

MAGNETIC FIELD COMPENSATOR FOR A CRT

The invention relates to an automatic cancellation of external magnetic fields and, in particular, to apparatus for compensating for an external magnetic field affecting the operation of a cathode ray tube (CRT) display.

The earth's magnetic field in the northern hemisphere is characterized by magnetic lines of force dipping downward and toward what is commonly referred to as the earth's north magnetic pole, but which by electromagnetic theory is actually a south magnetic pole. At a point of one of the lines of force a vector H may be drawn to represent the direction and intensity of the earth's field. The vector H that is substantially uniform at any geographical location may be separated into vertical and horizontal components, H_y and H_h , respectively. For the continental United States the horizontal intensity H_h in the direction of the magnetic North varies from about .27 gauss in the southern parts to about .16 gauss in the northern parts.

Color purity in a color television receiver tends to be adversely affected by the earth's magnetic field. An example of such a color television receiver is the shadow mask receiver. In such a color television receiver, the CRT has three electron guns and an apertured mask through which the electron beams pass to impinge upon the screen, which has phosphor stripes thereon emissive of light of different colors. For proper color rendition, it is desirable that the electron beams be properly directed and properly convergent so that at each scanning instant when an elemental area of the color image is being reproduced, the electron beams will pass through the correct aperture of the mask and impinge on the proper phosphor stripe of the screen.

A CRT having a large screen, such as a 32-inch (81 cm) CRT, may be more sensitive to the earth's magnetic field than a CRT having a small screen. Greater sensitivity may exist for large screen CRT than for a



smaller screen CRT because a given bending of the electron beam path caused by the earth's magnetic field results in a larger change in landing position on the face of the larger screen CRT, due to the longer distance from the yoke to the screen. A larger change in landing position requires a tighter tolerance for color purity. Such sensitivity to the earth's magnetic field may occur even when a magnetic shield is used, since ideal magnetic shielding is not feasible.

10 In a given geographical location, the effect of the vertical component H_y on the electron beams that affects the color purity is substantially the same at any directional angle δ of the CRT. Directional angle δ is defined as the angle between an electron beam axis Z of the CRT and the direction of the magnetic North. Therefore, automatic neutralization of the vertical component H_y as a function of the directional angle δ may not have a significant effect on color purity. On the other hand, after the CRT is rotated in the horizontal plane by, for example, a viewer, a situation encountered in normal usage of television receiver, directional angle δ changes. It is well known that a change of angle δ may tend to degrade or reduce the tolerance of the color purity in the CRT. It may be desirable to neutralize the horizontal component H_h of the earth's magnetic field when directional angle δ changes.

In a magnetic field compensator of a television apparatus embodying an aspect of the invention, a fluxgate magnetometer is used for generating first and second magnetic field sensing signals representative of corresponding magnetic field components of horizontal component H_h of the earth's magnetic field. The sensing signals are applied to a pair of substantially planar coils disposed in a nonparallel, side-by-side vertical direction arrangement fitted on the periphery of the CRT. The sensing signals are used for generating corresponding currents in the coils that compensate or neutralize the effect of the horizontal component H_h of the earth's



magnetic field on the electron beam inside the CRT. Whenever the position of the receiver is changed, rotationally or geographically, the currents in the coils are automatically adjusted to compensate for the effect of the horizontal component H_h of the earth's magnetic field.

Thus, neutralization is obtained by directly interacting and sensing the horizontal component H_h of the earth's magnetic field by means of the transducing magnetometer. The magnetometer generates the sense signals in a manner that is independently derived from the generation of the electron beam in CRT 10. The sense signals are independent of and unaffected by the beam landing position on the CRT screen. In contrast, in one prior art compensator, an optical output produced on the CRT screen by the electron beam is utilized for sensing the effect of the earth's magnetic field on the electron beam and for generating a neutralizing magnetic field in accordance with the direct effect of the earth's magnetic field on the electron beam landing position. Such prior art arrangement, disadvantageously, requires a complicated optical interface with the CRT screen for monitoring the electron beam landing position on the CRT screen, and a complicated signal processing arrangement that may be costly.

In accordance with another aspect of the invention, an apparatus for neutralizing a first magnetic field that undesirably affects electron beam landing in a video apparatus includes an arrangement responsive to the first magnetic field for generating a first sense signal that is indicative of a magnitude of the first magnetic field. A first current that is determined in accordance with the first magnetic field is generated. A first magnetic field neutralizing coil coupled to conduct the first current produces the neutralizing second magnetic field. The second magnetic field is of a magnitude that is in accordance with the magnitude of the first magnetic field. The second magnetic field automatically changes to



maintain neutralization of the first magnetic field when a change in position of the video apparatus occurs.

