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ELECTRON BEAM FOCUSING CIRCUIT

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2 Sheets-Sheet 1

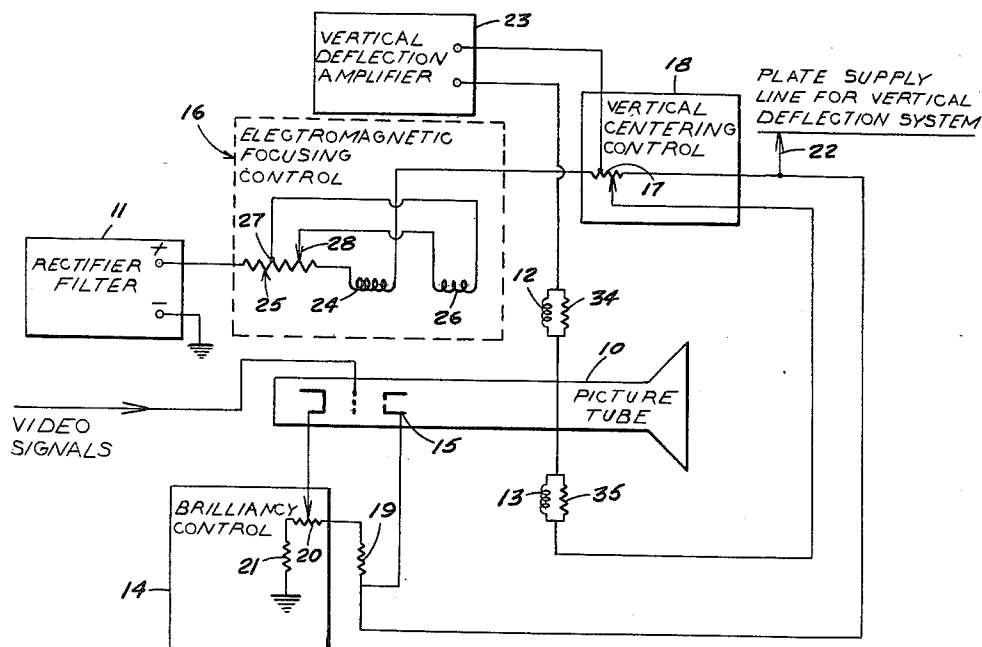


Fig. 1

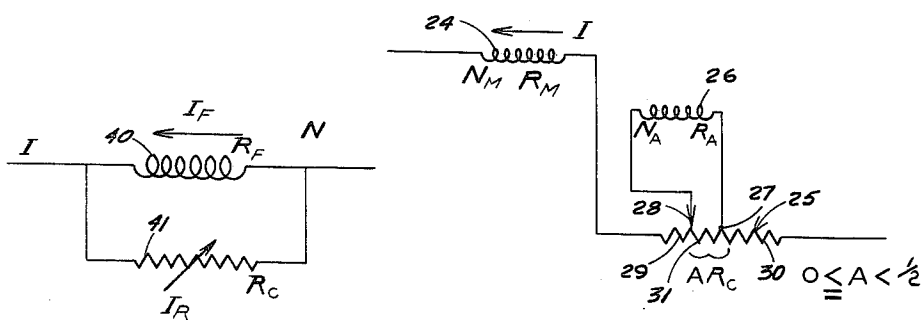


Fig. 2

Fig. 3

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2 Sheets-Sheet 2

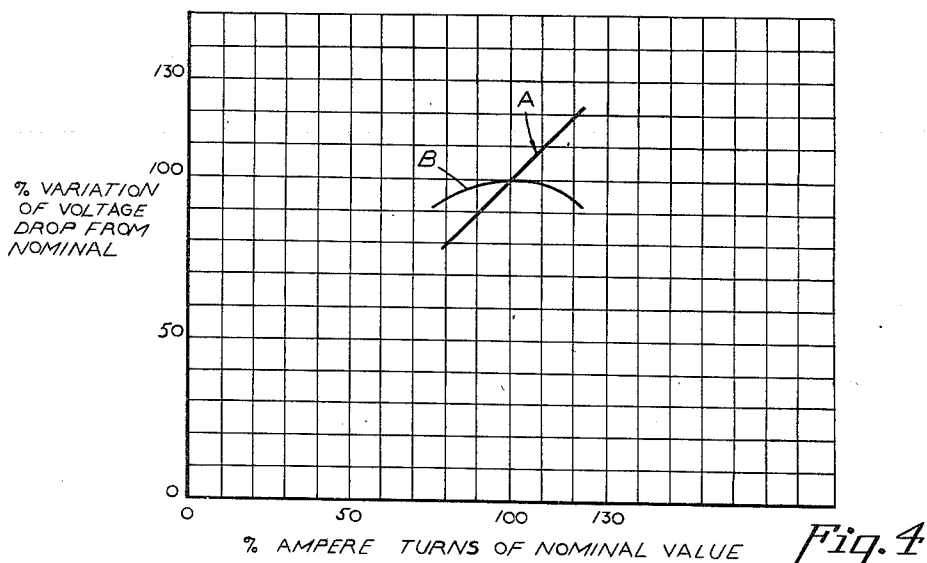


Fig. 4

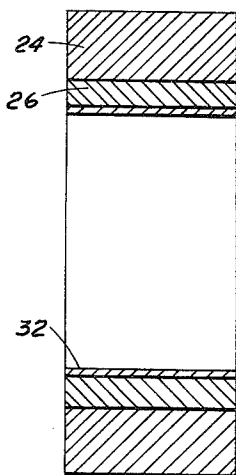


Fig. 6

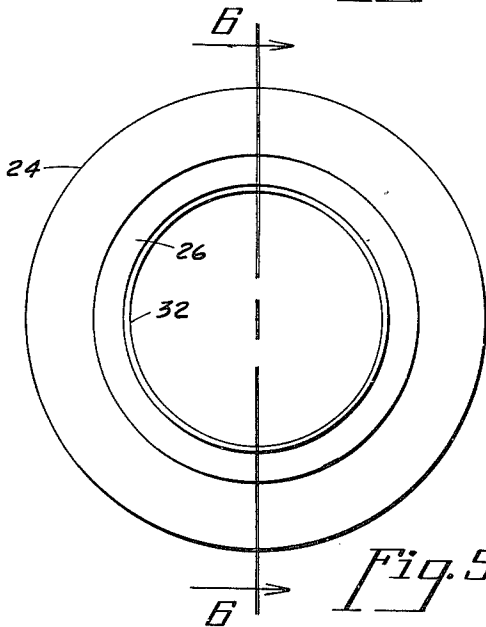


Fig. 5

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ELECTRON BEAM FOCUSING CIRCUIT

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8 Claims. (Cl. 315—31)

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The present invention relates to an improved circuit and method for electromagnetic focusing of cathode-ray tube beams.

The basic object of the invention is to provide, for association with an electronic-beam tube, a system of electromagnetic focusing coils having such circuit arrangement and operation that a wide range of magnetostatic field intensities may be produced thereby but at the same time the resultant voltage variations across the system are reduced to a minimum.

Another object of the invention is to provide an electromagnetic focusing circuit which affords a considerable range of control and which has such voltage drop characteristics that it minimizes interference with power supply regulation and undesired voltage variations in other circuits deriving their potentials from the same source, such as the cathode-ray tube anode circuit, the brilliancy control circuit, and the centering circuits, for example.

Still another object of the invention is to provide an electromagnetic focusing circuit wherein the alternating current impedance of the focusing coil and its associated control elements is substantially higher than the direct current resistance, thus providing a convenient and effective series filter element at no extra cost.

