

## Description

The present invention relates to a magnetic sensing proximity detector. Magnetic sensing proximity detectors have been used previously to detect the close presence of a ferrous metal mass. In one form these detectors have a central hollow magnet with end magnets supported on a rod connecting them which extends through the opening in the central magnet. A switch is connected at one end of the two connected magnets to be operated by the movement of such two magnets relative to the central magnet and the housing in which it is secured. The approach of a ferrous metal close to the end of the magnet away from the switch end causes the magnets and their connecting rod to move toward the ferrous metal to thus change the position of the switch. An example of this type of magnetic sensing proximity switch is disclosed in US-A- 4,117,431.

Another type of magnetic sensing proximity detector is shown in US-A- 4,674,338 in which a central magnet is positioned within two annular magnets so that the movement of the central magnet which is normally biased in one direction by the positioning of the poles of the three magnets, moves in the opposite direction when a magnetic material approaches sufficiently close to change the forces on the central magnet to overcome the force biasing it toward the one direction.

A further type of magnetic sensing proximity detector is shown in US-A- 3,176,096 and -4,225,837 wherein side-by-side magnets are used so that the position of the switch arm is normally in one position and pivots to the opposite position on the approach of a ferrous metal within the range of sensitivity of the detector. The latter patent is stated to be an improvement on the former patent.

One disadvantage which has been experienced with the prior magnetic sensing proximity detectors is their limited range in which they can sense the approach a ferrous metal material and the fact that such prior devices are not adjustable to preselect the exact point at which the approach of ferrous metal causes the detector to change its position.

According to the present invention a magnetic proximity detector for ferrous metals comprising a housing; an assembly of magnets, at least one of which is movable, positioned within the housing; a switch; and means connecting the movable magnet to the switch to change its position when the magnet moves, the movable magnet being biased to one position by the other magnets of the assembly and moving to its other position responsive to the presence of a ferrous metal within its effective sensitivity range, is characterised by an annular magnet surrounding the housing for focusing the flux of the magnets, and means coacting with the annular magnet to adjust its position axially with respect to the housing and hence

changing the shape of the magnetic field to thereby change the effective sensitivity range for movement of the movable magnet responsive to the presence of a ferrous metal.

In one embodiment the detector includes a tubular housing, a tubular magnet fixed in position within the housing, a first tubular magnet within the housing at one end of the tubular magnet, a second movable magnet within the housing at the other end of the tubular magnet, an annular magnet positioned in surrounding relationship to the housing, means for adjusting the position of the annular magnet to control the sensitivity of the assembly, means connecting the first magnet and the second magnet, a switch including a blade, a first contact and a second contact, means connecting the first and second magnet to the blade so that movement of the first and second magnets moves the blade between contact with the first and second contacts, the first magnet having its poles arranged so that it is attracted to the tubular magnet the second magnet having its poles arranged so that it is repelled by the tubular magnet, the nearness of a ferrous metal to the end of the housing containing said first magnet moving the two magnets and the blade to change the position of the switch, adjusting the axial position of the annular magnet changing the flux from the end of the housing containing the first magnet to adjust the distance at which a ferrous metal causes the change of position of the switch blade.

An embodiment of the invention will be described now by way of example only, with particular reference to the accompanying drawings. In the drawings:

FIGURE 1 is a longitudinal sectional view of the improved magnetic proximity detector illustrating the components in one position which does not indicate the presence of ferrous metal.

FIGURE 2 is a similar sectional view of the detector but showing the components in their opposite position as a result of the detections of a ferrous metal.

FIGURE 3 is a schematic view of the three magnets used with proximity detectors of the prior art and illustrates the relative position of the poles of the magnets and their flux fields.

FIGURE 4 is a schematic view of the three magnets used in the detector of the present invention and illustrates the relative position of the poles of the magnets, their flux fields and the focusing effect on the flux field at the end of the detector resulting from the annular focusing magnet.

The improved structure of the present invention is shown in FIGURES 1 and 2. Detector 10 includes housing 12, tubular magnet 14 secured within housing 12, assembly 16 of movable magnets, and switch contacts 24 and 26 and blade 28. Movable magnet 18 is positioned in end 29 of housing 12 and has its poles arranged with respect to the poles of tubular magnet 14, as shown, so that it is attracted by tubular magnet

14. Movable magnet 20 is positioned within housing 12 on the opposite side of tubular magnet 14 from magnet 18 and has its poles arranged with respect to the poles of tubular magnet 14, as shown, so that it is repelled by tubular magnet 14. A suitable non-magnetic closure 29a is positioned across end 29 of housing 12.

