Sept. 17, 1940. W. H. HICKOK 2,214,729

MAGNETIC FIELD NEUTRALIZING SYSTEM

Filed Aug. 31, 1939 2 Sheets-Sheet 1

Fig. 2

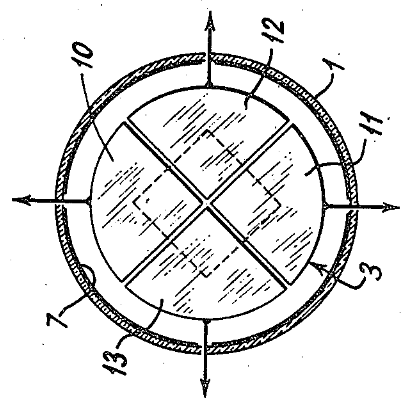
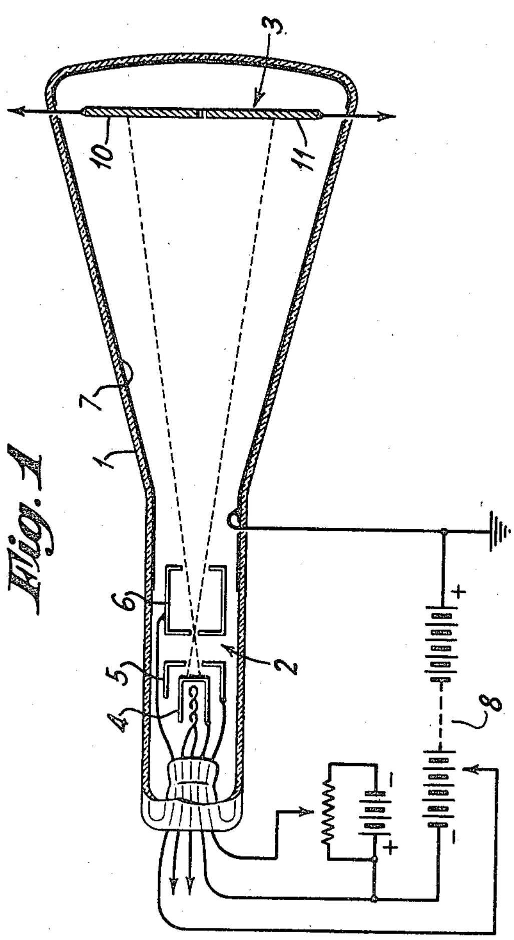



