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(54) **Antenna device for a shoplifting detection system.**

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Description

The invention relates to an antenna device for a shoplifting detection system, the antenna device comprising at least one loop antenna comprising at least one wire loop constituted by an electrical conductor which extends in at least one conductive tube and is mounted in the conductive tube such that it is electrically insulated therefrom, the free ends of the conductor in operation being connected to a transmitter and/or receiver for energizing the antenna or receiving signals of detection tags, detected by the antenna.

A shoplifting detection system can, for example, operate as follows:

A transmitting antenna constituted by a conductive tube containing a wire loop mounted therein in such a manner that it is insulated therefrom, generates an alternating magnetic field. The frequency of said alternating field is periodically swept over a predetermined frequency range. A passive tag including a resonant circuit comprising a coil and a capacitor will generate a secondary alternating magnetic field at such instants when the instantaneous frequency of the field is equal to the resonant frequency of the tag, as soon as this tag is introduced into the field of the transmitting antenna. Thereafter, this secondary alternating magnetic field can be received by a second antenna, coupled to a receiving and detection arrangement. In a shoplifting detection system of the absorption type, this secondary alternating magnetic field is picked up by the same antenna as that generating the primary field.

The antennas referred to above can be realised by mounting a wire in a tube. The tube is disposed on top of or forms part of a base.

Such an antenna device of the type described above is known from US-A-4,251,808, which discloses a number of antenna configurations for use in a shoplifting detection system. The prior art antenna configurations include two or more wire loops which are located in the same plane and are each rotated through 180° with respect to each other, so that the currents in the wire loops are directed oppositely. The wire loops themselves are arranged in corresponding tubes. If, for example, two wire loops are used, these loops form together an antenna in the shape of an eight. The same holds for the tubes in which the wire loops are fitted. The wire loops of an eight-shaped antenna are of the same size, so that interfering fields generated at a relatively large distance generate signals in the loops, which cancel each other out. Also the alternating electromagnetic fields generated by the antenna device itself compensate for each other at larger distances from the antenna, so that the antenna device itself does not generate or hardly generates interfering fields for further equipment.

When three wire loops arranged one above the

other are employed, the upper and the lower wire loops are both shifted through 180° with respect to the central wire loop and the lower and upper wire loop together have a surface area equal to that of the central wire loop. This arrangement again provides a balanced antenna device, which causes little interference and is also insensitive to external interfering fields.

The object of the invention is to improve the prior art antenna device. More generally, it is an object of the invention to provide a simplified, relatively easy-to-produce and solid antenna device for a shoplifting detection system, which is relatively insensitive to external interfering fields, itself hardly generates interfering fields, and enables efficient detection of the tags or detection plates of the shoplifting detection system.

The invention will now be described in greater detail with reference to the accompanying drawing.

Fig. 1 shows an embodiment of a prior art antenna device for a shoplifting detection system;

Fig. 2 is a cross-sectional view of a portion of the device shown in Fig. 1;

Fig. 3 shows a further prior art antenna device; and

Fig. 4 is a schematic view of an example of an antenna device according to the invention.

Fig. 1 shows the elementary embodiment of an antenna device 1 for a shoplifting detection system with antenna tube 2, a base 3 and a wire loop 4. The tube is interrupted at its upper end and the tube portions thus obtained are electrically interconnected at the lower end by the base portion. The leads of the wire loop are disposed in the base. The base may fully or partly be constituted by the tube and is usually grounded in practice. An AC voltage V1 is applied to the leads of the wire loop by means of a transceiver, not shown. In response thereto, a current I1 starts flowing through the wire 4. A magnetic field forms around the wire, as shown in Fig. 2. The wire is contained in a metal tube having a wall thickness greater than what is usually called the skin depth associated with the frequency of the alternating field. As a result thereof the magnetic field around the wire will be limited to the space between the wire and the interior wall of the tube.

