Jan. 5, 1954 C. V. BOCCIARELLI 2,665,393

DEFLECTING AND HIGH VOLTAGE SUPPLY CIRCUIT

Filed Sept. 6, 1950 2 Sheets-Sheet 1

FIG. 5.

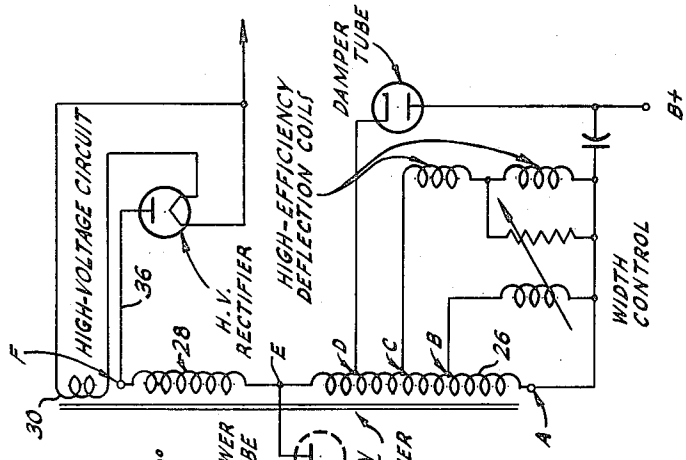


FIG. 2.

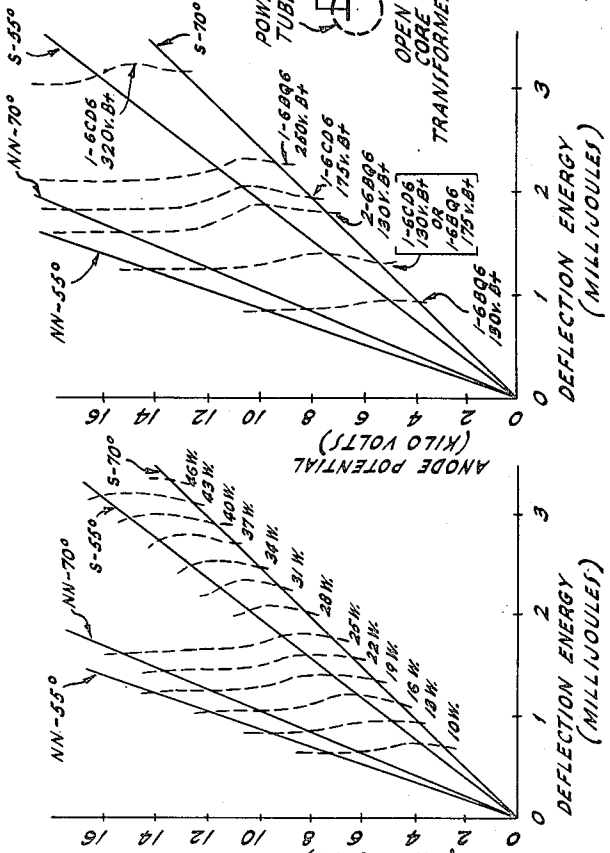


FIG. 1.

