Aug. 20, 1968 L. PIEKARSKI 3,398,384

MAGNETIC PROXIMITY SWITCH

Filed March 4, 1966

Fig. 1

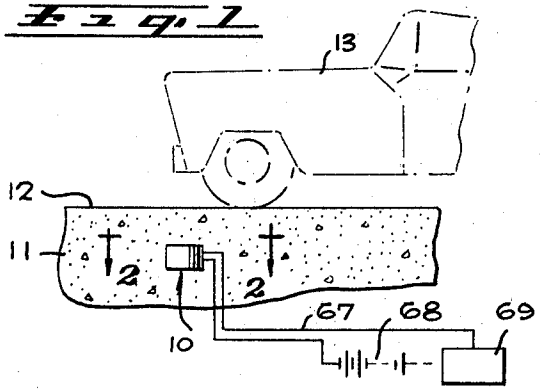


Fig. 4

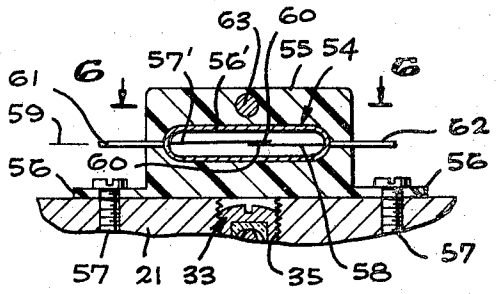


Fig. 2

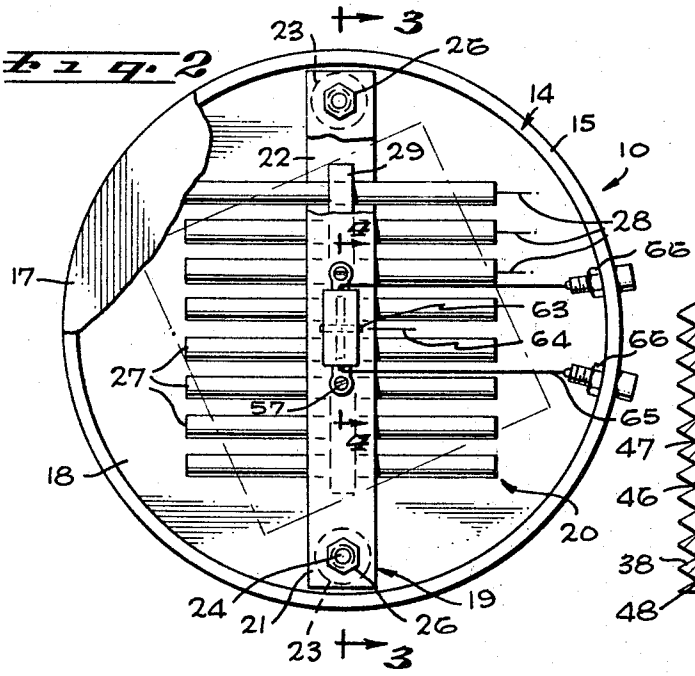


Fig. 5

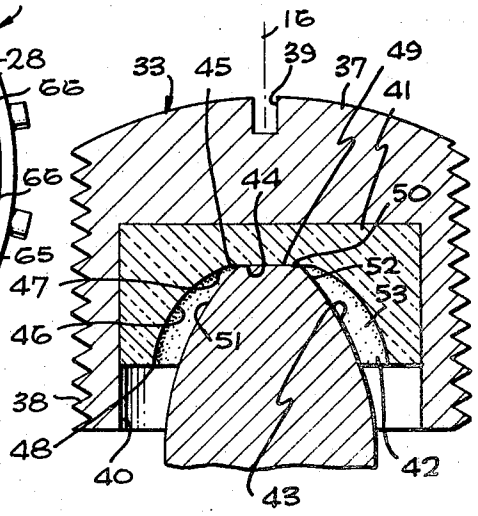


Fig. 3

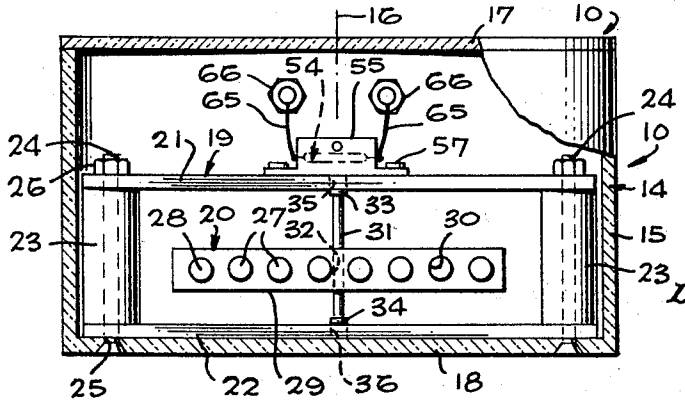
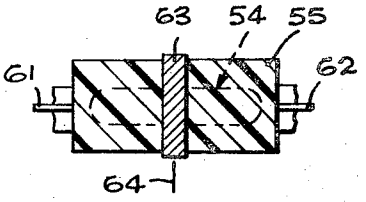


Fig. 6



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MAGNETIC PROXIMITY SWITCH

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This invention relates to an improved proximity device, for automatically actuating an electrical circuit in a predetermined manner in response to the movement of a body of magnetic material into the vicinity of the device. It is contemplated broadly that the device may be applied to any of numerous different uses, in which response to the presence of a body or bodies of magnetic material is desirable, for instance in counting items passing along a conveyor system, in sorting items, or the like; but the inventon will be described primarily and typically as utilized in responding to the movements of a motor vehicle, as for parking control or traffic control purposes.

Though numerous types of magnetically actuated proximity devices or switches have been proposed in the past, great difficulty has been encountered in attempting to render such devices sufficiently reliable in operation to be certain under all conditions that the device will respond properly to a particular change in conditions. For example, many of these prior devices have been so insensitive as to require movement of an automobile or other body of magnetic material into such close proximity to the device as to render it useless for most practical purposes. Other previously proposed devices have been so non-positive or indecisive in operation that their actuation from one condition to another could not be relied upon as a definite indication of the presence or absence of magnetic material in the vicinity, since these devices may sometimes respond properly and other times fail to respond.

A major object of the present invention is to provide an improved proximity device which is considerably more reliable in its operation than any of the various prior arrangements with which I am acquainted. A unit embodying the invention functions in such a positive manner as to invariably produce the proper response to the presence of magnetic material within the vicinity, and to reliably and invariably produce a reverse response to the absence of such material. Additionally, the device functions on a principle giving it very great sensitivity, so that it may be utilized for response to the presence of magnetic material within a very substantial distance of the device, and not necessarily require movement of the magnetic material into extremely close proximity to the device.