A voltage which at the interior side produces a current I2 which flows in the opposite direction of I1 will now be generated in the longitudinal direction at the interior side of the tube. The current I2 amplifies the magnetic field H1 by H2 between the wire and the interior side of the tube, but reduces the magnetic field of the wire around the interior side of the tube to zero: $H1 - H2 = 0$. In the regions in which there is an opening in the tube or where the tube ends such as is shown in Fig. 1 at 5, the interior side of the tube contacts the exterior side. The opening 5 then constitutes a potential source V2 which itself will generate a current I3 at

the exterior side of the tube. This current I3 now generates a magnetic field H3 around the exterior side of the tube, this field H3 being the ultimate magnetic field H of the antenna structure. There can be no alternating magnetic field in the tube wall, except in a layer equal to the skin depth, since such a field would be compensated for by eddy currents in the metal. This consequently acts as a transformer, wire 4 or, for the case of a plurality of series-arranged windings, wires 4 forming in the tube the primary winding, and the interior side of the tube 2 constituting the secondary winding. The exterior side of the tube then forms a one-turn coil generating the magnetic field.

The above-described prior art antenna has a practical drawback. Because of the single loop, the so-called 0-shape, this antenna shape generates also at a larger distance, outside of the operating range of the shoplifting detection system, a considerable alternating magnetic field, which may then be the cause of interference in radio receivers or neighbouring shoplifting detection systems. Also when used as a receiving antenna, this antenna structure will receive many (RF-) interfering signals from the exterior. It is therefore important to choose such a shape for the antenna, that, close to the antenna, for example at a distance of approximately 1 to 2 metres, the magnetic field is large and that this shape simultaneously minimizes the field at a larger distance. Such a configuration is the likewise known 8-shape such as the one shown in Fig. 3.

The antenna depicted in Fig. 3 is formed by two oppositely-directed loops, an upper loop and a lower loop. Consequently, two opposite magnetic fields Ho and Hb, which compensate for each other at large distances, are produced at the top and at the bottom. Conversely, an external field originating from a source located at a large distance is homogeneous and consequently generates an identical voltage in both loops. Since both loops are interconnected cross-wise, the net voltage at the terminals of the antenna has zero value. So this antenna is little sensitive to external interfering signals. At short distances a tag couples either to the lower field Ho or to the upper field Hb. At one half of the height, halfway the two loops, a combined field is produced which extends in the vertical direction. In that region coupling to a tag will occur, if the coil thereof is located in the horizontal plane. Consequently, adequate coupling to tags in the detection area of the shoplifting detection system will occur, while the interfering radiation to the outside and the sensitivity to interfering radiation from the outside is minimized. This technique is known and widely used. A disadvantage of the 8-shaped antennas shown in Fig. 3 is that the crossover connection is at "trouser pocket height". This means that if an article to which a tag is attached, is carried along in a coat pocket or a trouser pocket, the tag passes the passage at the same height as where the crossover

connection is located. There is a great chance that the tag in the trouser pocket or coat pocket is in a vertical position. In that case, the coupling to the magnetic field is poor because the field in the region of the crossover connection extends in the vertical direction and only couples adequately to a horizontal tag. This results in a reduced chance of detection.

For optimum detection of tags in a trouser pocket or a coat pocket the field in that region must extend horizontally. This can be achieved by moving the crossover connection. As a consequence, however, the surface areas of the individual loops are no longer identical, so that at equal current the magnetic dipole moments of the two loops become unequal, as a result of which the two fields do not correct for each other at larger distances.

The object of the invention is to provide a solution to this problem. To that end, first the symmetrical eight-shaped antenna will be considered in greater detail. In Fig. 3 the voltages and currents are designated in the same manner as in Fig. 1. The voltage VI is applied by a transceiver to the lead portion of the antenna wire 4, which is mounted in the shape of an 8 in the tube 2. This results in a current II being produced in the wire, which, because of the magnetic coupling, generates an inverse voltage at the interior side of the tube. In the region in which the interior side contacts the exterior side, i.e. at the openings 6 halfway and the interruption 5 at the top, this becomes manifest as a series of potential differences across the exterior side of the tube. Thus, the voltages V4,l,o and V4,r,o prevail between the openings 6 and the centre of the base portion 3. Since the currents in the left-hand and right-hand tube portions are directed oppositely, the voltages V4,l,o and V4,r,o are also opposite to each other, but equally large. Consequently, the voltage $V2 = 2 \times V4,l,o$ is present between the two openings 6 halfway the tube. The currents flowing in the antenna wire 4 in the upper tube portions are inverse to the current in the lower tube portions. In response thereto, the voltage V4,l,b between the interruption 5 and the opening 6 flows in the inverse direction of V4,l,o. Likewise V4,r,b is inverse to V4,r,o. From the fact that II in the two upper tube portions are identical, it then follows that the magnitude of V4,l,b is equal to the magnitude of V4,r,b. Likewise the magnitude of V4,l,b is equal to that of V4,l,o. Adding up the voltages across the upper and lower tube portions shows that the voltage across the interruption 5 at the top, V3, equals zero. The consequence of the observation that $V3 = 0$ is that the upper opening 5 may be electrically throughconnected without this basically having an effect on the currents and voltages in this antenna device. However, the tubes now form an uninterrupted electrical loop in the shape of a 0. This means that the total flux of each alternating magnetic field flowing through the 0-shape induces a short-circuit in the tube and thereby generates an inverse