In the Drawing:

FIGURE 1 illustrates an arrangement, embodying an aspect of the invention, including a magnetometer and neutralizing coils, for neutralizing the effect of the horizontal component of the earth's magnetic field on an electron beam of a CRT, shown in FIGURES 2, 3 and 4a;

FIGURE 2 is a back view of the CRT that is to be magnetically neutralized;

FIGURE 3 is a sectional view of the CRT of FIGURE 2;

FIGURE 4a illustrates a perspective view of the CRT of FIGURE 2 fitted with a pair of magnetic field neutralizing coils;

FIGURE 4b illustrates the magnetometer of FIGURE 1;

FIGURE 4c illustrates a vectorial diagram representing horizontal magnetic field components useful for explaining magnetic field neutralization by the coils;

FIGURE 5 is a vectorial diagram representing the lines of force of the earth's magnetic field relative to an electron beam path of a CRT;

FIGURE 6a illustrates a fluxgate magnetometer of the arrangement of FIGURE 1; and

FIGURE 6b is a vectorial diagram useful for the explanation of the operation of the magnetometer.

FIGURE 1 illustrates a fluxgate magnetometer 61 and a current driver arrangement, embodying an aspect of the invention, of, for example, a television receiver, for generating currents i_{11} and i_{12} that are applied to magnetic field neutralizing coils 11 and 12, respectively. As described later on, coils 11 and 12 are fitted near CRT 10 of FIGURE 5 of the television receiver. Fluxgate magnetometer 61 of FIGURE 1 includes a drive winding 100 and a pair of sensing windings 100_U and 100_V , having axes U and V, respectively, that are, for example, perpendicular. The windings are constructed in the manner shown in FIGURE



6a. Similar symbols and numerals in FIGURES 1, 5 and 6a and 6b illustrate similar items or functions. Coils 11 and 12 of FIGURE 1 produce magnetic fields that are applied to the electron beam path of CRT 10 of FIGURE 5 for neutralizing the horizontal component of the earth's field, as described later on.

A saturable toroidal core 150 of magnetometer 61 of FIGURE 6a, on which windings 100_v and 100_u are wound, is alternately saturated and unsaturated. This is accomplished by winding core 150 with toroidal drive winding 100, which is excited by an approximately square wave current i_{in} of FIGURE 1. Square wave current i_{in} , alternating from a positive value to a zero value at a frequency of, for example, 50 kHz, is applied to input terminals 100a and 100b of drive winding 100. During transition times of current i_{in} , toroidal core 150 of FIGURE 6a is unsaturated. Between transition times when current i_{in} is flowing, the core is saturated.

Toroidal core 150 and toroidal drive winding 100, confine the magnetic field produced by drive winding 100 to circular core 150 itself, so that, by itself, the circular magnetic field, that is produced as a result of current i_{in} , induces a voltage of only a negligible amplitude into sensing windings 100_v and 100_u . The geometric symmetry of the toroidal core permits the use of more than one sensing winding on a single saturating core. The successful use of more than one sensing winding on a single core is contingent upon the selection of a core exhibiting uniform magnetic properties and cross-sectional area around its circumference.

When core 150 of FIGURE 6a becomes unsaturated, during transitions of current i_{in} of FIGURE 1, the permeability of core 150 of FIGURE 6a becomes high. Therefore, the core material acts as a low impedance path to lines of magnetic flux in the surrounding environment, formed by horizontal component H_h of the earth's magnetic field. When the core material is saturated, and its permeability is low, it no longer presents a low impedance



path for external lines of flux, and they return to their original paths. Each time the core passes from the saturated state to the unsaturated state, the surrounding flux lines are drawn into it, cutting the winding turns of sensing windings 100_U and 100_V surrounding the core and inducing a voltage pulse S_U in sensing winding 100_U , and a voltage pulse S_V in sense winding 100_V . Each time the core passes from the unsaturated to the saturated state, the flux lines caused by horizontal component H_h of the earth's magnetic field are driven out of the core, generating a pulse of equal amplitude, but of opposite polarity.