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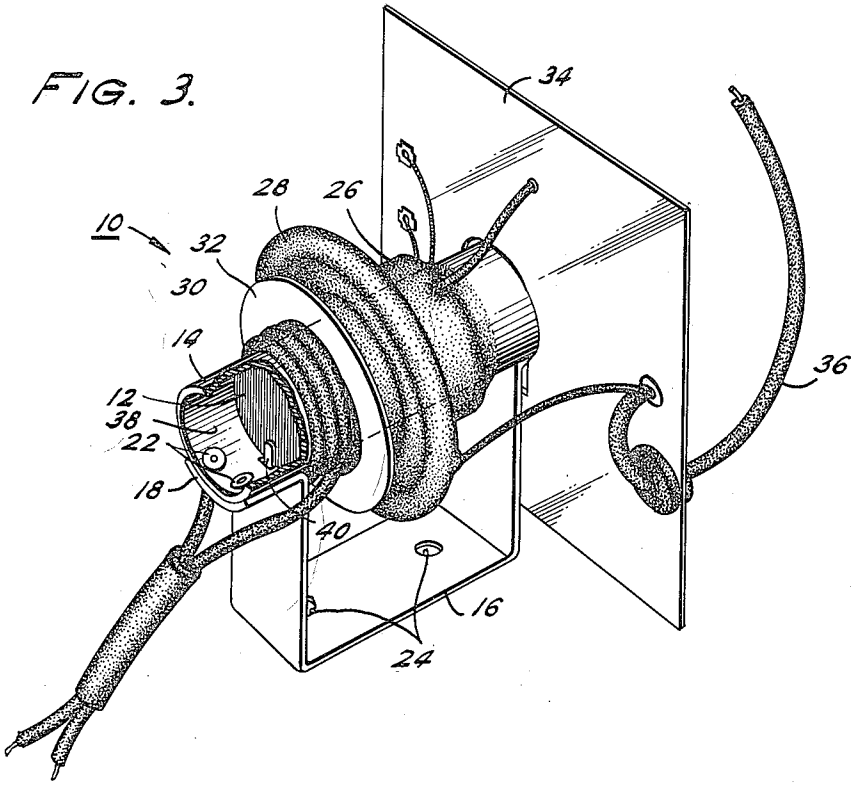
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2 Sheets-Sheet 2

FIG. 3.



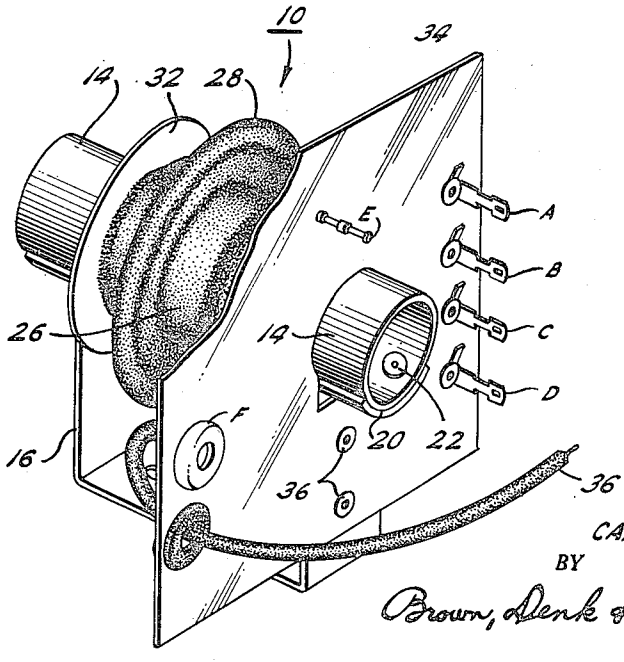


FIG. 4.

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UNITED STATES PATENT OFFICE

2,665,393

DEFLECTING AND HIGH VOLTAGE SUPPLY CIRCUIT

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Application September 6, 1950, Serial No. 183,395

6 Claims. (Cl. 315—27)

1

This invention relates to combination deflecting and high-voltage supply circuits for use with cathode-ray tubes.

It has been customary for some time, in television and other cathode-ray tube systems, to provide circuits in which a portion of the energy from a source which supplies the signal for deflecting the electron beam of a cathode-ray tube is rectified to provide a high D.-C. potential suitable for supplying the second anode of the cathode-ray tube. In such arrangements according to the prior art, the fraction of the total energy supplied by the deflecting signal source, which was required by the high-potential rectifying circuit, was invariably a relatively small fraction (e. g. 10%). This was largely due to the fact that the deflecting yokes commonly used in such circuits were of relatively low efficiency.