Reference is made to Fig. 1 of the drawings in stating the very troublesome problem which the present invention successfully solves. In Fig. 1 there is illustrated a picture tube 10 and some of its associated control circuits, as embodied in a television receiver. It will be noted that the rectifier-filter unit 11 is the source of potentials for the centering control 18 of the vertical deflection coils 12 and 13, the brilliancy control unit 14 and the picture-tube first anode 15. According to the prior art, the conventional focusing control may comprise a parallel combination of inductor and variable resistor, as illustrated in Fig. 2. When such a combination is used for focusing control in series with and preceding other circuits, those skilled in the art will readily perceive that variations in the voltage drop across the parallel combination will cause variations in the potentials available for portion 17 of the potentiometer included in the vertical centering control unit 18 and for the series combination of resistors 19, 20 and 21 from which the brilliancy control and anode bias potentials are obtained. Additionally, the same potential source may be used to supply plate voltages for the vertical deflection system as indicated by the line 22. Manifestly, wide variations in the voltage drop across the focusing control circuit will cause undesired variations in the potentials available at the vertical centering control, the brilliancy control and any other circuits (such as the horizontal or vertical deflecting circuits) deriving their potential

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from such a system including a common voltage source 11. It is highly desirable to provide a circuit which will effect a wide range of magnetic intensities in the magnetostatic focusing field but which will at the same time have a relatively narrow range of voltage drop variations. The present invention provides an arrangement whereby, notwithstanding the great latitude of focusing control which it affords, voltage drop variations across unit 16 are confined to very narrow limits.