Pulses S_V of FIGURE 1 are applied to an input terminal of an amplifier U1A through a resistor R6. A half-wave, phase-sensitive demodulator of pulses S_V is implemented with an analog switch arrangement IC1, operating synchronously with current i_{in} for shorting out the signal at the input terminal of amplifier U1A that is produced by sensing winding 100_V during the occurrence of alternate pulses of pulses S_V . Such alternate pulses occur when core 150 of FIGURE 6a goes out of saturation. The other alternate pulses of pulses S_V of FIGURE 1, occurring when core 150 of FIGURE 6a goes into saturation, are applied to the input terminal of amplifier U1A of FIGURE 1 to form a demodulated portion of signal S_V . The demodulated portion of signal S_V is voltage amplified in amplifier U1A, low pass filtered by a capacitor C6 and applied via a variable voltage divider that includes a resistor R15 to an input terminal of a voltage amplifier U1B having a power stage 60 that includes transistors Q1 and Q2.

In accordance with an aspect of the invention, an output voltage V_{out} of output stage 60, that is indicative of that portion of horizontal component H_h of the earth's magnetic field of FIGURE 6b, which cuts across sensing winding 100_V , is applied via a resistor R_V to neutralizing coil 11 of FIGURE 1. Variable resistor R15 is used for adjusting the level of current i_{11} . In a similar manner current i_{12} , that is adjustable by adjusting a resistor R24, is generated from pulses S_U and flows in coil explained later on, neutralizing coils 11 and 12

corresponding magnetic fields that automatically neutralize the horizontal component H_h of the earth's magnetic field at any directional angle δ between the electron beam axis Z of CRT 10 of FIGURE 5 and the magnetic north.

5 Assume that pulses S_V and S_U of FIGURE 1, that are used for generating currents i_{11} and i_{12} , respectively, are unaffected by the magnetic fields that are produced by coils 11 and 12 of FIGURE 1. Such assumption is justified when the fluxgate magnetometer is located inside the
10 television receiver cabinet, not shown in the FIGURES, but sufficiently far from coils 11 and 12.

As shown in the vectorial diagram of FIGURE 6b, horizontal component H_h has a direction that forms corresponding angles with axes U and V, respectively.
15 Consequently, horizontal component H_h may be vectorially separated into a first component H_U having a direction that is coaxial with axis U and a second component H_V having a direction that is coaxial with axis V and that is perpendicular to axis U.

20 At any directional angle δ of CRT 10 of FIGURE 5, the amplitude of pulses S_V , for example, produced between terminals 100e and 100d of sensing winding 100_V of FIGURE 1 is linearly proportional to the intensity of the surrounding magnetic field component H_V which lies parallel
25 to the axis V of sensing winding 100_V of FIGURE 6a. The amplitude of pulses S_V of FIGURE 1 is unaffected by component H_U of horizontal component H_h of FIGURE 6b that is perpendicular to axis V. The polarity of pulses S_V of FIGURE 1 depends upon the vectorial direction of component
30 H_V with respect to sensing winding 100_V of FIGURE 6a that, in turn, is determined by directional angle δ of FIGURE 5. The polarity and amplitude relationship between pulses S_U of sensing winding 100_U and field component H_U is analogous to that between pulses S_V and field component H_V .

35 The ratio between the amplitude of pulses S_V and the magnitude of the corresponding component H_V is unaffected by the directional angle δ of CRT 10 of FIGURE 5. Similarly, the ratio between the magnitude of pulses S_U



of FIGURE 1 and that of component H_U of FIGURE 6b is unaffected by angle δ . In this way, pulses S_V and S_U are representative of components H_V and H_U , respectively.

Because current i_{11} of FIGURE 1 is linearly
5 proportional to pulses S_V , it is also linearly proportional to component H_V of FIGURE 6b and is unaffected by component H_U of the horizontal component H_h of the earth's magnetic field. Similarly, current i_{12} in coil 12 of FIGURE 1 is
10 linearly proportional to component H_U of FIGURE 6b but is unaffected by component H_V of the horizontal component H_h of the earth's magnetic field.

Each of FIGURES 2, 3 and 4a illustrates
neutralizing coils 11 and 12 of FIGURE 1, mentioned before, that are fitted on CRT 10. Coils 11 and 12 of FIGURE 1 are
15 used for producing a resultant neutralizing magnetic field that neutralizes the effect of horizontal component H_h of the earth's magnetic field on the electron beam in CRT 10. Similar symbols and numerals in FIGURES 1-6 indicate similar items or functions.