In such circuits it was customary to employ a conventional closed-core transformer for transferring energy from the deflecting signal source to both the deflecting yoke and the high-voltage rectifying circuit. Such a transformer functioned initially to transfer substantially all of the energy from the deflecting signal source to the deflecting yoke. During the return of the cathode-ray beam from the end of one line to the beginning of the next, a relatively small portion of this energy, which was stored in the field surrounding the deflecting yoke, was returned through the transformer to the high-voltage rectifying circuit.

Recently there have been developed deflecting yokes of much higher efficiency, such, for example, as the one described and claimed in my copending application Serial No. 164,465, filed May 26, 1950, in which the windings of the yoke are disposed at all points in close proximity to the path of the electron beam so as to exert the maximum force tending to deflect the beam at all points along its path, whereby the maximum possible deflection of the beam is effected in response to a minimum of deflecting energy.

When such a high efficiency yoke is employed in a combination deflecting and high-voltage supply circuit of the sort above referred to, the fraction of the total energy supplied by the deflecting signal source which goes to the high-voltage rectifying circuit is substantially increased (e. g. to as much as 30%) by reason of the reduction in the energy requirements of the deflecting yoke. It was found in practice however, that the advantages of increased efficiency of such yokes could not be realized in a combination deflecting and high-voltage circuit constructed in accordance with the prior art. Further it appeared that such an arrangement tended to provide too high a deflecting current in the yoke, while at the same time developing an insufficiently high potential for second anode supply purposes. Upon investigation of this situation it appeared that the difficulty lay in the conventional form of transformer, which, while it operated efficiently to transfer energy from the deflecting signal source to the deflecting yoke, failed to permit the supply of a sufficient fraction of the deflecting energy to the high-voltage rectifying circuit. Thus if this transformer were designed to supply the right amount of power to the deflecting yoke, then an insufficient amount of power would be supplied to the high-voltage rectifying circuit, while, on the other hand, if it were designed to supply sufficient power to the high-voltage rectifying circuit, then an unnecessarily large amount of energy would be supplied to the deflecting yoke. Further it was noted that, since all of the energy from the deflecting signal source was initially supplied to the deflecting yoke and a portion of it later returned through the transformer to the high-voltage rectifying circuit, a substantial loss (e. g. as much as 20%) resulted from this unnecessary transfer of energy from the deflecting signal source to the deflecting yoke and then from the deflecting yoke back to the high-voltage rectifying circuit.

2

Accordingly it is the primary object of the invention to overcome the aforementioned difficulties and to provide a combined deflecting and high-voltage supply system for cathode-ray tubes, in which both a cathode-ray beam deflecting yoke and a high-voltage second anode supply circuit, whose energy requirements constitute a relatively large fraction of the total energy supplied to both said yoke and said high-voltage circuit, are energized from a common source of deflecting signal, and in which energy is supplied from said common source to said deflecting yoke and said high-voltage supply circuit in proportion to their respective requirements and with maximum efficiency.

I have discovered that this objective can be achieved by substituting, for the conventional closed-core type of transformer customarily employed in such circuits of the prior art, an open-core transformer having an air gap sufficiently large to cause a portion of the total energy supplied by the deflecting signal source to be stored in the field surrounding the transformer, said portion being substantially equal to the portion of the total supplied energy which is required by

high-potential rectifying circuit. When such arrangement is used, there is supplied from deflecting signal source to the deflecting yoke the open-core transformer only an amount energy sufficient to satisfy the requirements the deflecting yoke. The remainder of the rgy supplied by the deflecting signal source be momentarily stored in the field surnding the transformer and will subsequently ransferred to the high-voltage rectifying cir-. In contradistinction to the mode of operaof the prior art arrangement, the portion energy supplied from the deflecting signal rce to the high-voltage rectifying circuit is plied directly from the source to the rectifycircuit without an intermediate transfer to deflecting yoke and back again. Hence the es inherent in the prior art arrangement are inated and maximum efficiency is insured.

further feature of the arrangement in acdance with the present invention lies in the t that the open-core transformer employed rein not only provides for the proper disution of energy between the deflecting yoke l the high-voltage rectifying circuit to cause m to operate properly and to insure the ded overall high efficiency, but is also substanlly cheaper and more readily manufactured n the conventional closed-core type employed prior art arrangements.