Briefly described, the invention comprises a circuit for producing a focusing field having a wide range of intensities. This circuit includes a pair of coils so arranged that there is a relatively small variation of voltage drop in comparison with the variation in ampere-turns. For a better understanding of the present invention, together with other and further advantages, objects and capabilities thereof, reference is made to the accompanying drawings in which there is illustrated a picture tube system suitable for use with a television receiver including an illustrative form of electromagnetic focusing control circuit in accordance with the invention.

In the drawings, Fig. 1 symbolically represents a picture tube and certain of its associated circuits having a common power supply, showing their relationship to the novel electromagnetic focusing control provided in accordance with the present invention; Fig. 2 represents a typical prior art focusing control; Fig. 3 symbolically represents a preferred form of focusing control circuit in accordance with the invention; Fig. 4 comprises a set of curves providing a basis for comparing the performance of the novel control circuit with that of a conventional prior art circuit; and Figs. 5 and 6 are, respectively, elevational sectional (as taken on line 5—5 of Fig. 6) and top plan views of a novel structure including main and auxiliary coils provided in accordance with the invention.

Referring now specifically to Fig. 1, there is illustrated a conventional picture tube 10 which is provided with the usual cathode, video signal grid, first anode 15 and vertical electromagnetic deflecting coils 12 and 13. Since the video circuits, the horizontal deflection oscillator and associated circuits, the horizontal centering control circuit and the horizontal deflection system are per se conventional and need not be shown in order to disclose and to impart an understanding of the circuit arrangement, operation and significance of the present invention, such circuits are herein omitted.

In accordance with the conventional practice, a vertical deflection amplifier 23 causes saw-tooth cathode-ray beam-deflecting currents to flow in coils 12, 13 and the beam is deflected to provide the required fields and frames. Vertical center-

ing is effected by potentials due to direct current flow in the resistance 17 of the potentiometer included in unit 18. Rectifier-filter unit 11 is the source of the various potentials required in the portions of the system illustrated. Its positive terminal is connected to the novel electromagnetic focusing control unit 16. The remaining terminal of the focusing control unit is electrically serially related to potentiometer 17 and to the series combination of resistors 19, 20 and 21. In accordance with the conventional practice, the high potential side of resistor 19 is connected to the anode 15 to provide a high positive bias therefor and a sliding contact on resistor 20 is connected to the cathode to impart thereto a positive bias which may be adjusted at the will of the operator to control the brilliancy or intensity of the electron beam. It will readily be seen that although a wide range of focusing control is desired the voltage drop across unit 16 should be confined to as narrow a range as is practicable, in order that the operation of the vertical centering control 18, the brilliancy control 14 and the anode 15 and the voltage regulation of the power supply system not be impaired. It will also be seen that when line 22 is employed to supply bias potentials to the plates of the various tubes in the vertical deflection system this objective becomes even more important.

In accomplishing this objective, there are provided a first inductor 24, a resistor 25 in series with that first inductor, a second inductor 26 having one terminal 27 permanently conductively connected to a fixed tap on the resistor 25 and another terminal 28 provided with means (indicated by the arrow in Fig. 3) adjustably conductively contacting the resistor 25 on either side of that tap (left side shown). The series combination shown in Fig. 3 comprises two sub-combinations. One sub-combination includes inductor 24 and portions 29 and 30 of resistor 25. The other sub-combination comprises the second inductor 26 shunted by the remaining portion 31 of resistor 25 between the tap 27 and the terminal 28. It will be readily apparent to those skilled in the art that if the two coils 24 and 26 produce aiding magnetic fields in tube 10 when the variable contact 28 is in contact with the resistor body in one side of the fixed tap 27 then opposing magnetic fields will be produced if the resistor body is contacted at the other side of the fixed tap 27.