Structurally, a unit embodying the invention includes at least one magnet (preferably a number of such magnets) mounted to swing between a normal position of essential alignment with an ambient magnetic field, such as the earth's field, and a deflected position, in response to movement of a body of magnetic material into the vicinity of the magnet or magnets. In conjunction with these magnets, I utilize electrical switching means which are operable magnetically by the field of the swinging magnet or magnets in a manner opening or closing an electrical circuit upon deflection of the magnets from their normal position. The switching means preferably include a reed switch, which responds in a positive and reliable manner to slight swinging movement of the magnets from their normal position. The sensitivity of the reed switch may be increased by positioning near that switch a biasing magnet, which extends transversely of the contacts of the reed in a manner enabling the device to respond to very slight swinging movement of the main magnet or magnets.

Another feature of the invention relates to a preferred bearing structure for mounting the swinging magnets, or more broadly for mounting any of numerous different types of pivotal elements, in a manner minimizing the friction of the moving part, and preventing binding of that part. For this purpose, I employ two interfitting bearing parts, one of which forms a socket recess into which a projection on the other part extends in bearing relation. The projection has an essentially transverse end surface engageable against an inner end surface of the socket recess, but with the parts being spaced radially apart as their surfaces advance axially from the mentioned end surface areas. This leaves minute clearance spaces about the periphery of the projection in a manner preventing the development of excessive friction between the parts by the presence of small particles of dust or the like in the bearing areas.

To avoid disturbance of the magnetic characteristics of the discussed proximity device, I prefer to form the pivotal mounting bearing or bearings of a nonmagnetic material, such as sapphire, so that magnetic flux cannot flow through these bearings.

The above and other features and objects of the invention will be better understood from the following detailed description of the typical embodiment illustrated in the accompanying drawing, in which:

FIG. 1 shows somewhat diagrammatically the manner in which a device embodying the invention may be utilized for response to the presence of an automobile or other motor vehicle;

FIG. 2 is an enlarged plan view of the detector device of FIG. 1, partially broken away to reveal its inner construction;

FIG. 3 is a vertical section taken on line **3—3** of FIG. 2;

FIG. 4 is a further enlarged fragmentary vertical section taken on line **4—4** of FIG. 2;

FIG. 5 is a greatly enlarged axial vertical section through one of the bearings for mounting the swinging magnets; and

FIG. 6 is a horizontal section taken on line **6—6** of FIG. 4.