Connecting means 22 includes rod 30 extending through the central axial opening of tubular magnet 14 with support by low friction plastic bearings 32 and 34 which are positioned in the ends of the axial opening through tubular magnet 14 as shown. One end of rod 30 is connected to movable magnet 18 and the other end is connected to movable magnet 20. Extension 36 connects to movable magnet 20 and is secured to blade 28 which is pivotally mounted to contact 37 so that movement of magnet assembly 16 moves blade 28 between positions engaging contacts 24 and 26. In the position shown in FIGURE 1 blade 28 connects contact 37 with contact 26.

Annular magnet 38 is positioned around the exterior of housing 12 generally at a position surrounding movable magnet 18. Nuts 40 and 42 are threaded onto threads 44 on the exterior of housing 12 on either side of annular magnet 38 to secure it in a preselected position with respect to movable magnet 18. Nuts 40 and 42, or other suitable adjustable positioning means, are used to adjust the position of annular magnet 38 which adjusts the range of sensitivity of the structure as hereinafter explained.

As shown in FIGURE 1 movable magnet assembly is in its right position with blade 28 in engagement with contact 26 since ferrous mass 46 is spaced outside the sensitivity range of detector 10.

Mass 48, shown in FIGURE 2, is positioned closer to detector 10 so that it is within the sensitivity range, considering the position of annular magnet 38 and assembly 16 has been moved to its left causing blade 28 to move into engagement with contact 24 to complete the circuit between contact 37 and contact 24. It should be noted that annular magnet 38 is shown including pole pieces 38a and 38b but may be used without such pole pieces.

Dashed line 49 in FIGURE 3 illustrates the outer limit of the sensitivity range for detector 10 when annular magnet is not used with detector 10. Detector 50 shown in FIGURE 3 is illustrative of the prior art detectors. Detector 50 includes movable magnet 52, fixed tubular magnet 54 and movable magnet 56 controlling the position of blade 58. Detector 50 does not include an external annular magnet for focusing the flux field as hereinafter described. With detector 50 as shown in FIGURE 3, the sensitivity range is limited to a maximum of 0.10 inch.

FIGURE 4 is a schematic illustration of proximity detector 110 which is the same structure as detector 10 previously described and the components shown are given the same number for identification with the

prefix numeral "1". A comparison of the flux field of movable magnet 118 with the flux field of movable magnet 52 illustrates the focusing effect of annular magnet 138 on the flux field to flatten the field and cause it to extend a greater distance beyond the end of magnet 118 than it would extend without annular magnet 138. Dashed line 149 is drawn in position with respect to the end of the housing to illustrate the outer limit of the sensitivity range of detector 110. In comparison the the maximum range of sensitivity of detector 50 being 0.10 inch, the maximum range of sensitivity for detector 110 having all of the same components as detector 50 except for the addition of annular focusing magnet 138 is approximately 0.50 inch. Additionally, the adjusting of the position of annular focusing magnet 138 provides an adjustment of the focusing of the flux field of movable magnet 118 to preselect the exact distance at which a ferrous metal will cause a change in the position of blade 128.

It should be noted the present invention has application to other types of magnetic proximity sensing devices, particularly to a device which includes at least three magnets with at least one magnet movable with respect two fixed magnets in a housing as disclosed in US-A- 4,674,338.

#### Claims

1. A magnetic proximity detector for ferrous metals comprising a housing (12); an assembly (16) of magnets, at least one of which is movable, positioned within the housing; a switch (24, 26, 37); and means (30) connecting the movable magnet (20) to the switch to change its position when the magnet moves, the movable magnet (20) being biased to one position by the other magnets of the assembly (16) and moving to its other position responsive to the presence of a ferrous metal within its effective sensitivity range,

characterised by an annular magnet (38) surrounding the housing for focusing the flux of the magnets, and means (40, 42) coaxing with the annular magnet to adjust its position axially with respect to the housing (12) and hence changing the shape of the magnetic field to thereby change the effective sensitivity range for movement of the movable magnet (20) responsive to the presence of a ferrous metal.