field that counteracts the original magnetic flux. Short-circuiting the antenna tube portions at the upper end, as denoted by means of a throughconnection 7, therefore has for its result that any deviations in the magnetic field of the original symmetrical 8-shaped loop are compensated for, so that the alternating magnetic field at a large distance is further reduced and that the sensitivity to external interfering signals decreases further.

Now, according to the invention, the crossover connection can be disposed asymmetrically with respect to the centre, such that this crossover connection is no longer at trouser pocket height. More specifically, the crossover connection can be arranged below the centre, for example at about 25% of the overall height, as shown in Fig. 4. Utilizing the transformer action described hereinbefore, it is possible to replace the 8-shaped loop by a single loop and to place it in the lower part of the tube. Fig. 4 illustrates this configuration. In response to the transformer-coupling the current I_1 through the wire generates a symmetrical voltage V_2 between the openings 6. In response thereto two currents are produced at the exterior side of the tube, namely, $I_{3,o}$ in the lower portion and $I_{3,b}$ in the upper portion. These currents are inverse to each other and the magnitude is mainly determined by the ratio between the self-induction of the two tube portions. The upper portion has a longer path for the current, and hence a higher self-induction, than the lower portion. Accordingly, $I_{3,b}$ will be less than $I_{3,o}$. But the surface area of the upper antenna portion exceeds the surface area of the lower portion.

Since the magnetic field at a large distance is determined by the magnetic dipole moment, which is the product of the current and the surface area of the current loop, the two antenna halves, in spite of the disturbed asymmetry, will nevertheless provide an almost symmetrical contribution to the large-distance field and consequently cancel each other out. Further, the tube of the antenna forms an uninterrupted short-circuited conductor, so that the asymmetry in magnetic fluxes through the lower portion (H_o) and through the upper portion (H_b) causes a short-circuiting current I_c to flow, which provides that the total flux through the overall antenna is minimized. This provides a further reduction of the remote magnetic field. Likewise an external interfering field will be stopped by the short-circuiting loop, and consequently induce a minimal voltage at the terminals of the antenna. Thus, the design requirement of minimal interfering radiation at large distances and minimal sensitivity to external interfering signals is satisfied, in spite of the asymmetrical shape of the antenna. Viewed from some distance, the asymmetrical structure operates as a symmetrical antenna. The above-mentioned single wire loop can also have a plurality of turns. Its mode of operation does not differ from

the mode of operation described in the foregoing, but a plurality of turns may be desirable, depending on the operating frequency and the impedance match to the electronic transmitting and receiving units. In that case, too, the antenna is very simple since there is no need for the wire loop to be in the shape of an eight.

In the practical implementation, there may be variations of design for aesthetic reasons and variations based on constructional features. Thus the specified base portion may be replaced by tube material having a built-in electrical connection. A closed rectangular tube construction is then obtained. Variations on this rectangular shape are also possible by providing it with rounded and/or beveled corners.

Between the openings 6 there can be provided a crossover tube which is insulated with respect to the tube or is made of insulating material, but the wire section extending between the openings 6 can alternatively be included in a panel which partly or completely occupies the antenna tube or is contiguous thereto. Alternatively, the antenna can be disposed upside down, i.e. with the base portion at the top, or in a horizontal position. If so desired, the openings may be spaced differently from the base portion.

All these variations, which do not have any effect on the operation of the antenna, are considered to fall within the framework of the invention.