20 Neutralizing coils 11 and 12 of FIGURE 3 are fitted along the outer periphery of CRT 10 to spatially surround a magnetic shield 16 of FIGURE 3 received within a conical section 22 of CRT 10. Inner vertical portions 11b and 12b of neutralizing coils 11 and 12, respectively,
25 partly surround a neck section 17 of CRT 10 and intersect each other at vertically disposed two opposite points across neck section 17. Inner portions 11b and 12b are disposed between a rear end portion 16b of magnetic shield 16 and a forward end portion 27a of a deflection yoke
30 arrangement 27. Outer portions 11a and 12a of coils 11 and 12, respectively, are positioned near a shadow mask 16a, which is also part of magnetic shield 16, in parallel relationship with inner portions 11b and 12b, respectively. The number of turns in each coil may be such so as to
35 provide the required number of ampere-turns, such as, three, for example. It should be understood that deflection yoke arrangement 27 is not shown in FIGURE 4a so as to provide a better view of coils 11 and 12.



When CRT 10 of FIGURE 3 is placed relative to a horizontal plane in a position similar to its position in normal usage, portions 11a and 11b of coil 11 define a vertical plane having an axis V' of coil 11 that is perpendicular to such horizontal plane. The spatial orientation between coil 11 and winding 100_v of fluxgate magnetometer 61, shown in FIGURE 4b, is arranged such that the axis V of winding 100_v is close to being in parallel with the axis V' of coil 11 as shown in FIGURE 3. In a like manner, coil 12 defines a corresponding vertical plane having an axis U' of FIGURE 2 that is close to being in parallel with axis U of winding 100_u . Magnetometer 61 of FIGURE 4b is secured in a cabinet of the television receiver, not shown in the Figures, behind the back portion of CRT 10 of, for example, FIGURE 4a. The orientation of axes U and V of magnetometer 61 relative to CRT 10 is shown in FIGURE 3. Axes U and V are disposed approximately symmetrically relative to axis Z of CRT 10.

Current i_{11} , flowing in the winding turns of coil 11 of FIGURES 3 or 4a, produces a linearly proportional neutralizing magnetic field shown in the vectorial diagram H_{11} of FIGURE 4c outside magnetic shield 16 of CRT 10 of FIGURE 3 in a volume that includes magnetic shield 16 and the electron beam path of CRT 10.

Assume that neutralizing magnetic field H_{11} , shown by the vectorial diagram of FIGURE 4c, is uniform, perpendicular to axis U and coaxial with axis V of winding 100_v . Similarly, assume that current i_{12} , flowing in coil 12, produces a neutralizing magnetic field H_{12} of FIGURE 4c that is uniform, perpendicular to axis V and coaxial with axis U . It should be understood that the above mentioned assumptions represent only an approximation that is used for simplifying the explanation.

The magnitude and polarity of current i_{11} of FIGURE 1 may be manually adjusted by varying resistor R_{15} so as to produce magnetic field H_{11} of FIGURE 4c at the opposite direction and at the same magnitude of component H_v . Thus, magnetic field H_{11} neutralizes component H_v or



reduces the effect of component H_v of horizontal component H_h of the earth's magnetic field on the electron beam of CRT 10. Such adjustment of current i_{11} of FIGURE 1 is made in a given geographical location such as, for example, at the factory and at a given direction angle δ of CRT 10 of FIGURE 5. Similarly, current i_{12} of FIGURE 1 is manually adjusted so as to produce magnetic field H_{12} that neutralizes component H_u . By neutralizing components H_v and H_u , horizontal component H_h of the earth's magnetic field is neutralized.

Current i_{11} that produces magnetic field H_{11} of FIGURES 4c is linearly proportional to component H_v , as described before. Magnetic field H_{11} is linearly proportional to component H_v , is in a direction that opposes that of component H_v and is unaffected by component H_u . The above mentioned relationship between magnetic field H_{11} and component H_v is maintained at any directional angle δ of CRT 10 of FIGURE 5. A similar, corresponding relationship between magnetic field H_{12} of FIGURE 4c and component H_u is also maintained at any angle δ .

Consequently, in accordance with a feature of the invention, once currents i_{11} and i_{12} of FIGURE 1 are adjusted in the manner described before, neutralization of horizontal component H_h of the earth's magnetic field is maintained automatically, that is without manual or operator intervention, at any other directional angle δ of CRT 10 and at any other geographical location.

It should be understood that even though the assumptions made before represent only an approximation, a sufficient cancellation or neutralization of the horizontal component H_h of the earth's magnetic field is obtained at any angle δ of CRT 10 of FIGURE 5.