2. A detector according to claim 1, wherein one of the magnets (14) of the assembly is fixed within the housing and two of the magnets (18, 20) are movable with respect to the fixed magnet (14), and means (30) for connecting the two movable magnets.

3. A detector according to claim 2, wherein one (18)



14. Movable magnet 20 is positioned within housing 12 on the opposite side of tubular magnet 14 from magnet 18 and has its poles arranged with respect to the poles of tubular magnet 14, as shown, so that it is repelled by tubular magnet 14. A suitable non-magnetic closure 29a is positioned across end 29 of housing 12.

Connecting means 22 includes rod 30 extending through the central axial opening of tubular magnet 14 with support by low friction plastic bearings 32 and 34 which are positioned in the ends of the axial opening through tubular magnet 14 as shown. One end of rod 30 is connected to movable magnet 18 and the other end is connected to movable magnet 20. Extension 36 connects to movable magnet 20 and is secured to blade 28 which is pivotally mounted to contact 37 so that movement of magnet assembly 16 moves blade 28 between positions engaging contacts 24 and 26. In the position shown in FIGURE 1 blade 28 connects contact 37 with contact 26.

Annular magnet 38 is positioned around the exterior of housing 12 generally at a position surrounding movable magnet 18. Nuts 40 and 42 are threaded onto threads 44 on the exterior of housing 12 on either side of annular magnet 38 to secure it in a preselected position with respect to movable magnet 18. Nuts 40 and 42, or other suitable adjustable positioning means, are used to adjust the position of annular magnet 38 which adjusts the range of sensitivity of the structure as hereinafter explained.

As shown in FIGURE 1 movable magnet assembly is in its right position with blade 28 in engagement with contact 26 since ferrous mass 46 is spaced outside the sensitivity range of detector 10.

Mass 48, shown in FIGURE 2, is positioned closer to detector 10 so that it is within the sensitivity range, considering the position of annular magnet 38 and assembly 16 has been moved to its left causing blade 28 to move into engagement with contact 24 to complete the circuit between contact 37 and contact 24. It should be noted that annular magnet 38 is shown including pole pieces 38a and 38b but may be used without such pole pieces.

Dashed line 49 in FIGURE 3 illustrates the outer limit of the sensitivity range for detector 10 when annular magnet is not used with detector 10. Detector 50 shown in FIGURE 3 is illustrative of the prior art detectors. Detector 50 includes movable magnet 52, fixed tubular magnet 54 and movable magnet 56 controlling the position of blade 58. Detector 50 does not include an external annular magnet for focusing the flux field as hereinafter described. With detector 50 as shown in FIGURE 3, the sensitivity range is limited to a maximum of 0.10 inch.

FIGURE 4 is a schematic illustration of proximity detector 110 which is the same structure as detector 10 previously described and the components shown are given the same number for identification with the

prefix numeral "1". A comparison of the flux field of movable magnet 118 with the flux field of movable magnet 52 illustrates the focusing effect of annular magnet 138 on the flux field to flatten the field and cause it to extend a greater distance beyond the end of magnet 118 than it would extend without annular magnet 138. Dashed line 149 is drawn in position with respect to the end of the housing to illustrate the outer limit of the sensitivity range of detector 110. In comparison the the maximum range of sensitivity of detector 50 being 0.10 inch, the maximum range of sensitivity for detector 110 having all of the same components as detector 50 except for the addition of annular focusing magnet 138 is approximately 0.50 inch. Additionally, the adjusting of the position of annular focusing magnet 138 provides an adjustment of the focusing of the flux field of movable magnet 118 to preselect the exact distance at which a ferrous metal will cause a change in the position of blade 128.

It should be noted the present invention has application to other types of magnetic proximity sensing devices, particularly to a device which includes at least three magnets with at least one magnet movable with respect two fixed magnets in a housing as discloses in US-A- 4,674,338.

#### Claims

1. A magnetic proximity detector for ferrous metals comprising a housing (12); an assembly (16) of magnets, at least one of which is movable, positioned within the housing; a switch (24, 26, 37); and means (30) connecting the movable magnet (20) to the switch to change its position when the magnet moves, the movable magnet (20) being biased to one position by the other magnets of the assembly (16) and moving to its other position responsive to the presence of a ferrous metal within its effective sensitivity range,

characterised by an annular magnet (38) surrounding the housing for focusing the flux of the magnets, and means (40, 42) coaxing with the annular magnet to adjust its position axially with respect to the housing (12) and hence changing the shape of the magnetic field to thereby change the effective sensitivity range for movement of the movable magnet (20) responsive to the presence of a ferrous metal.

