can trip the permanent magnet from one stable position to the other stable position. To avoid this, the detent mechanism described is useful. Ordinarily in either position of the permanent magnet, detent body **29** will have one hook portion strongly attracted by that pole of permanent magnet **42** which is nearest to center pole **17**. Thus, longitudinal travel of the magnet will be blocked by the detent hook. When winding **18** of the annunciator is energized, the magnetic field at pole portion **17** is strong enough to pull the entire detent body into aperture **25** of guide plate **24**. The detent rocker pin is free to give rearwardly. The permanent magnet is now free to move in the appropriate direction. When the field due to winding **18** collapses upon cessation of current flow, the appropriate pole of the permanent magnet will attract the appropriate hook portion of the detent to lock the magnet in the stable position the magnet has assumed. The magnet length, detent body and hook dimensions and frame aperture depth are related to permit the mechanism to operate as set forth.

What is claimed is:

1. An electromagnetic structure comprising a magnetically "soft" core having, in plan view, an E shape comprising a straight rear portion with end legs and a center leg between said end legs, said core portion having substantial depth along a plane perpendicular to the E, said three legs terminating in pole tips, an energizing winding disposed about the center leg, a thin flat permanent magnet having its line of magnetization along the length thereof, said permanent magnet being long enough to cooperate at any one time with only two adjacent core legs, said permanent magnet having a width generally equal to the width of the pole tips, means for guiding said permanent magnet so that said magnet lies in a plane parallel to the core depth and has its width parallel to the widths of the core legs and its length perpendicular to the lengths of the core legs but movable along the length of said magnet from one extreme position where said magnet cooperates with the center leg and one end leg of the core to the other extreme position where said magnet cooperates with the center leg of said core and other end leg, said permanent magnet in one position having one pole in proximity to the center leg pole tip and in the other position having its other pole in proximity to the center leg pole tip and signalling means coupled to said permanent magnet, whereby, when an electrical pulse of appropriate polarity is impressed on the energizing winding, said permanent magnet will move generally in its own plane along its length from one position to the other position and cause said signalling means to be actuated.

2. The structure according to claim **1** wherein said signalling means includes a flag plate movable with said permanent magnet.

3. The construction according to claim **1** wherein said guiding means includes a non-magnetic frame having its length parallel to and generally equal to the length of the E rear portion and having its width parallel to and generally equal to the depth of the core E, said frame being disposed across the tip portions of the core legs, said frame being shaped to provide guide rails for slidingly supporting said permanent magnet and maintain said magnet clear of the core pole tips.

4. The structure according to claim **3** wherein said frame has an opening therethrough between said guide rails and symmetrically disposed with respect to the center leg pole tip and detent means disposed in said opening for locking the permanent magnet in an end position between winding energizing pulses, said detent means being of ferro-magnetic material and being disabled during winding energization so that said permanent magnet may operate in response to such energization.

5. The structure according to claim **4** wherein said detent means comprises a body portion having its length along the line of magnet travel, means at the midpoint of said body portion for providing a rocking axis transversely of the body portion, said body portion being symmetrically disposed with respect to said center leg pole tip and being spaced forwardly therefrom but being movable toward said center leg pole tip in response to magnetic attraction, said body portion having a forwardly extending hook portion at each end, said body portion length and magnet length being so proportioned that in an end magnet position and in the absence of coil energization there will be one hook portion only which can be magnetically attracted to that magnet pole tip which is opposite the core center leg and mechanically lock the magnet in its end position, said detent body portion being rockable to dispose the inactive hook end within the frame opening clear of the magnet, said entire detent body being pulled into the frame opening on coil energization and both hook portions being clear of the magnet body to permit magnet movement in response to a current pulse of proper polarity.

6. The structure according to claim **3** wherein said magnet has attached thereto a flat flag plate, said frame being shaped to provide a surface upon which said plate may rest and slide with the magnet, a flat smooth screen disposed adjacent the flag plate surface, said screen and flag plate being relatively loose and arranged to prevent binding of the magnet and flag plate during an operating cycle.

7. The structure according to claim **3** wherein said non-magnetic frame has undercut edge portions for receiving end portions of the core end legs to retain them in desired relation.

8. The structure according to claim **3** wherein said E core straight rear portion, when viewed in rear elevation, has a generally rectangular shape with said legs extending forwardly, a non-magnetic shell for said entire assembly, said non-magnetic shell having opposed open ends for the rear and front ends of said entire assembly, said legs having laterally extending fingers near the core rear portion engaging slots in corresponding opposed walls of the shell for locking the assembly within the shell, said shell extending only to the straight rear portion of the core so that the unlocked opposed shell walls may be sprung inwardly to cause the remaining two shell wall portions to spring away from the core legs for clearing said core fingers from the slots to permit withdrawal of the assembly from the shell.

9. The structure according to claim **8** wherein the forward end of the shell has an inner lip cooperating with the forward end of the assembly within the shell for limiting shell movement up to the core rear portion.

10. The construction according to claim **9** wherein a flat screen is provided within the shell at the forward end thereof and retained in position by said shell lip, the flag plate being immediately back of the screen, said screen

having transparent and opaque portions for showing the flag plate position; said screen and flag plate opposing surfaces being smooth and having sufficient clearance to prevent binding.

11. The construction according to claim **1** in combination with a capacitor and switching means for connecting a direct current source to said capacitor and winding in series so that a charging current moves the magnet and signal means to one position, said switching means providing for disconnecting said current source and connecting the charged capacitor across the winding to discharge therethrough and return the magnet and signal means to

original position, said construction requiring momentary current pulses for setting and resetting.

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U.S. Cl. X.R.

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