For an understanding of the results achieved by the present invention, reference is made to Figs. 2 and 3 so that the operation of the novel circuit may be contrasted to that of the typical prior art circuit. In the conventional circuit shown in Fig. 2 the electromagnetic focusing field is varied by adjusting the variable resistor 41 and changing the current I_F through the focusing coil 40. If the line current through the Fig. 2 circuit is I , then the portion passing through inductor 40 may be calculated as follows:

Let I_F equal the current in the inductor 40, I_R the current flowing in the resistor 41, R_F the resistance of the inductor 40, and R_C the resistance of resistor 41. The parallel resistance of R_F and R_C is equal to

$$\frac{R_F R_C}{R_F + R_C}$$

and the voltage drop across this combination is equal to

$$I_x \left(\frac{R_F R_C}{R_F + R_C} \right)$$

Consequently, the current through the focusing coil 40 is

$$\frac{I R_C}{R_F + R_C}$$

and the ampere-turns provided by the focusing coil are

$$\frac{N I R_C}{R_F + R_C}$$

If it be assumed for purposes of discussion that the current I is independent of the setting of R_C , then it becomes evident that the voltage drop across the combination and also the ampere-turns are directly proportional and may be illustrated by curve A of Fig. 4. Curve A is a characteristic curve empirically derived by plotting ampere-turns as abscissae against voltage drops as ordinates. This characteristic is rising and indicates that in prior art circuits of the character illustrated in Fig. 2 a wide variation in field intensities is accompanied by a correspondingly wide variation in voltage drops across the focusing control circuit. The disadvantages and limitations attendant upon this wide variation in voltage drop are pointed out hereinabove. The above results are working approximations, but they suffice to show the highly undesirable variation and voltage drop which workers in this art have persistently endeavored to overcome, and the effectiveness of the invention in providing a remedy.

The novel circuit which the invention provides is illustrated in Figs. 1 and 3. It is immediately apparent that this circuit has an outstanding advantage in that the voltage drop across unit 16 will be the same (if terminal 27 at a center tap on resistor 25) whenever adjustably positioned contact 28 is at either of its extreme positions on resistor 25. Assuming as before that the line current I remains constant, then the voltage drop across the combination illustrated in Fig. 3 is directly proportional to its resistance, which may be determined as follows:

$$R_M + (1-A)R_C + \frac{A R_C R_A}{A R_C + R_A}$$

Where A has a value between zero and $\frac{1}{2}$, where R_M is the resistance of resistor 24, R_C is the resistance of resistor 25, R_A is the resistance of inductor 26, and $A R_C$ is equal to the resistance of that portion of resistor 25 which is between terminals 27 and 28.

It is evident that by choosing various values of A corresponding values of impedance and ampere-turns may be calculated and plotted, as indicated by the characteristic curve illustrated at B in Fig. 4. It will be observed that the Fig. 3 circuit has a non-linear and relatively level characteristic of ampere-turns plotted as abscissae against voltage drop as ordinates. A comparison of curves A and B indicates that the undesired voltage drop variation has been reduced by the invention to a magnitude less than one-fourth of that which characterized the prior art circuit.

In order to obtain so signal a result, it is preferable that the auxiliary winding 26 be placed adjacent the neck of the tube 10 so that the resistance per turn of inductor 26 (the factor R_A) may be reduced to a minimum. The novel simple mechanical structure illustrated in Fig. 5 therefore functions as a useful sub-combination in attaining a new and surprising result. The structure there shown comprises a circular coil form 32, adapted to be slipped in concentric relation over the neck of tube 10, an auxiliary inductor

26 and a main inductor 24, the auxiliary inductor being radially disposed between the coil form 32 and the main inductor 24. In one successful commercial embodiment of the present invention, the following parameters were found suitable:

Element	Parameters
26-----	700 turns, #25 enamel random wound, resistance 14 ohms, the completed coil being wrapped with varnished tape to secure the leads and to insulate for 1000 volts.
32-----	Paper, varnished, impregnated, insulated for 1000 volts.
24-----	1350 turns, #25 enamel random wound, resistance 36 ohms, insulated in the same manner as coil 26.
25-----	20 ohms.
19-----	82,000 ohms.
20-----	50,000 ohms.
21-----	33,000 ohms.
10-----	10 FP4.
34-----	1000 ohms.
35-----	1000 ohms.
Unit 11-----	360 volts, 300 milliamperes.