Other objects and advantages will be apparent m the following description of a preferred m of the invention and from the drawings, which:

Figures 1 and 2 are graphs of anode potential sus deflection energy, showing the manner in ich these two factors vary for different types cathode-ray tubes and for different deflecn angles;

Figures 3 and 4 are perspective views of a prered type of coupling transformer for use in evision deflection and H.-V. circuits designed accordance with the present invention; and

Figure 5 is a schematic diagram of one form cathode-ray beam deflection circuit designed accordance with the present invention and nploying the transformer of Figs. 3 and 4.

In order to comprehend fully the advantages a deflection and high-voltage circuit of the ture set forth in the present disclosure, it is lpful to consider the manner in which the wer developed in a television deflection circuit utilized by different types of cathode-ray tubes. will be sufficient for the purpose of the present ustration to consider four cathode-ray tubes, ne of which is a standard, or conventional, tube ving a 55° deflection angle, the second of which a similar tube having a 70° deflection angle, ne third of which is a 55° narrow-neck tube signed in accordance with the principles set rth in applicant's copending case above-menoned, and the last of which is another narrowck tube with a 70° deflection angle.

Considering first the 55° standard tube, there shown in Figure 1 a curve of the energy which ay be supplied to this tube for deflection, versus ne high voltage, or anode potential, developed t any particular deflection energy value. It will e observed that the relationship takes the form f a straight line the lower portion of which within the anode potential region of approximately 8 to 10 kv.) corresponds to a domain here a standard 10" tube of this type might e operated. The above portion is followed, for igher anode voltages, by a similar one characteristic of a 12" tube, then one of a 16" tube, and so on. The linearity of the curve is primarily due to the fact that any increase in deflection current (for an equal deflection angle) is proportional to the square root of the anode potential, and hence the deflection energy (which may be expressed as $\frac{1}{2} Li^2$) is directly proportional to the high voltage. In practice, various circuit losses will cause the curve to depart slightly from a perfectly linear condition.

The other curves of Figure 1 similarly indicate the anode potential versus deflection energy relationship for the other tube types mentioned above. It will be noted in this connection that, the more efficient the tube type, the steeper the slope of the line which represents it. Furthermore, while the narrow-neck 55° and 70° tubes may be deflected by a B+ supply of approximately 125 volts, the standard 55° normally requires 250 volts, and the standard 70° in the neighborhood of 330 volts.

It may readily be seen from Figure 1 that with a power input of, say, 19 watts, the standard 70° tube may be supplied with about 1¼ millijoules of deflection energy, and hence the maximum anode potential which can be developed is in the neighborhood of 6 kilovolts. With the narrow-neck 70° deflection angle tube, however, almost as much deflection energy is obtained from the same input, while the high voltage is increased to nearly 12 kv. when using a transformer of the type to be later described.

Figure 2 is a graph showing the number of driver tubes, and the value of B+ power supply, required for cathode-ray tubes of the types now being considered. For example, with a single 6BQ6 driver tube, and a B+ supply of 130 volts, approximately one millijoule of deflection energy is produced for a standard 70° cathode-ray tube together with approximately 4 kv. of anode potential. With a narrow-neck 70° tube, and using the transformer of the present application, nearly as much deflection energy is developed, while at the same time the high voltage output is raised to approximately 8 kv., or nearly double the amount. Other relationships are apparent from an inspection of the graph. However, a portion of the data which is available therein may be summarized in the following table:

Tube Type	Screen Diameter	H. V. (kv.)	Number of Rectifiers	B+	Driver Stage
				Volts	
Narrow-neck 55°	12	10	Single	130	1—6BQ6
Narrow-neck 70°	16	14.5	do	130	2—6BQ6's
55° Standard 12	12	9	do	250	1—6CD6
55° Standard 16	16	14.5	Double	250	2—6BQ6's
70° Standard 16	16	14.5	do	330	1—6CD6

It will be noticed that the graph of Figure 2 may be roughly divided into three zones. The first is a region utilizing the transformer described in the present application, the second is a section lying closer to the $\frac{1}{2} Li^2$ axis where a transformer with a closed core is normally required, and the third is an intermediate region where not only a closed core transformer but also a voltage doubler would probably be necessary and which includes a large majority of the standard cathode-ray tubes now known in the art. It is of course apparent that each location lying progressively further from the origin will require progressively larger power output tubes for satisfactory operation.

Referring now to Figures 3 and 4 of the drawings, there is shown a preferred form of coupling, or output, transformer designed for use in a circuit according to the present invention. This transformer, generally indicated by the reference numeral 10, includes a core member 12 composed of some suitable finely-divided ferromagnetic material, such as powdered iron, in combination with a binder. The core member 12 (which may also be called a "slug") is of generally cylindrical form, and is enclosed within an insulating tube 14 which serves as a support upon which a plurality of coils are wound.

As hereinbefore pointed out, the configuration and dimensions of this core are chosen so as to provide an air gap in the magnetic flux path linking the windings of the transformer which is sufficiently large to cause a portion of the total energy supplied by the deflecting signal source to be stored in the field surrounding the transformer, said portion being substantially equal to the portion of the total supplied energy which is required by the high-potential rectifying circuit. Under these conditions the impedance of the transformer looking into the terminals to which the yoke is connected is small compared to the yoke impedance. In the circuit for which the present transformer was designed, the requirement of the deflecting yoke was 9 watts, while that of the high-voltage supply circuit was 3 watts. The procedures involved in designing a core to satisfy this requirement are well understood by those skilled in the art of magnetic circuit and transformer design, and therefore need not be discussed in detail in this specification. Suffice it to point out that, in the present instance the length of the core satisfying this requirement is substantially equal to the longitudinal distance measured along the core axis which is occupied by the various windings associated therewith.

The insulating tube 14 is positioned by a U-shaped mounting bracket 16 having a pair of flanges 18 and 20 to which the ends of the tube 14 are respectively secured by means of removable rivets 22, the flanges 18 and 20 being curved in such a manner that the tube 14 is effectively cradled therein. The entire assembly may be bolted to a television chassis or other apparatus through openings 24 formed in the lower portion of the bracket 16.

A pair of concentric coil windings 26 and 28 are supported by the insulating tube 14, the coil 26 being laid down next to the tube so that it encircles the core member 12, and coil 28 being wound upon coil 26 in the general form of a disc which lies midway between the ends of the latter.

Adjacent to the coil 26 is a further coil 30, these two windings being separated by an insulating spacer 32. The coil 30, as best shown in Figure 3, may consist of not more than two or three turns of wire loosely wound on the tube 14.

While three coil windings have been shown in the drawings, it will be appreciated that the number of such coils employed will depend upon the use to which the transformer 10 is to be put. For example, the coils 26 and 28 may represent portions of an auto-transformer for the horizontal deflection circuit of a television receiver employing a surge-type rectifier, while the coil 30 may represent the rectifier heater winding. However, it should be clearly understood that the number and arrangement of the coils themselves forms no specific part of the present invention, and that numerous other winding arrangements may be used if desired in place of the one illustrated.

Mounted on one of the side members of the bracket 16 is a terminal board 34 having a central aperture through which projects one end of the insulating tube 14, as well as the flange 20 to which that end of the tube 14 is attached by the rivets 22. This construction is best shown in Figure 4. Additional rivets 36 secure the terminal board 34 to the support 16.