Claims

1. An antenna device for a shoplifting detection system, the antenna device comprising at least one wire loop constituted by an electrical conductor which extends in at least one conductive tube and is mounted in the conductive tube such that it is electrically insulated therefrom, the free ends of the conductor in operation being connected to a transmitter and/or receiver for energizing the antenna or receiving signals of detection tags, detected by the antenna, and the conductive tube extending from a base portion and, together with the base portion, forming a continuous loop-shaped electrical conductor, characterized in that the conductive tube is provided remote from the base portion with openings made in two facing sections and the at least one wire loop extends from the base through one of the facing sections to as far as the opening, extends further between the facing sections from the opening to the other opening and thence continues in the other one of the facing sections from the other opening to the base portion.
2. An antenna device as claimed in claim 1, characterized in that the portion of the at least one wire loop that extends between the two facing sections from one opening to the other opening div-

ides the surface area enclosed by the conductive tube into two unequal portions.

3. An antenna device as claimed in claim 2, characterized in that the portion of the least one wire loop that extends between the two facing sections is located at a height of approximately 25% of the overall height of the antenna, taken from the base portion. 5
4. An antenna device as claimed in claim 1 or 2, characterized in that the two openings are spaced differently from the base portion. 10
5. An antenna device as claimed in any one of the preceding claims, characterized in that the portion of the wire loop that extends between the two facing sections is disposed in a crossover tube which is insulated with respect to the conductive tube. 15
6. An antenna device as claimed in claim 5, characterized in that the crossover tube is a tube made of insulating material. 20
7. An antenna device as claimed in any one of claims 1-4, characterized in that the portion of the wire loop that extends between the two facing sections is incorporated in a panel which at least partly fills the space surrounded by the conductive tube. 25
8. An antenna device as claimed in any one of claims 1-4, characterized in that the portion of the wire loop that extends between the two facing sections is incorporated in a panel which surrounds at least partly the loop of the conductive tube. 30
9. A shoplifting detection system provided with an antenna device as claimed in any one of the preceding claims. 35

Patentansprüche

1. Antennenvorrichtung für ein Ladendiebstahlerkennungssystem, mit wenigstens einer Drahtschleife, die aus einem elektrischen Leiter besteht, der sich in wenigstens einem Leiterrohr erstreckt und in dem Leiterrohr derart angebracht ist, daß er von diesem elektrisch isoliert ist, wobei die freien Enden des Leiters im Betrieb mit einem Sender und/oder einem Empfänger verbunden sind, um die Antenne zu erregen oder von der Antenne detektierte Signale von Erkennungsmarkierungen zu empfangen, und wobei das Leiterrohr sich von einem Basisbereich aus erstreckt 50

und zusammen mit dem Basisbereich einen durchgehenden schleifenförmigen elektrischen Leiter bildet, dadurch gekennzeichnet, daß das Leiterrohr von der Basis entfernt zwei Öffnungen aufweist, die in zwei gegenüberliegenden Abschnitten ausgebildet sind, und die wenigstens eine Drahtschleife von der Basis durch eine der einander gegenüberliegenden Abschnitte bis zur Öffnung, weiter zwischen den einander gegenüberliegenden Abschnitten von einer Öffnung zur anderen Öffnung verläuft und sich sodann durch den anderen der einander gegenüberliegenden Abschnitte von der anderen Öffnung zum Basisbereich fortsetzt.

2. Antennenvorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß der Bereich der wenigstens einen Drahtschleife, der sich zwischen den beiden einander gegenüberliegenden Abschnitten von einer Öffnung zur anderen Öffnung erstreckt, die von dem Leiterrohr eingeschlossene Fläche in zwei ungleiche Teile teilt.
3. Antennenvorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß sich der Bereich der wenigstens einen Drahtschleife, der sich zwischen den beiden einander gegenüberliegenden Abschnitten erstreckt, auf einer Höhe von ungefähr 25% der Gesamthöhe der Antenne, gemessen vom Basisbereich, befindet.
4. Antennenvorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die beiden Öffnungen unterschiedlich von dem Basisbereich beabstandet sind.
5. Antennenvorrichtung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß der Bereich der Drahtschleife, der sich zwischen den beiden einander gegenüberliegenden Abschnitten erstreckt, in einem gegen das Leiterrohr isolierten Kreuzungsrohr angeordnet ist.
6. Antennenvorrichtung nach Anspruch 5, dadurch gekennzeichnet, daß das Kreuzungsrohr ein Rohr aus isolierendem Material ist.
7. Antennenvorrichtung nach einem der Ansprüche 1-4, dadurch gekennzeichnet, daß der Bereich der Drahtschleife, der sich zwischen den beiden einander gegenüberliegenden Abschnitten erstreckt, in einer Platte enthalten ist, die den von dem Leiterrohr umschlossenen Raum wenigstens teilweise ausfüllt.
8. Antennenvorrichtung nach einem der Ansprüche 1-4, dadurch gekennzeichnet, daß der Bereich der Drahtschleife, der sich zwischen den beiden