Fig. 1

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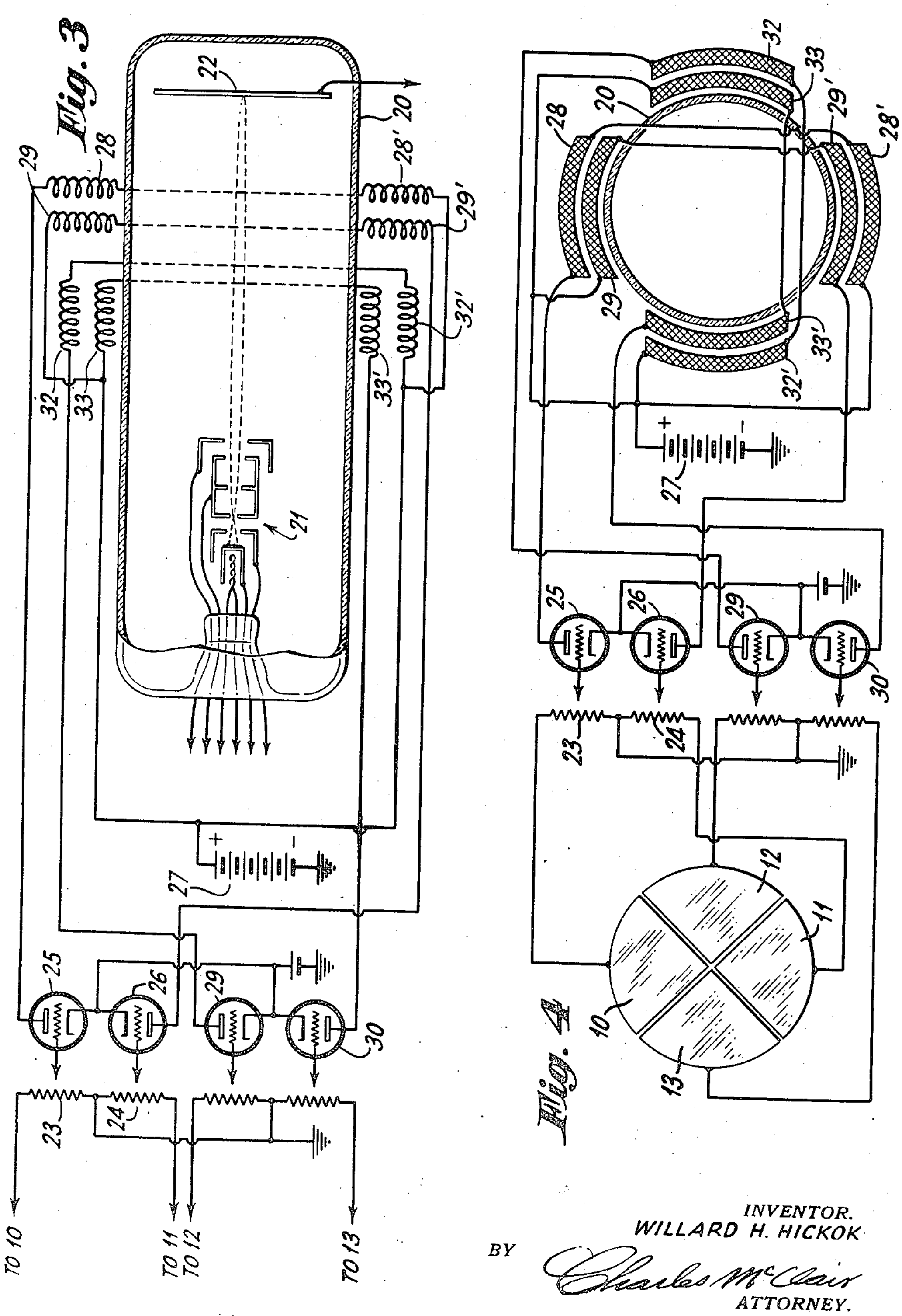


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# UNITED STATES PATENT OFFICE

2,214,729

## MAGNETIC FIELD NEUTRALIZING SYSTEM

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6 Claims. (Cl. 250—27)

My invention relates to magnetic field neutralizing arrangements and particularly to field compensating devices for use with electron discharge tubes.

I have found that certain electron discharge tubes are affected and disturbed by stray magnetic fields such as the earth's magnetic field which change the path of an electron beam from the desired trajectory, thereby introducing distortion or displacement. To overcome this difficulty it has been proposed to utilize a strong magnetic field having lines of force parallel with the desired beam trajectory, but such arrangements are ineffective to remove the distortion. This distortion effect is particularly noticeable in electron tubes of the low velocity electron beam type, such as the type of television transmitting tube utilizing a low velocity electron beam from a cathode to scan a target which is at or near cathode potential. The effect of a stray magnetic field on the low velocity beam is to displace the beam while it is passing from the cathode to the target under the influence of the deflection forces such as the horizontal and vertical deflection fields to which the beam is subjected. The difficulty becomes even more aggravated when a tube is moved so that the axis of the electron beam is tilted with respect to the horizontal or vertical components of the field. An example of this condition is the use of an electron discharge tube of the television transmitting type mounted on a tripod and used as a panoramic camera.

It is an object of my invention to provide an electron discharge device with means to compensate stray magnetic fields over a volume within which the device may operate. It is another object of my invention to provide a magnetic field compensating system in combination with an electron discharge device subjected to varying magnetic fields. It is a still further object to provide a magnetic field neutralizing device for use with television tubes and other devices subjected to varying magnetic fields.