A comparison of Fig. 2 and Fig. 3 will disclose that in the conventional circuit as shown in Fig. 2 the resistance R_c will be of the same order of magnitude as the resistance R_r of the coil 40 and that the impedance of the combination will be limited by the value of R_c . No such limitation is evident in the circuit according to the invention where the large coil 24 never is shunted by a resistance. In consequence, the A. C. impedance of the focusing circuit as disclosed is therefore substantially higher and better filter action may be achieved, when the focusing circuit is used as a series element in the power supply filter.

While there has been shown and described what is at present considered to be the preferred form of focusing circuit in accordance with the invention, it will be obvious to those skilled in the art that various modifications and substitutions of equivalents may be made therein without departing from the true scope of the invention, and it is accordingly intended in the appended claims to cover all such changes and variations as fall within the true scope of the invention and without the proper scope of the prior art. Such construction of the claims is desired as will best protect the true invention.

Having thus described my invention, I claim:

1. A circuit for producing in an electronic-beam tube a magneto-static focusing field having a wide range of controlled intensities, said circuit having a relatively level characteristic of ampere-turns as abscissae plotted against voltage drops as ordinates comprising: a first magnetic field winding, a resistor in series with said first winding, a second magnetic field winding having one terminal permanently conductively connected to a tap on said resistor and another terminal provided with adjustable control means conductively contacting said resistor on either side of said tap, the series combination of the sub-combination of said first winding and a portion of said resistor and the parallel sub-combination of said second winding and the remaining portion of said resistor between said tap and said other terminal being adapted to be coupled to a source of electrical energy, whereby said windings produce aiding magnetic fields when said other terminal is connected to one side of said tap and opposing magnetic fields when said other terminal is connected to the other side of said tap.

2. A circuit for producing a magnetic field having a wide range of intensity, said circuit having a non-linear characteristic of ampere-turns plotted against voltage drop comprising: a first

magnetic field winding, an impedance in series with said first winding, a second magnetic field winding having a terminal connected to a tap on said impedance and an adjustably positioned terminal conductively contacting said resistor on one side of said tap, the series combination of the sub-combination of said first winding and a portion of said impedance and the parallel sub-combination of said second winding and the remaining portion of said impedance between said terminals being adapted to be coupled to a source of electrical energy, whereby said windings produce aiding magnetic fields when said adjustably positioned terminal is positioned on one side of said tap and opposing magnetic fields when said adjustably positioned terminal is positioned on the other side of said tap.

3. In combination, an electron-beam tube having a neck, a pair of concentric magnetic field windings, one of said windings being annularly disposed around said neck and the other of said windings being annularly disposed around said first winding, a tapped potentiometer in electrical series with said other winding, one terminal of said first winding being connected to the tap on said potentiometer, and the other terminal of said first winding being adjustable for conductive contact with any desired point on said potentiometer.

4. In an electromagnetic focusing circuit for use in conjunction with an electron-beam tube the combination of a pair of magnetic field windings and tapped potentiometer means for encircling one of said windings with either polarity relative to the other of said inductors.

5. In combination, a cathode-ray tube, an electrical energy source and an electromagnetic focusing circuit comprising a pair of windings and tapped potentiometer means for reversing the direction of current flow in one of said windings whereby to produce either aiding or opposing magnetic focusing fields in said tube, both of said windings being in series circuit with said source and one of said windings being in parallel with a part of said potentiometer.

6. In combination, a pair of electron-beam focusing coils, and adjustable means, comprising a resistance parameter effectively in series with one of said coils and slidably adjustable conductive polarity reversing means coupling the other of said coils to a part of said resistance parameter, for so coupling said coils that the magnetic effects can be varied at will through a range of aid and a range of opposition.

7. In combination, a pair of electron-beam focusing coils and means including an impedance in series with one of said coils and having a variable portion in parallel with the other of said coils for reducing over-all voltage-drop variations as the net intensity of the magnetic field produced by said coils is varied.

8. The combination according to claim 7 wherein said impedance is a potentiometer having a tap and an adjustably positioned contact coupled to said other coil.

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The following references are of record in the file of this patent:

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