einander gegenüberliegenden Abschnitten erstreckt, in einer Platte enthalten ist, die die Leiterrohrschleife wenigstens teilweise umgibt.

9. Ladendiebstahlerkennungssystem mit einer Antennenvorrichtung nach einem der vorhergehenden Ansprüche.

Revendications

1. Dispositif d'antenne pour un système de détection de vol à l'étalage, le dispositif d'antenne comprenant au moins un cadre constitué par un conducteur électrique qui s'étend dans au moins un tube conducteur et est monté dans le tube conducteur en sorte qu'il soit électriquement isolé de celui-ci, les extrémités libres du conducteur étant connectées en fonctionnement à un émetteur et/ou un récepteur pour exciter l'antenne ou recevoir des signaux provenant d'étiquettes de détection, détectés par l'antenne, et le tube conducteur s'étendant à partir d'une partie de base et, en conjonction avec la partie de base, formant un conducteur électrique ininterrompu en forme de boucle, caractérisé en ce que le tube conducteur est muni, à l'opposé de la partie de base, d'ouvertures et constitué de deux sections en regard et le au moins un cadre s'étend depuis la base à travers une des sections en regard jusqu'à l'ouverture, s'étend de plus entre les sections en regard depuis l'ouverture jusqu'à l'autre ouverture et de là poursuit ensuite dans l'autre des sections en regard depuis l'autre ouverture jusqu'à la partie de base.
2. Dispositif d'antenne selon la revendication 1, caractérisé en ce que la partie du au moins un cadre qui s'étend entre les deux sections en regard d'une ouverture à l'autre ouverture partage la surface délimitée par le tube conducteur en deux parties inégales.
3. Dispositif d'antenne selon la revendication 2, caractérisé en ce que la partie du au moins un cadre qui s'étend entre les deux sections en regard est placée à une hauteur d'approximativement 25 % de la hauteur totale de l'antenne, prise à partir de la partie de base.
4. Dispositif d'antenne selon la revendication 1 ou 2, caractérisé en ce que les deux ouvertures sont espacées différemment à partir de la partie de base.
5. Dispositif d'antenne selon l'une quelconque des revendications précédentes, caractérisé en ce que la partie du cadre qui s'étend entre les deux

sections en regard est disposée dans un tube de croisement qui est isolé par rapport au tube conducteur.

6. Dispositif d'antenne selon la revendication 5, caractérisé en ce que le tube de croisement est un tube constitué d'un matériau isolant.
7. Dispositif d'antenne selon l'une quelconque des revendications 1 à 4, caractérisé en ce que la partie du cadre qui s'étend entre les deux sections en regard est incorporée dans un panneau qui remplit au moins partiellement l'espace entouré par le tube conducteur.
8. Dispositif d'antenne selon l'une des revendications 1 à 4, caractérisé en ce que la partie du cadre qui s'étend entre les deux sections en regard est incorporée dans un panneau qui entoure au moins partiellement la boucle du tube conducteur.
9. Système de détection de vol à l'étalage muni d'un dispositif d'antenne selon l'une quelconque des revendications précédentes.