2. A detector according to claim 1, wherein one of the magnets (14) of the assembly is fixed within the housing and two of the magnets (18, 20) are movable with respect to the fixed magnet (14), and means (30) for connecting the two movable magnets.

3. A detector according to claim 2, wherein one (18)



of the movable magnets is positioned within the housing at one end of the fixed magnet (14) and has its poles arranged with respect to the poles of the fixed magnet so that it is attracted to the fixed magnet, the other (20) of the movable magnets is positioned within the housing at the other end of the fixed magnet (14) and has its poles arranged with respect to the poles of the fixed magnet so that it is repelled by the fixed magnet, the position of the movable magnets being biased in one direction when not detecting the presence of a ferrous metal and the presence of the movable magnets moving from the biased position toward the ferrous metal which comes within the effective range of sensitivity of the detector to the ferrous metal.

4. A detector according to claim 2 or claim 3, wherein the fixed magnet (14) is tubular with a central opening therethrough, and the connecting means (30) extends through the central opening with a movable magnet positioned within the housing on each end of the fixed magnet.
5. A detector according to any one of the preceding claims, wherein the housing (12) includes threads (44) along its exterior, and the adjusting means includes at least one member (40, 42) threaded to the exterior of the housing and held against the annular magnet.
6. A detector according to claim 5, wherein the adjusting means includes a first nut (40) threaded onto the external housing threads (44), and a second nut (42) threaded onto the external housing threads, the annular magnet (38) being positioned between the first and second nuts.

#### Patentansprüche

1. Magnetischer Näherungsschalter für eisenhaltige Metalle, mit einem Gehäuse (12), einer Anordnung (16) von Magneten, von denen zumindest einer beweglich ist, wobei diese innerhalb des Gehäuses angeordnet sind; einem Schalter (24, 26, 37); und Einrichtungen (30) die den beweglichen Magneten (20) mit dem Schalter verbinden, um dessen Position zu verändern, wenn sich der Magnet bewegt, wobei der bewegliche Magnet (20) durch die anderen Magneten der Anordnung (16) an einer Position vororientiert ist und sich abhängig von der Anwesenheit eines eisenhaltigen Metalles innerhalb seines effektiven Sensitivitätsbereiches an seine andere Position bewegt, **gekennzeichnet durch einen ringförmigen Magneten (38), der das Gehäuse zur Fokussierung des magnetischen Flusses umgibt, sowie Ein-**
- richtungen (40, 42), die mit dem ringförmigen Magneten zusammenwirken, um dessen Position axial bezüglich des Gehäuses (12) einzustellen und dadurch die Gestalt des magnetischen Feldes zu verändern, um wiederum den effektiven Sensitivitätsbereich für die Bewegung des beweglichen Magneten (20), abhängig von der Anwesenheit eines eisenhaltigen Metalles, zu verändern.
2. Näherungsschalter nach Anspruch 1, **dadurch gekennzeichnet, daß einer der Magneten (14) der Anordnung innerhalb des Gehäuses befestigt ist und daß zwei der Magneten (18, 20) beweglich bezüglich des festen Magneten (14) sind sowie durch Einrichtungen (30) zur Verbindung der beiden beweglichen Magneten.**
3. Näherungsschalter nach Anspruch 2, **dadurch gekennzeichnet, daß einer der beweglichen Magneten (18) innerhalb des Gehäuses an einem Ende des festen Magneten (14) angeordnet ist und dessen Pole bezüglich der Pole des festen Magneten so angeordnet sind, daß er von dem festen Magneten angezogen wird, daß der andere der beweglichen Magneten (20) innerhalb des Gehäuses am anderen Ende des festen Magneten (14) angeordnet ist, wobei dessen Pole bezüglich der Pole des festen Magneten so angeordnet sind, daß er von den festen Magneten abgestoßen wird, wobei die Position der beweglichen Magneten in eine Richtung vororientiert ist, wenn keine Anwesenheit eines eisenhaltigen Metalles angezeigt wird und die Anordnung der beweglichen Magneten aus der vororientierten Position in Richtung des eisenhaltigen Metalles bewegt, welches in den effektiven Sensitivitätsbereich des Näherungsschalters für eisenhaltiges Metall kommt.**
4. Näherungsschalter nach Anspruch 2 oder 3, **dadurch gekennzeichnet, daß der feste Magnet (14) ein röhrenförmiger mit einer zentralen durchgehenden Öffnung ist, und daß sich die Verbindungseinrichtung (30) durch die zentrale Öffnung erstreckt, mit einem beweglichen Magneten innerhalb des Gehäuses an jeder Seite des festen Magneten angeordnet.**
5. Näherungsschalter nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß das Gehäuse (12) Gewinde (44) entlang seines Außenbereiches umfaßt, und daß die Einstelleinrichtung zumindest ein Teil (40, 42) enthält, welches auf den Außenbereich des Gehäuses aufgeschraubt ist und den ringförmigen Magneten hält.**