In accordance with my invention I provide means to generate a magnetic field or fields which neutralize stray magnetic fields irrespective of the direction of the stray magnetic field by providing an electron tube wherein a beam of electrons is subjected to the field to be neutralized and collected in accordance with the deflection of the beam caused by the field to produce currents which are used to neutralize the stray magnetic field surrounding a space in which little or no stray magnetic field is desired. This space in which the stray magnetic field is neutralized may be occupied by a device such as a television cathode ray tube which is normally sensitive to stray fields.

These and other objects, features and advantages of my invention will appear and a better understanding of my invention will be obtained from the following description taken in connection with the accompanying drawings, in which:

Fig. 1 is a longitudinal view partially in section illustrating one form of my magnetic field neutralizing tube.

Fig. 2 is a plan view showing a portion of the electrode structure of the tube of Fig. 1,

Fig. 3 is a schematic view of the principal parts of my device and its circuit connections and

Fig. 4 is a sectional view of a cathode ray tube showing the location of the field neutralizing coils shown schematically in Fig. 3.

Considered broadly, my device comprises means to subject an electron beam to the stray magnetic field which varies the degree of deflection of the beam to generate voltages or currents which vary in magnitude or intensity in accordance with the effect of the stray magnetic field upon the electron beam. These voltages or currents are utilized to generate compensating electro-magnetic fields occupying the space over which field compensation is desired. More specifically, my device includes a cathode ray tube subjected to the stray magnetic field so that the beam within the tube may be directed to one or more of a plurality of electrodes depending upon the horizontal and vertical components of the stray magnetic field to generate currents or voltages which are amplified to produce electric currents which are fed to suitably arranged neutralizing coils so that the space enclosed between the coils is freed from the undesired magnetic field for all directions of the field.

Referring to Figs. 1 and 2 of the drawings, my control tube preferably comprises an evacuated elongated envelope or bulb 1 enclosing at one end an electron gun structure 2 and at the opposite end facing the electron gun a composite target electrode 3. The electron gun is preferably of a type which produces an electron beam having a square cross-section and comprises a cathode 4 from which electrons may be drawn, a control electrode 5 connected to the usual biasing battery and an apertured or first anode 6 maintained positive with respect to the cathode 4. The first anode 6 is preferably provided with a square masking aperture to provide an electron beam having a square cross-section. The electron stream leaving the cathode 4 is accelerated by the first anode 6 and formed into an electron beam having a square cross-section focused on the composite target electrode 3 by a second anode 7 which is preferably a conductive coating on the wall of the envelope between the first anode 6 and the target electrode 3. The first anode 6 and the second anode 7 are maintained at low positive potentials with respect to the cathode by a battery 8.

The composite target 3 preferably comprises four triangular-shaped electrodes or segments at the end of the tube opposite the electron gun and equally spaced with respect to and about the normal undeflected path of the beam. The segment electrodes 10 and 11 are on opposite sides of the undeflected beam path and the segments 12 and 13 are similarly located but displaced 90° from the segments 10—11. The electron beam from the electron gun 2 is focused to give a constant-density beam and directed so as to impinge equally on all four target segments, the sides of the square cross-section of the beam being parallel or perpendicular to the edges of the triangular segments which intersect at the center of the target. The static position of the beam on the target sections is shown by the area enclosed by the discontinuous lines in Fig. 2. Each of the segments is provided with a current-carrying lead sealed through the end wall of the bulb 1 which may serve as a mechanical support for the individual segments.