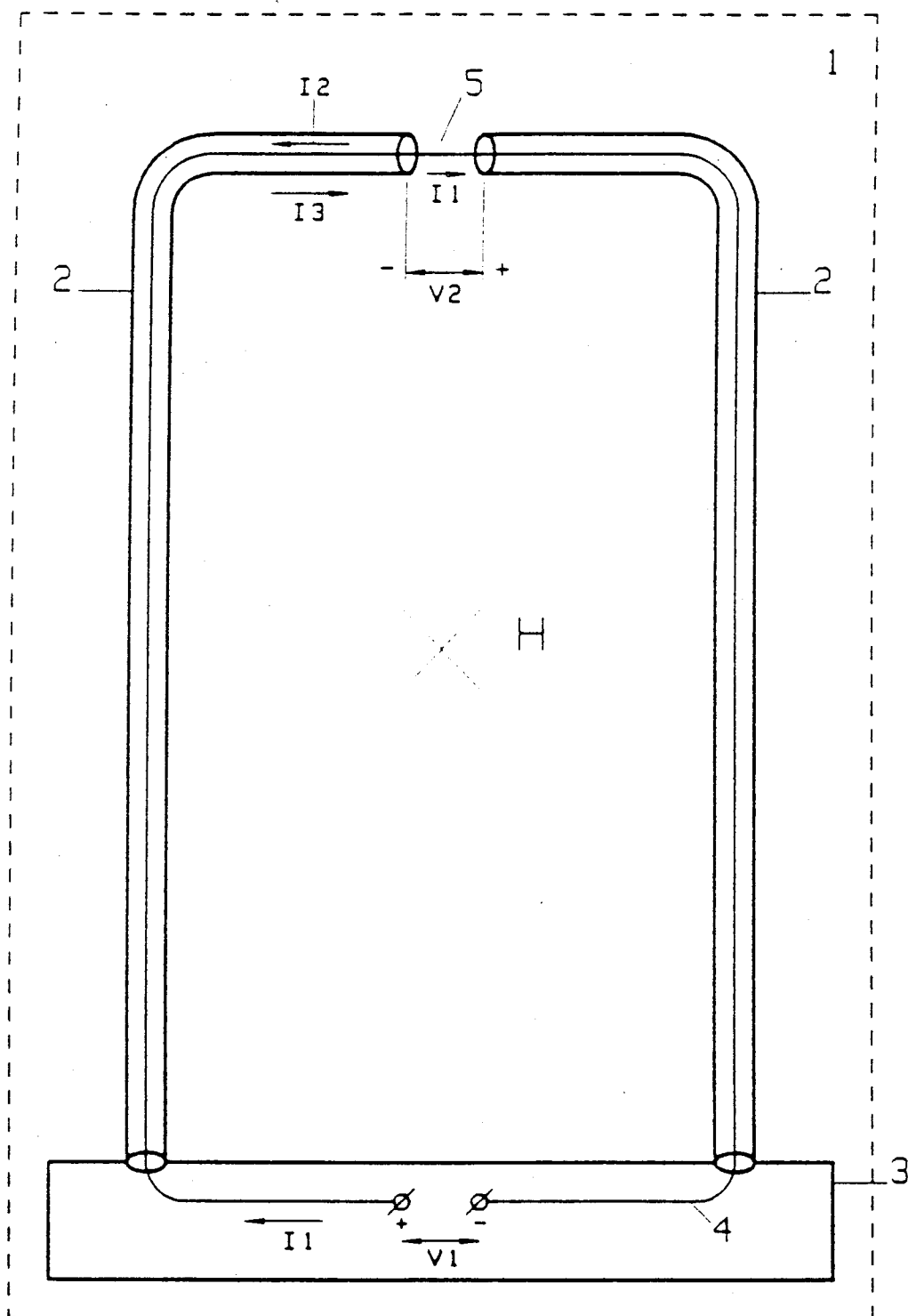


FIG.1