With reference first to FIG. 1, I have illustrated at **10** a proximity device or detector constructed in accordance with the invention, and represented as buried within a roadbed **11**, at a location spaced beneath the upper horizontal road surface **12** along which automobiles **13** and other motor vehicles travel. The device **10** may typically be buried a few inches (say for example about six inches) beneath road surface **12**, and is adapted to respond automatically to the movement of automobile **13** to a position over device **10**, by virtue of the alteration of the ambient magnetic field resulting from the presence of the steel or other magnetic material constituting the body and other parts of the automobile.

As seen best in FIGS. 2 and 3, the proximity device **10** may have an outer housing **14**, preferably formed of an appropriate rigid nonmagnetic material such as a fiberglass reinforced resinous plastic material. Housing **14** is typically represented as of cylindrical configuration, having a vertically extending cylindrical side wall **15** centered about a vertical axis **16**, and having top and bottom horizontal walls **17** and **18**, with these three walls **15**, **17** and **18** desirably being fluid impervious and sealed at their contacting edges and other points in a fluid tight relation effectively hermetically sealing the interior of the housing from its exterior.

Extending diametrically across the interior of housing **14**, there is provided a rigid frame structure **19** (FIGS. 2 and 3), which movably mounts a swinging magnet assembly **20** for pivotal movement about vertical axis **16**.

Frame structure 19 may include two upper and lower typically identical rigid horizontal elements 21 and 22, extending diametrically across the cylindrical housing in vertically spaced and parallel relation. These parts 21 and 22 are maintained in their illustrated vertically spaced relation by two tubular spacers 23 at their opposite ends, with two screws 24 extending vertically through and being sealed with respect to apertures 25 in bottom wall 18 of the housing, and then through bottom frame part 22, spacer tubes 23, and top frame part 21, and with the upper ends of these screws being connected to nuts 26 in a manner securely holding all of the parts 21, 22 and 23 in their illustrated relative positions, and in fixed positions relative to the housing. The parts 21, 22 and 23, as well as screws 24 and nuts 26, may all be formed of an appropriate rigid but nonmagnetic material, such as brass.

Magnetic assembly 20 includes several desirably identical magnets 27, which may be cylindrical as shown, and elongated along a series of individual horizontally extending parallel north-south axes 28 of the magnets. These magnets have north poles at a first end, say for example the left ends of all of the magnets as illustrated in FIG. 2, and have south poles at their opposite ends, so that they all tend to normally swing to a predetermined position of alignment with the horizontal component of the earth's field or other ambient field in the vicinity of the device. This normal ambient-field-aligned position of the magnets is the position illustrated in full lines in FIG. 2.

The magnets 27 are all carried by a common carrier element 29, which may be a horizontally elongated piece of rigid desirably nonmagnetic metal. This carrier element 29 may contain a series of identical horizontally spaced aligned circular openings 30 through which the various magnets extend, and within which the magnets are rigidly held by appropriate welding, brazing, or other suitable means. Carrier element 29 is in turn rigidly secured to and mounted by a vertical mounting shaft 31, which may extend through and be welded or otherwise secured within a vertical passage 32 in carrier element 29, and which extends along and is rotatable about vertical axis 16 of the device. The upper and lower ends of the shaft 31 are pivotally mounted by a pair of upper and lower bearings 33 and 34, which may be identical and are screwed into vertical threaded passages 35 and 36 in frame elements 21 and 22 respectively.

As seen best in FIG. 5, the upper bearing 33 includes a first part 37 having external threads 38 which are screwed into threaded passage 35 in part 21, with part 33 being adjustable within part 21 by means of a screwdriver received within a screwdriver slot 39. At its underside, part 33 of the bearing has a typically cylindrical recess 40 centered about vertical axis 16, and containing a bearing element proper designated 41. Element 41 is a pressed fit within recess 40, or is otherwise secured in fixed position within that recess, and is desirably formed of a nonmagnetic and noncorrosive material, preferably sapphire. Externally, bearing element 41 is shaped cylindrically in conformance with the recess. Internally, this bearing element contains a socket recess 42 within which a tapered upper end portion 43 of shaft 31 is pivotally received. Recess 42 is centered about axis 16, and is of circular cross section, and has at its upper end an upper or inner wall surface 44 desirably disposed directly transversely of axis 16 and defined peripherally by a circular edge 45 of that surface. Radially outwardly beyond circular edge 45 of transverse surface 44, socket recess 42 has an annular side wall surface 46, which may advance primarily radially outwardly at a location 47 directly adjacent to edge 45, but which then curves progressively in a more axially extending direction as seen in FIG. 5, to ultimately extend primarily axially at 48.