It will be appreciated from the foregoing description of the tube shown in Fig. 1 that if the tube is subjected to a magnetic field such that the magnetic field intersects the tube axis at an angle, the magnetic field will deflect the electron beam from its normal position. Thus the beam, while cutting a magnetic field, will be deflected in a direction normal to the field so that it impinges on the target segments by unequal amounts and the current in the leads connecting the target sections will vary accordingly. It is desirable that the currents from the target sections bear a linear relation with respect to the intensity of the field deflecting the beam, and it is for this reason that I desire to use a beam having a square cross-section and triangular segments as shown. Furthermore, the maximum deflection of the beam on any segment by a stray magnetic field is limited to one half the distance between the diagonal corners of the beam cross-section to obtain linearity between the current in the segment leads and the stray field producing the deflection. The deflection of the beam may be limited to the desired maximum amount by adjusting the potential applied to the electron gun second anode 7 so that the velocity of the beam is such that the maximum deflection field gives maximum deflection of the proper amount. These currents may be used to neutralize the magnetic field in a space closely adjacent the bulb 1 which space is subjected to a substantially identical stray magnetic field as the space occupied by the bulb 1. Since the tube shown in Fig. 1 controls the neutralization of the magnetic field, I will hereafter refer to this tube as the "control tube". The length of the control tube between the electron gun and the target 3 may be relatively long, the desired length varying directly with the strength of the magnetic field which is to be neutralized. Likewise, the potentials applied between the electron gun cathode and the target segments of the control tube are preferably low so as to provide a low velocity electron beam which is more susceptible to the stray magnetic field but still sufficiently high to prevent too great a deflection of the beam for the maximum stray magnetic field. In the absence of stray magnetic fields the beam will not be deflected but impinge equally on the target electrode segments.

Referring to Fig. 3 which shows the circuit associated with the target electrode segments 10—11 and 12—13, I have illustrated the use of my device for neutralizing stray magnetic fields within the electron beam tube 20 which is of the low velocity beam deflection type, the normal beam deflection means such as magnetic coils or electrostatic plates not being shown. The electrodes of the tube 20 may comprise means for forming an electron beam such as the electron gun 21 oppositely disposed from a target 22 of any desired type. My invention does not reside in the particular structure of the tube 20, this tube being shown merely to explain the operation of my device in similar applications and being referred to later as the "controlled tube." Therefore, the electron gun 21 may be of any known type, and likewise the target or screen 22 may be of any desired structure such as a mosaic electrode, fluorescent screen or other electron responsive structure.

Referring particularly to the circuit of Fig. 3, the target segments 10 and 11 within the bulb 1, which are on opposite sides of the normally undeflected beam, are connected through the resistors 23 and 24 to ground and to the positive terminal of the potential source or battery 8. The voltage drop across these two resistors is applied through a variable tap on the resistors to the electron discharge tubes 25—26 which may be of the triode or any other desired type so that the current to generate the neutralizing fields may be readily controlled. The tube 20 or other device for which a magnetic field-free space is desired is provided with two sets of field neutralizing coils, each set comprising two co-axial pairs of two serially connected coils, as shown in Fig. 4. The coils of each pair are located on opposite sides of the tube 20, the axes of the two sets of coils being mutually perpendicular and so located about the tube 20 that the magnetic fields produced by the coils are parallel to the horizontal and vertical components of the stray magnetic field. Each series pair of coils is connected through a current supply circuit to a target segment of the control tube. The output circuit of the tube 25 is energized from the potential source or battery 27, so connected that when the beam impinges on the segment 10 a current flows through a pair of series connected field neutralizing coils 28—28′, and the output circuit of tube 26 is similarly connected to the pair of series connected coils 29—29′ so that when the beam from the cathode 4 impinges on the target segment 11 a current flows in the coils 29—29′ to generate a magnetic field which is in an opposite direction to the magnetic field generated by current flowing in the coils 28—28′. The target segments 12 and 13 are similarly connected to energize the discharge tubes 30 and 31, the output circuits of which are similarly connected to the series connected pairs of deflection coils 32—32′ and 33—33′ so that when the beam is incident on either segment electrode 12 or 13 the coils 32—32′ or the coils 33—33′ will be energized with current flowing in opposite directions to generate magnetic fields which have lines of force extending in opposite directions. The coils are mounted about the space where it is desired to neutralize the undesired stray magnetic field so that the fields generated by the coils are parallel with the stray fields to be neutralized. Since the sets of coils are arranged mutually perpendicular to each other and are oriented with respect to the horizontal and vertical components of the stray magnetic field, the current in the coils is made to flow in such a direction that the fields neutralize the two components of the stray field. The location of the target segments shown in Fig. 2 is such that the segments 10—11 neutralize the horizontal magnetic field component and the plates 12—13, the vertical field component of the earth's magnetic field.