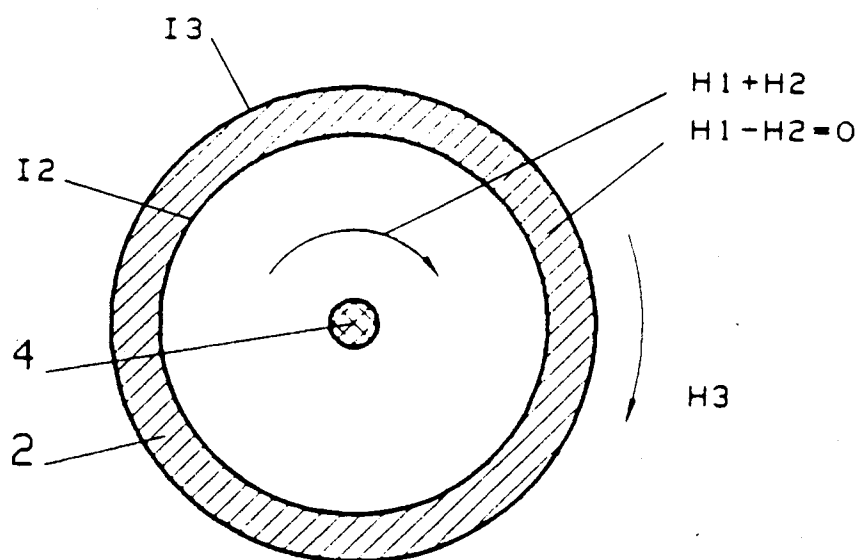


FIG. 2

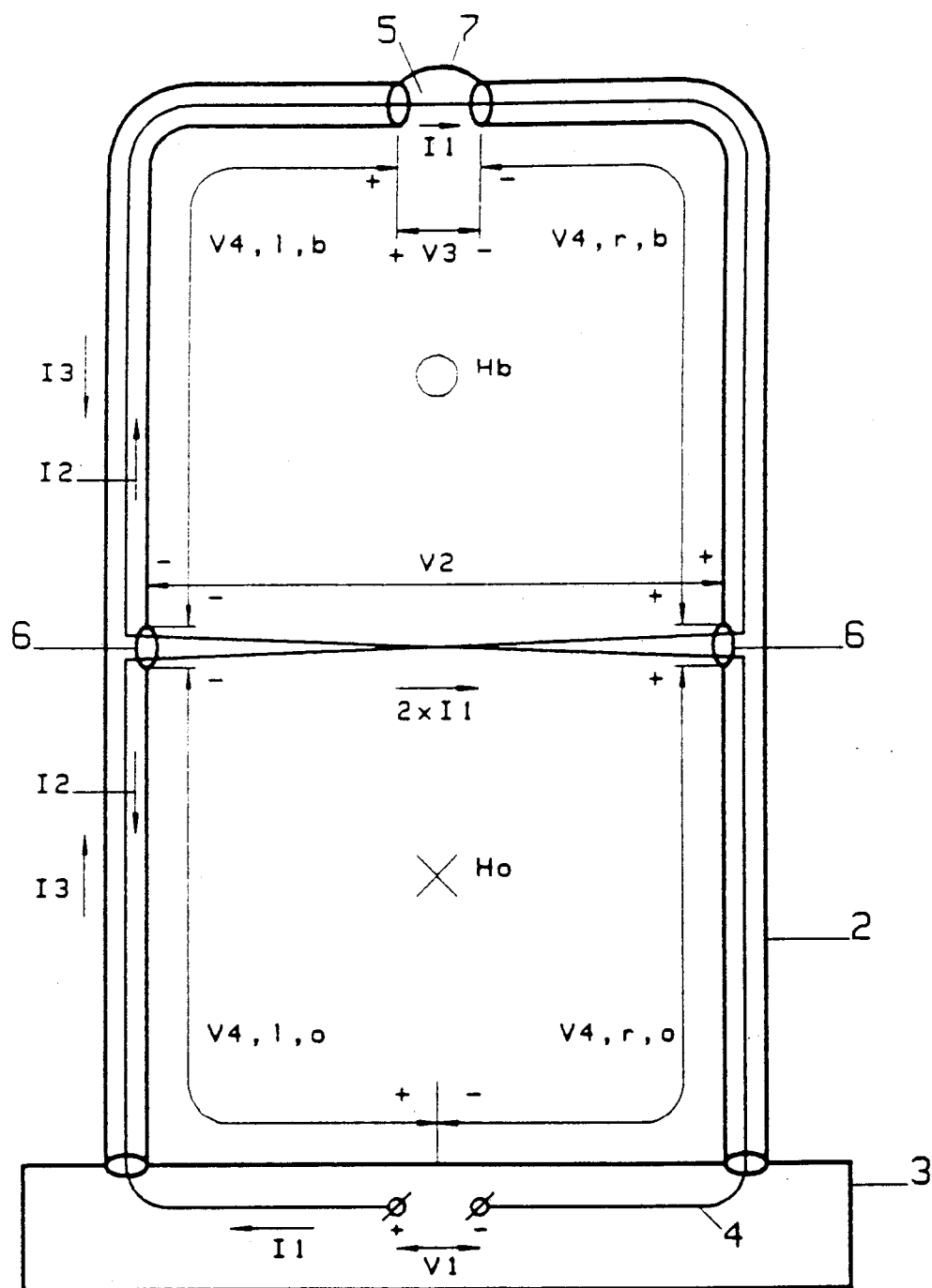