WHAT IS CLAIMED IS:

1. An apparatus for neutralizing a first magnetic field component to prevent said first magnetic field component from undesirably affecting electron beam landing in a cathode ray tube of a video apparatus, characterized by:

a first sensing winding (100_U) responsive to said first magnetic field component (H_U) for generating a first sense signal (S_U) that is indicative of a magnitude of said first magnetic field component (H_U) and that varies when said first magnetic field component varies;

means ($U2A, U2B$) responsive to said first sense signal (S_U) for generating a first current (i_{12}) that is determined in accordance with said first magnetic field component (H_U); and

a first magnetic field neutralizing coil (12)⁶ coupled to said first current generating means ($U2A, U2B$) for producing a neutralizing second magnetic field (H_{12}) in said video apparatus at a magnitude that varies in accordance with said magnitude of said first magnetic field component (H_U) such that said second magnetic field (H_{12}) automatically neutralizes said first magnetic field component (H_U) when a change in a position of said cathode ray tube (10) occurs.

2. An apparatus according to Claim 1 characterized in that said first sensing winding (100_U)⁷ comprises a sense winding of a fluxgate magnetometer (61).

3. An apparatus according to Claim 1 characterized by a second magnetic field neutralizing coil (11) for producing a neutralizing third magnetic field (H_{11}) such that said second (H_{12}) and third (H_{11}) magnetic fields neutralize the effect of corresponding field components (H_U, H_V) of the horizontal component (H_h) of the earth's magnetic field on an electron beam in said cathode ray tube (10).

4. An apparatus according to Claim 3 characterized in that said first (12) and second (11) neutralizing coils comprise substantially planar coils.





disposed in corresponding nonparallel vertical planes when said cathode ray tube (10) is placed in a normal usage position.

5. An apparatus according to Claim 4 characterized in that said neutralizing coils (12,11) are arranged symmetrically in proximate relation to a flared envelope portion (22) of said cathode ray tube (10).

6. An apparatus according to Claim 1 characterized by a second magnetic field neutralizing coil (11) having an axis that is disposed in a nonparallel manner with an axis of said first magnetic field neutralizing coil (12) and a second sensing winding (100_V) having an axis that is disposed in a nonparallel manner relative to an axis of said first sensing winding (100_U) such that said axes of said neutralizing coils (12,11) are oriented in a predetermined manner relative to said axes of said sensing windings ($100_U, 100_V$) for producing a second sense signal (S_V) in said second sensing winding (100_V), wherein said second sense signal (S_V) is applied to said second coil (11) for producing in accordance therewith a neutralizing third magnetic field (H_{11}) in said second neutralizing coil (11).

7. An apparatus according to Claim 6 characterized in that said first sensing winding (100_U) has an axis that is disposed approximately in the same direction as an axis of said first neutralizing coil (12) and wherein an axis of said second sensing winding (100_V) is disposed approximately in the same direction as an axis of said second neutralizing coil (11).

8. An apparatus according to Claim 6 characterized in that the axes of said sensing windings ($100_U, 100_V$) are substantially perpendicular.

9. An apparatus according to Claim 1 characterized by a second magnetic field neutralizing coil (11), said first (12) and second (11) substantially planar neutralizing coils disposed in corresponding vertical planes, when said cathode ray tube is placed in a normal usage position, and are arranged symmetrically in proximate





relation to a flared envelope portion (22) of a cathode ray tube (10) so as to produce, in response to currents (i_{12}, i_{11}) flowing in said coils (12,11), corresponding magnetic fields (H_{12}, H_{11}) in counteracting relation to corresponding magnetic field components (H_U, H_V) of the horizontal component of the earth's magnetic field (H_h) and means responsive to said sense signals (S_U, S_V) for supplying said currents (i_{12}, i_{11}) to said coils (12,11) such that said magnetic fields (H_{12}, H_{11}) produced by said coils (12,11) substantially compensate for said magnetic field components (H_U, H_V) of the horizontal component (H_h) of the earth's magnetic field.

10. An apparatus for neutralizing an undesirable effect of the earth's magnetic field on an electron beam in a cathode ray tube, characterized by:

a transducer (61), directly interacting with the earth's magnetic field, for generating a first sense signal (S_U) independently of the position of said electron beam and unaffected thereby, said first sense signal (S_U) being indicative of a magnetic field component (H_U) produced by the earth's magnetic field;

means (U2A,U2B) responsive to said first sense signal (S_U) for generating a first current (i_{12}) in accordance with said magnetic field component; and

a first magnetic field neutralizing coil (12) fitted adjacent said cathode ray tube (10) and coupled to said first current generating means (U2A,U2B) for conducting said first current (i_{12}) to produce, in a path of said electron beam, a neutralizing second magnetic field (H_{12}) that varies in accordance with said first sense signal (S_U) such that said neutralizing second magnetic field (H_{12}) automatically neutralizes said magnetic field component when a change in a position of said cathode ray tube (10) occurs.