In the operation of my magnetic field neutralizing device, the control tube shown in Fig. 1 is positioned in a fixed relation with respect to the device to be controlled. Furthermore, the normal undeflected direction of the beams of the control and the controlled tube should be parallel and in the same direction so that the stray magnetic field is effective in deflecting the beams of both tubes in the same direction.

From the above it will be appreciated that my device is particularly adapted to television camera tubes which are usually positioned so that they may be swung either in horizontal or vertical directions and that for such applications the control tube should be mounted directly on or within the camera box enclosing the controlled tube which, in this case, would be the camera tube.

While I have disclosed my system with respect to neutralizing two components of a stray magnetic field such as the earth's field, it may be desirable to provide a system to neutralize only one component, and again to neutralize the one component for only a limited set of positions for the control and controlled tubes. If the controlled tube is to be operated in a plane where one component of the stray field is ineffective to deflect the beam and cause distortion, only one set of the neutralizing coils such as the coils 28—28′ and the coils 29—29′ need be used. Consequently, only the target segments 10 and 11 would be used. This system is suitable for neutralizing the filed component in a single plane such as the horizontal magnetic field component. Such a field component may be defined as that field component which is perpendicular to the axis or undeflected beam path of the control tube (or of the cathode ray tube) and may be neutralized by a single set of coils which generate a field parallel to this component and having equal strength but an opposite direction with respect to this component. A single pair of field neutralizing coils such as the coils 28—28′ and the associated target segment 10 may be used for neutralization of the stray magnetic field component if the control and controlled tubes are to be rotated only 180° in the zero plane of the other field component. Thus the tubes may be continuously rotated from zero deflection, through maximum and to zero deflection again or through an arc of 180° using only one pair of coils and one target segment.

While I have indicated the preferred embodiments of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

I claim:

1. A system for minimizing the effect of stray magnetic fields in a cathode ray tube comprising a control tube including an electron gun to develop a beam of electrons and a target electrode to receive electrons when said tube is immersed in the stray magnetic field and said beam is deflected by said field, a cathode ray tube adjacent said control tube and exposed to substantially the same stray magnetic field, said cathode ray tube having means to generate an electron beam and a screen adapted to receive said beam, means to maintain said control tube and said cathode ray tube in fixed relative orientation during movement of said tubes, a pair of serially connected coils, each coil of said pair being located on opposite sides of said cathode ray tube and of a portion of the path of the beam in said cathode ray tube, said coils being positioned to produce between them a magnetic field parallel to the component of said stray magnetic field which is perpendicular to the undeflected electron beam path of said control tube, and circuit means between said target and said pair of coils for passing through said coils, while the beam of electrons of said control tube is on said target, a direct current of an amount and in a direction to produce between said coils a magnetic field equal in intensity and opposite in direction to the said component of said stray magnetic field between said coils.

2. A system for minimizing the deflection of a cathode ray beam in a cathode ray tube produced by stray magnetic fields comprising a control tube subjected to a stray magnetic field and having an electron gun to develop an electron beam and a target including two segments on opposite sides of the normal undeflected path of the beam, a cathode ray tube including an electron gun to generate a beam of electrons and a target to receive the electrons so positioned with respect to said control tube that the stray magnetic field deflects the beams of both tubes, a set of coaxial field neutralizing coils comprising two pairs of serially connected coils, the coils of each pair being on opposite sides of said cathode ray tube, one pair of said coils being connected to one of said segments and the other pair to the other segment, said set of neutralizing coils being so located about said cathode ray tube that the magnetic fields between said coils are parallel to the component of said stray magnetic field which is perpendicular to the undeflected electron beam path of said control tube, the magnetic field between said set of coils being equal in intensity and opposite in direction to the said component of said stray magnetic field when the beam of said control tube impinges on one or the other of said segments.