The tapering portion 43 of shaft 31 which extends into socket recess 42 may have an upper bearing surface 49 desirably disposed directly transversely of axis 16, and engaging upwardly against surface 44 of bearing element 41. As in the case of surface 44, the surface 49 of shaft 31 is desirably circular, terminating in a peripheral circular edge 50, but of a diameter somewhat less than the diameter of surface 44. Beyond this edge 50 of surface 49, shaft 31 has an annular tapering surface 51, which gradually curves to extend in a progressively less radial and more axial direction as this surface advances downwardly in FIG. 5. It is also noted that surface 51 preferably extends more directly axially at the location 52 directly adjacent edge 50 than does socket wall surface 46 at its corresponding radially opposite location 47.

The diameters of inner surface 46 of the socket recess and outer surface 51 of the shaft 31 differ sufficiently to provide radially between these surfaces an annular clearance space 53, which extends entirely about shaft 31 and which desirably extends the entire axial length of bearing element 41 from the plane of transverse surface 44 to the lower extremity of that element 41. Though this clearance space appears in the figure to be of very substantial width, it is actually very narrow. For example, it is preferred that the difference in diameter between the two end surfaces 44 and 45 be no more than a few thousandths of an inch, say for example no more than three thousandths. Thus, in a preferred form of the invention, surface 49 has a diameter of five thousandths, while surface 44 has a diameter of seven thousandths, and the clearance space 53 between the two bearing parts may have an average radial extent of approximately two thousandths of an inch.

The lower bearing 34 may be identical with the upper bearing 33, which has been described above in detail and is illustrated in FIG. 5. Similarly, the lower end of shaft 31 may be tapered in the same manner as its upper end, to have the same interfitting relationship with the lower bearing as is illustrated in FIG. 5.

To the upper side of top frame part 21, there is mounted a reed switch 54, which may be contained and encapsulated within a block 55 of an appropriate nonmagnetic rigid resinous plastic material. This block 55 may have ears or tabs 56 by which it is secured rigidly to frame part 21, by means of screws represented at 57.

As seen clearly in FIG. 4, the reed switch 54 may be of a completely conventional well known construction, including an outer horizontally elongated glass tube closed at its opposite ends in fluid tight sealed relation, and containing two flexible metal reed contacts 57' and 58 extending essentially along a horizontal axis 59 from opposite ends of tube 56'. The inner free ends 60 of the two reed contacts 57' and 58 are normally received in the slightly spaced relation illustrated in FIG. 4, so that the switch is open at this point. In response to the development of a magnetic field in the vicinity, having a sufficient component in the direction of axis 59 to actuate the switch, the adjacent ends 60 of reed contacts 57' and 58 are magnetically actuated toward one another and into engagement, to thereby close the circuit through the switch and between the two leads 61 and 62 at opposite ends of the reed switch. As seen in the figures, the reed switch 54 is so mounted that its longitudinal axis 59 extends transversely of the north-south axes 28 of magnets 27, when the magnets are in their FIG. 2 full line normal positions.

For increasing the sensitivity of reed switch 54 to slight deflections of magnets 27, I provide closely adjacent and preferably slightly above the reed switch a biasing magnet 63 (FIG. 4), which may be embedded within and located in fixed position by plastic block 55. Magnets 63 may be elongated along a north-south axis 64 (FIGS. 2 and 6), which is disposed transversely of and slightly above axis 59 and the reed switch, and which is parallel to north-south axes 28 of the main magnets 27 when the latter are in their full line normal position of FIG. 2. The polarity of biasing magnet 63 should however be reversed as compared with magnets 27 (in their normal position), so that the south pole of magnet 63 is to the left in FIG.

2, and its north pole is to the right. Biasing magnet **63** is of course much weaker in magnetic strength than are the combined magnets **27**, or for that matter the individual magnets **27**.