FIG. 3

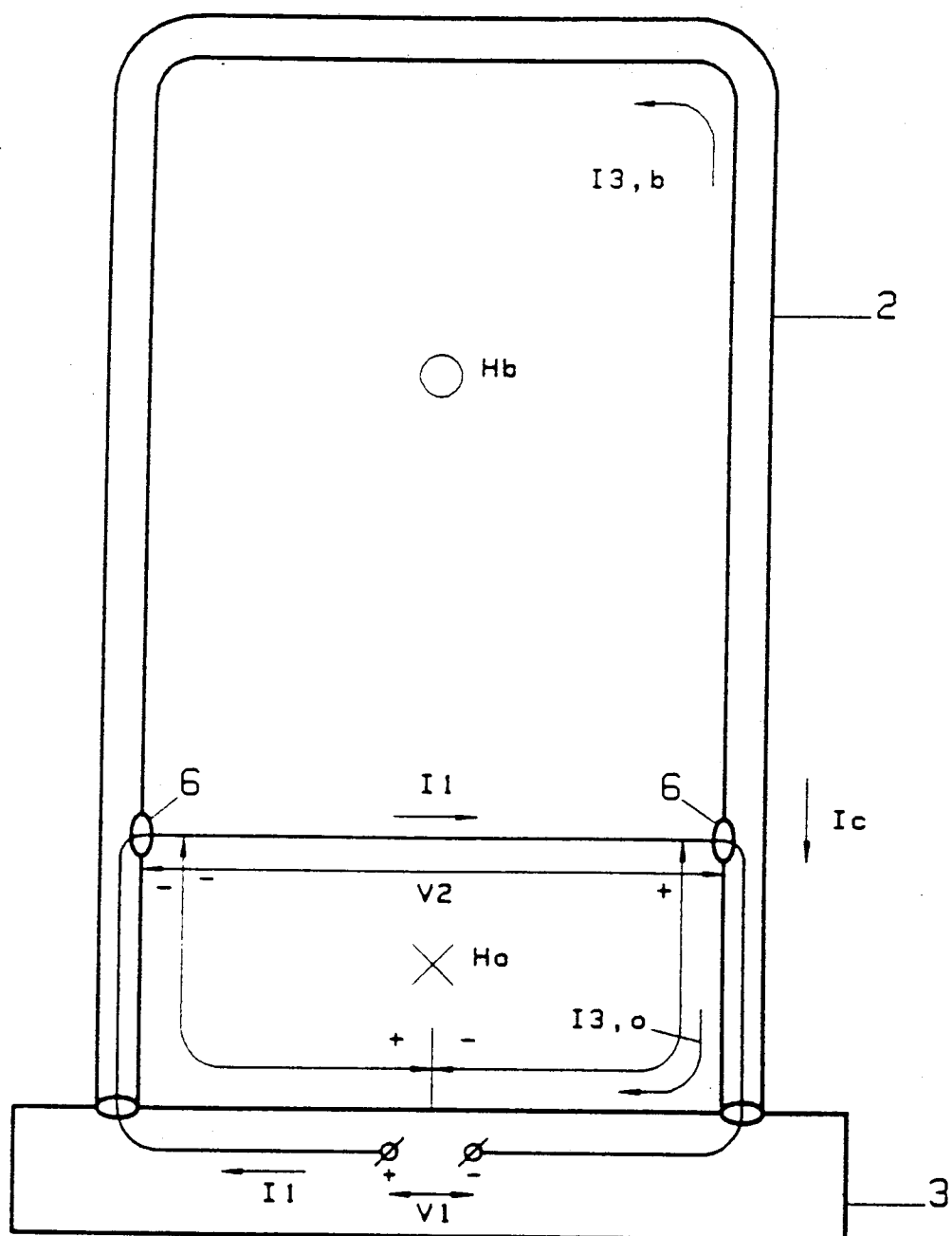


FIG. 4