Terminal board 34 is provided with a number of connector lugs A, B, C, D and E. When the transformer 10 is utilized as a coupling element in a horizontal deflection circuit of the type shown in Figure 5, then the lugs A and E are respectively joined to the ends of the winding 26. This permits the anode of a power output tube to be connected to the terminal E, and the positive terminal of the B+ supply to be connected to the terminal A either directly or through a so-called "boost" condenser as shown in the drawing. Lugs B, C and D respectively represent taps on the winding 26, as also indicated by the circuit arrangement of Figure 5. Accordingly, the terminal D may be connected to the cathode of a diode damper tube, and terminal B connected to one end of an adjustable width-control inductor the other end of which is joined to terminal A. A pair of high-efficiency deflection coils are connected across the terminals A and C. These may be of the sort described and claimed in my aforementioned copending application. Winding 28, which is the high-voltage, or step-up, winding of the transformer 10, has its high-voltage end connected to a terminal F on the board 34, to which point a cable 38 is also soldered or otherwise securely attached. This cable leads to the anode of the high-voltage rectifier tube shown in Figure 5. It will of course be apparent that whereas a specific number of terminals or lugs have been illustrated as being mounted on the panel 34, nevertheless the number and nature of these terminals will depend upon the design of the particular circuit in which the transformer 10 is to be employed.

The performance and efficiency of the transformer 10 depends in part upon the nature of material composing the cylindrical core 12. It may be desirable at times to remove the core so that another one having different operating characteristics may be used. In order to accomplish this without completely disassembling the transformer, there is provided prong 38 which constitutes an extension of one of the side members of the bracket 16. This prong 38 (the insulating tube 14 being partially cut away in Figure 3 in order clearly to bring out this construction) projects through an opening 40 formed in the tube 14 in such a manner that, when the cylindrical core 12 is in position, the prong 38 lies flat against one of the end surfaces of the core.

However, when it is desired to remove the core 12 for replacement or other reasons, the rivets 22 are extracted from that end of the transformer. This permits a separation of the tube 14 and the flange 18, the prong 38 withdrawing through the aperture 40. Since the prong is no longer present to hold the core 12 in position, the latter may be easily removed from the tube 14. Following the insertion of another core element, the tube 14 is again brought in contact with the flange 18 and the rivets 22 reinserted.

hough such replacement means is only neces-
y at one end of the transformer, it may ob-
usly be employed at both ends if found neces-
y or desirable.

The high-voltage winding **28** is provided with
elatively large number of turns as compared
a standard transformer. Normally this would
an that the retrace portion of each scanning
le would be increased to a prohibitive degree.
the case of the transformer as described in the
sent application, this undesirable increase in
race time is not present due to the looser cou-
ng between the turns of the winding which re-
ts from the relatively small amount of core
terial employed. Thus it is possible to achieve
high-voltage output from the transformer,
ile at the same time maintaining the inverse
tage on the damper tube and the direct "kick"
the power tube comparatively low. This sim-
fies circuit design and permits cheaper power
es to be utilized. If it is found that the rela-
ely loose coupling between turns of the high-
ltage winding causes a tendency of the trans-
mer to "ring," this tendency can be almost
mpletely overcome by slightly increasing the
efficient of coupling between turns by the use
wire having a slightly higher degree of resist-
ce. For example, if fine magnetic wire is sub-
tuted for the usual copper wire, the coefficient
coupling will be increased, while at the same
ne the circuit losses will not be appreciably
eater since the current drawn by the cathode-
y tube does not normally exceed 10^{-4} amperes.
the same time, the use of cheaper iron wire
rther reduces the cost of the transformer.

Another advantage obtained through the use
a transformer constructed in accordance with
e showing of Figures 3 and 4 is that the high-
ltage winding **28** has a relatively low capaci-
nce to ground. This is due principally to the
sence of a closed core, since, when such a
ember is used, its proximity to the "high" end
the step-up winding reduces the L/C ratio of
e transformer and undesirably increases the
oportion of each deflection cycle that is re-
ired for retrace. Inasmuch as only a single
slug" is employed in the transformer of the
esent disclosure, there is no iron mass near the
igh" end of the winding **28**, and hence the
inimum "snap-back" time is determined in
ractice mainly by the reactance of the remain-
g components of the deflection circuit.