3. A system for compensating the deflection of a cathode ray beam in a cathode ray tube subjected to the earth's magnetic field comprising a control tube having an electron gun to develop an electron beam and a four-segment target wherein the segments are equally spaced about and from the normal undeflected path of the beam, a cathode ray tube including a target and an electron gun to develop and project a beam of electrons upon the target, said cathode ray tube being so positioned with respect to said control tube that the earth's magnetic field deflects the beams of both tubes, two sets of field neutralizing coils, each set comprising two coaxial pairs of

serially connected coils, the coils of each pair being on opposite sides of said cathode ray tube and the axes of said two sets of coils being mutually perpendicular, said two sets of neutralizing coils being so located about said cathode ray tube that the magnetic fields between said sets of coils are parellel to the horizontal and vertical components of the earth's magnetic field, individual circuit means between two opposite segments of said control tube target and the coaxial pairs of one set of said coils for passing through one or the other of said pairs of coils, while the beam is on one or the other of said two segments, a direct current of an amount and in a direction to produce between said one set of coils a magnetic field equal in intensity and opposite in direction to the horizontal component of the earth's magnetic field between said one set of coils, and individual circuit means between the other two segments of said target and the coaxial pairs of the other set of said coils for passing through one or the other of said last-mentioned pairs of coils, while the beam is on one or the other of said other two segments, a direct current of an amount and in a direction to produce between said other set of coils a magnetic field equal in intensity and opposite in direction to the vertical component of the earth's magnetic field between said other set of coils.

4. A system as claimed in claim 3 wherein the said control tube and the said cathode ray tube are aligned with the undeflected beams of the two tubes parallel and flowing from the electron gun to the target of each tube in the same direction.

5. A system for neutralizing a portion of the earth's magnetic field comprising a control tube having an electron gun to develop an electron beam and a target including four equally spaced segments uniformly disposed with respect to and about the center of said target, to individually receive electrons from the beam when said control tube is subjected to the horizontal and vertical components of the earth's magnetic field, two sets of field neutralizing coils adjacent said control tube, each set comprising two coaxial pairs of serially connected coils, the coils of each pair being on opposite sides of the space where a neutralizing field is desired, said two sets of coils being so located about said space that the magnetic fields between said sets of coils are parallel to the horizontal and vertical components of the earth's magnetic field, one pair of coils of one set being connected to one of said target segments, the other pair of coils of the same set of coils to the diagonally opposite target segment, the pairs of coils of the other set of coils being connected respectively to the remaining two target segments for passing through said coils, while the beam of said control tube is on the respective target segments, a direct current of an amount and in a direction to produce between the coils of said sets of coils magnetic fields equal in intensity and opposite in direction to the horizontal and vertical components of the earth's magnetic field between the pairs of coils and over the space where a neutralizing field is desired.

6. A system for neutralizing a portion of the earth's magnetic field comprising a control tube having an electron gun including a square electron beam masking aperture to develop an electron beam having a square cross-section normal to the path of the beam, and a target including four equally spaced triangular-shaped segments uniformly disposed with respect to and about the center of said target, the said target being so oriented with respect to said beam that limited movement of the beam on said target produces substantially linear variation in the current collected by said segments from said beam when the beam of said control tube is subjected to the horizontal and vertical components of the earth's magnetic field, two sets of field neutralizing coils adjacent said control tube, each set comprising two coaxial pairs of serially connected coils, the coils of each pair being on opposite sides of the space where a neutralizing field is desired, said two sets of coils being so located about said space that the magnetic fields between said sets of coils are parallel to the horizontal and vertical components of the earth's magnetic field, one pair of coils of one set being connected to one of said target segments, the other pair of coils of the same set of coils to the diagonally opposite target segment, the pairs of coils of the other set of coils being connected respectively to the remaining two target segments for passing through said coils, while the beam of said control tube is on the respective target segments, a direct current of an amount and in a direction to produce between the coils of said sets of coils magnetic fields equal in intensity and opposite in direction to the horizontal and vertical components of the earth's magnetic field between the pairs of coils and over the space where a neutralizing field is desired.

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