The two electrical leads **65** from opposite ends of reed switch **54** are connected through sealed water tight and fluid tight terminals **66** to the exterior of housing **14**, and are then connected by external leads **67** (FIG. 1) into a series circuit including a battery or other source of electrical energy **68** and an appropriate indicator device **69** adapted to provide an indication of the magnetic actuation of detector switch **10**. Indicator **69** may for example be a light or audible signal indicating that the switch has been actuated, or may be an automatic piece of parking control or traffic control equipment, or the like, adapted to respond in predetermined manner to actuation of the switch.

To now describe a cycle of operation of the switch, assume first of all that the automobile **13** of FIG. 1 is not present, within the response zone of proximity unit **10**, and that magnets **27** are therefore initially retained in their full line normal positions of FIG. 2, in which they are aligned with the horizontal component of the ambient earth's magnetic field, or other ambient field. In this condition, reed switch **54** is open, and indicator **69** is therefore not energized. If an automobile **13** now advances into proximity to device **10**, the magnetism of the automobile will act to cause magnets **27** and their mounting vertical shaft **31** to swing about vertical axis **16** to a deflected position, such as the broken line position of FIG. 2. This swinging of the magnets **27** causes their individual and composite magnetic fields to turn about axis **16**, and since reed switch **54** is within the magnetic fields of magnets **27**, these fields will at some deflected position have the effect of closing contact **60** of the reed switch and therefore energizing indicator **69**. It is found that a very few degrees of deflection of magnets **27** can have this desired effect, say for example five to ten degrees deflection, particularly in the presence of the biasing magnet **63**, which is also close enough to the reed switch that the latter is within the magnetic field of the biasing magnet.

The unique bearing structure illustrated in FIG. 5 mounts the magnet assembly for very low friction turning movement about axis **16**, and by virtue of the provision of the clearance space **53** within the bearing assemblies, has the effect of preventing binding of the bearings such as may result in other arrangements due to the presence of dust particles or the like in the bearings.

It will be understood that reed switch **54**, in addition to being within the field of magnets **27**, is also of course subjected directly to the magnetic field of the automobile **13**. However, this field of the vehicle is, at the switch location, necessarily relatively weak as compared with the field of magnets **27**, and is not great enough to actuate the reed switch directly, but will cause actuation of the switch indirectly in the discussed manner, by first swinging magnets **27** and then operating the switch by the field of these magnets.

I claim:

1. A proximity device comprising at least one magnet mounted to swing between a normal position of essential alignment with an ambient field and a deflected position in response to movement of a body of magnetic material into the vicinity of the magnet, and magnetically actuated electrical switching means positioned near said magnet and operable magnetically by the field of said magnet to open or close an electrical circuit upon deflection of said magnet from said normal position, said magnet having a North-South axis which in said normal position is essentially aligned with said ambient field, said switching means including a magnetically actuated reed switch located near said magnet and having reed contacts disposed essentially transversely of said North-South axis of the magnet when the magnet is in said normal position.

2. A proximity device comprising at least one magnet mounted to swing between a normal position of essential alignment with an ambient field and a deflected position in response to movement of a body of magnetic material into the vicinity of the magnet, and magnetically actuated electrical switching means positioned near said magnet and operable magnetically by the field of said magnet to open or close an electrical circuit upon deflection of said magnet from said normal position, said switching means including a reed switch having reed contacts extending in generally a predetermined direction, and a biasing magnet located in close proximity to said reed switch and having a North-South axis disposed essentially transversely of said predetermined direction.

3. A proximity device comprising a plurality of magnets connected together in essentially parallel relation, bearing means mounting said magnets for swinging movement in unison about an essentially vertical axis between a normal position of essential alignment with an ambient field and a deflected position in response to movement of a body of magnetic material into the vicinity of the magnet, said magnets having spaced parallel North-South axes which in said normal position are essentially aligned with said ambient field, and magnetically actuated electrical switching means positioned near said magnets and operable magnetically by the field of said magnets to open or close an electrical circuit upon deflection of said magnets from said normal position, said switching means including a reed switch located near said essentially vertical axis but vertically offset from said magnets and having magnetically actuated reed contacts extending essentially transversely of said North-South axes of the magnets when the latter are in said normal position, said switching means including a fixed biasing magnet located closer to said reed switch than are said swinging magnets and having much less magnetic force and having a North-South axis disposed essentially transversely of said reed contacts and essentially parallel to but reversed in polarity with respect to said North-South axes of said swinging magnets when the latter are in said normal position.

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