The absence of a closed core in the trans-
rmer has a still further advantage over con-
ntional designs in that the danger of arcing
etween this element and the H.-V. winding **28**
effectively eliminated. This introduces a fac-
r of safety into the deflection circuit that
ould not otherwise be obtainable.

Although the assembly of Figures 3 and 4 has
een shown to include only a single high-voltage
ectifier heater winding **30**, it is obvious that the
umber of such windings depends upon the num-
er of high-voltage rectifier tubes which are
tilized.

Further it is to be understood that, while the
pecific transformer herein described for use in
circuit according to the invention is of the
orm commonly referred to as an autotrans-
ormer, the invention is not limited to the use
f such a transformer. On the contrary, if de-
irable other forms of transformers, such as
hose having separate primary and secondary
windings may be utilized.

Having thus described my invention, I claim:

1. In a combined deflecting and high-voltage supply system for cathode-ray tubes, a source of deflecting energy, a cathode-ray beam deflecting yoke and a circuit for rectifying a portion of said deflecting energy to provide a high potential for supplying the second anode of a cathode-ray tube, the energy required by said high-potential rectifying circuit constituting a relatively large fraction of the total energy supplied by said source to both said yoke and said rectifying circuit, and an open-core transformer having input terminals connected to said source and having output terminals connected respectively to said deflecting yoke and said rectifying circuit and serving as an energy transfer device supplying energy from said source to both said deflecting yoke and said rectifying circuit, the core of said transformer having an air gap sufficiently large to cause a portion of the total energy supplied by said source to be stored in the field surrounding said transformer, said portion being substantially equal to the portion of the total supplied energy which is required by said high-potential rectifying circuit.

2. A combined deflecting and high-voltage supply system according to claim 1 in which said transformer is provided with a common winding to which are connected both the input terminals and also the output terminals associated with the said deflecting yoke, said transformer in addition being provided with a further winding, constituting an extension of said common winding, to which is connected the output terminal associated with the said rectifying circuit.

3. A combined deflecting and high-voltage supply system according to claim 2, wherein the wire of which the said further winding is composed has a higher coefficient of resistance than the wire comprising the said common winding.

4. A combined deflecting and high-voltage supply system according to claim 1 in which said transformer is provided with a plurality of windings arranged to overlie the said core, the configuration of the latter being such that it is substantially completely contained within the space occupied by the said windings.

5. In a combined deflecting and high-voltage supply system for cathode-ray tubes, a source of energy, a cathode-ray beam deflecting yoke having a given impedance and a circuit for rectifying a portion of said energy to provide a high potential for supplying the anode of a cathode-ray tube, the energy required by said high potential rectifying circuit constituting a relatively large fraction of the total energy supplied by said source of both said yoke and said rectifying circuit, and an open core transformer having input terminals connected to said source and having output terminals connected respectively to said deflecting yoke and said rectifying circuit, said transformer serving as an energy transfer device for supplying energy from said source to both said deflecting yoke and said rectifying circuit, said transformer exhibiting at the output terminals thereof connected to said deflecting yoke an impedance value smaller than the impedance value of said deflecting yoke, the core of said transformer having an air gap sufficiently large to cause a portion of the total energy supplied to said transformer by said source to be stored in the magnetic field surrounding said transformer, said portion being substantially equal to the portion of the total supplied energy which

is required by said high-potential rectifying circuit.

6. A combined deflecting and high-voltage supply system according to claim 5 wherein an output terminal of said transformer comprises an intermediary tapping point of a winding element connected to said input terminals, and wherein the said deflecting yoke is connected to said intermediary tapping point.

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