6. Näherungsschalter nach Anspruch 5, dadurch gekennzeichnet, daß die Einstelleinrichtung eine erste Mutter (40) umfaßt, welche auf das Außengewinde des Gehäuses (44) aufgeschraubt ist sowie eine zweite Mutter (42) welche auf das Außengewinde des Gehäuses aufgeschraubt ist, wobei der ringförmige Magnet (38) zwischen der ersten und zweiten Mutter angeordnet ist.

## Revendications

1. Détecteur magnétique de proximité pour des métaux ferreux comprenant un boîtier (12); un assemblage (16) d'aimants, dont au moins l'un est mobile, disposés dans le boîtier; un commutateur (24, 26, 37); et des moyens (30) connectant l'aimant mobile (20) au commutateur pour modifier sa position lorsque l'aimant se déplace, l'aimant mobile (20) étant sollicité dans une position par les autres aimants de l'assemblage (16) et se déplaçant dans son autre position sensible à la présence d'un métal ferreux à l'intérieur de sa plage effective de sensibilité,

caractérisé par un aimant annulaire (38) entourant le boîtier pour focaliser le flux des aimants, et des moyens (40, 42) co-agissant avec l'aimant annulaire pour régler sa position axialement par rapport au boîtier (12) et par conséquent changer la forme du champ magnétique afin de modifier la plage effective de sensibilité pour le déplacement de l'aimant mobile (20) sensible à la présence d'un métal ferreux.

2. Détecteur selon la revendication 1, dans lequel l'un des aimants (14) de l'assemblage est fixé à l'intérieur du boîtier et deux des aimants (18, 20) sont mobiles par rapport à l'aimant fixe (14), et des moyens (30) reliant les deux aimants mobiles.

3. Détecteur selon la revendication 2, dans lequel l'un (18) des aimants mobiles est disposé à l'intérieur du boîtier à une extrémité de l'aimant fixe (14) et a ses pôles disposés par rapport aux pôles de l'aimant fixe de telle sorte qu'il est attiré par l'aimant fixe, l'autre (20) des aimants mobiles est disposé à l'intérieur du boîtier à l'autre extrémité de l'aimant fixe (14) et a ses pôles disposés par rapport aux pôles de l'aimant fixe de telle sorte qu'il est repoussé par l'aimant fixe, la position des aimants mobiles étant sollicitée dans une direction lors de la non détection de la présence d'un métal ferreux et la présence des aimants mobiles se déplaçant entre la position sollicitée et le métal ferreux qui vient dans la plage effective de sensibilité du détecteur de métal ferreux.

4. Détecteur selon la revendication 2 ou la revendication 3, dans lequel l'aimant fixe (14) est tubulaire avec une ouverture centrale à travers celui-ci, et les moyens de liaison (30) s'étendent à travers l'ouverture centrale, un aimant mobile étant disposé à l'intérieur du boîtier sur chaque extrémité de l'aimant fixe.

5. Détecteur selon l'une quelconque des revendications précédentes, dans lequel le boîtier (12) comporte des filetages (44) le long de sa partie extérieure, et les moyens de réglage comportent au moins un élément (40, 42) fileté à l'extérieur du boîtier et maintenu contre l'aimant annulaire.

6. Détecteur selon la revendication 5, dans lequel les moyens de réglage comportent un premier écrou (40) engagé sur les filetages (44) extérieurs au boîtier, et un second écrou (42) engagés sur les filetages extérieurs au boîtier, l'aimant annulaire (38) étant disposé entre les premier et second écrous.