

Aug. 4, 1942.

A. D. BLUMLEIN ET AL

2,291,682

MAGNETIC FOCUSING ARRANGEMENT FOR CATHODE RAY TUBES

Filed Aug. 6, 1940

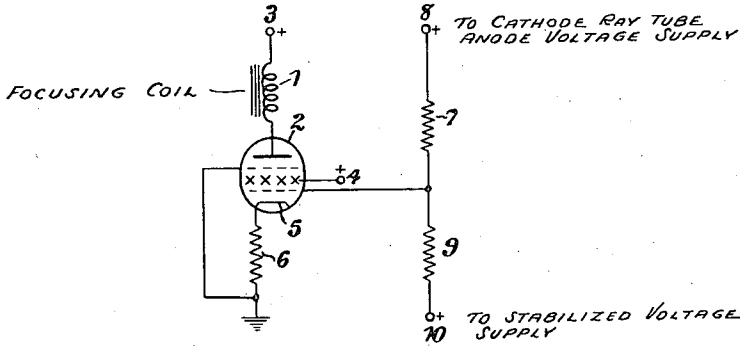


Fig. 1.

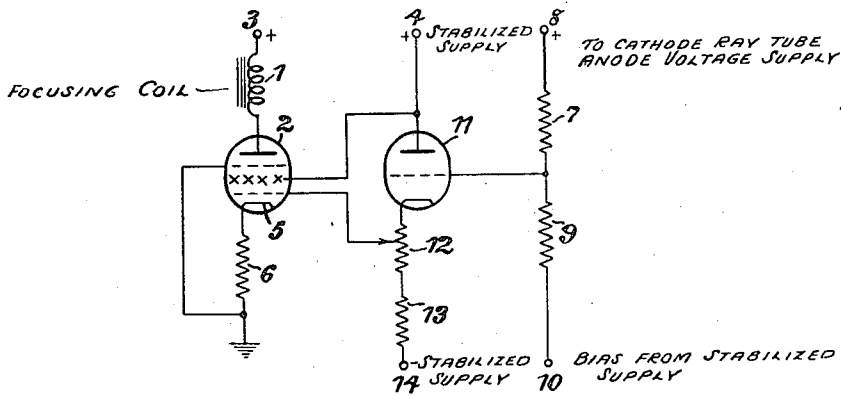


Fig. 2.

INVENTORS  
*Alan Dower Blumlein*  
and *Frank Blythen*  
BY *H.S. Sauer*  
ATTORNEY

# UNITED STATES PATENT OFFICE

2,291,682

## MAGNETIC FOCUSING ARRANGEMENT FOR CATHODE RAY TUBES

Alan Dower Blumlein, Ealing, London, and Frank Blythen, Hayes, England, assignors to Electric & Musical Industries Limited, Hayes, Middlesex, England, a company of Great Britain

Application August 6, 1940, Serial No. 351,592  
In Great Britain July 28, 1939

7 Claims. (Cl. 250-27)

This invention relates to magnetic focusing arrangements for cathode ray tubes and has particular although not exclusive reference to such tubes employing very high voltages as in the case of projection tubes used in television receivers in cinemas.

The electron beam in a cathode ray tube employing magnetic focusing is liable to become defocused if the voltage applied to the final anode of the tube should alter or if the magnetic focusing current should alter due to fluctuations in the main supply. Defocusing will also occur if the anode voltage alters due to regulation of the anode supply or again if the focusing current alters due to temperature changes in the magnetic focusing coil.

It is common to employ stabilising arrangements for the high tension voltages supplied to thermionic valves and cathode ray tubes and the known stabilising methods could be adapted to overcome all the undesirable effects referred to but for the fact that very much higher voltages are used in connection with the type of cathode ray tube with which the invention is more particularly concerned, and it would be inconvenient to develop the stabilising arrangements which would become necessary.

The object of the present invention is to provide a method and apparatus for overcoming defocusing in a magnetically focused cathode ray tube without the requirement of special stabilising arrangements.

According to the present invention in a circuit arrangement including a cathode ray tube, a source of operating potentials for said tube and electromagnetic means for focusing the electron beam thereof, defocusing of said electron beam due to variation in the resistance of the focusing coil or due to variation in the voltage applied to an anode of the tube is reduced or eliminated by arranging that the focusing coil is fed from a valve circuit having an impedance which is high compared with the resistance of the focusing coil, and it is further arranged that the current through said valve is controlled in dependence upon the variations in said voltage so as to reduce the defocusing of the beam due to said variations.

The connections to said valve circuit are preferably such that a percentage change in the voltage at the anode of said cathode ray tube produces a certain percentage change of focus current, and the ratio of these two percentages is fixed in accordance with the degree of saturation of any iron associated with the focusing coil. Further, the focus current may be varied in order that adjustment to obtain an optimum focus may be effected without substantial modification of said percentage ratio.

In a particular arrangement according to the

invention the focusing coil is connected in the anode circuit of a pentode type valve and variations in potential of the anode of the cathode ray tube are applied simultaneously to the control grid of the pentode valve. A potentiometer arrangement may be employed to transmit the anode potential variations to the control grid of the valve and in one modification, a cathode follower valve is interposed between the potentiometer and the pentode or other valve.

In order that the invention may be more clearly understood and readily carried into effect, two fragmentary circuit arrangements for carrying out the invention will now be described in greater detail by way of example with reference to the accompanying drawing. In the drawing Figure 1 shows a circuit arrangement for maintaining the desired relationship between the voltage of the anode of the tube and the coil current and simultaneously for preventing alteration of focusing current through temperature changes in the coil, while Figure 2 shows a modification of the arrangement of Figure 1.

It is known that, when a voltage V is applied between anode and cathode of a cathode ray tube and the focusing field is provided by a current I in a suitable coil, the relation between V and I to maintain complete focus is of the form  $L=KV^{1/2}$ , in the absence of magnetic saturation if the coil is provided with an iron yoke. For small variations of the order it is required to correct, this gives

$$\Delta I = \frac{1}{2} \frac{I}{V} \Delta V \dots \dots \dots (1)$$

In practice with iron clad coils magnetic saturation does occur to some extent and it is found experimentally that this affects the value of the fractional co-efficients of

$$\frac{I}{V} \Delta V$$

For instance, in the case of a coil of practical construction the relation is

$$\Delta I = .64 \frac{I}{V} \Delta V \dots \dots \dots (2)$$

If the expression is re-written as

$$\frac{\Delta I}{I} = .64 \frac{\Delta V}{V}$$

it is obvious that for maintenance of focus the fractional change of I should be .64 multiplied by the fractional change of V.

Referring to the drawing, 1 represents the focusing coil for a cathode ray tube which is connected in the anode lead of a pentode valve 2, anode current being derived from a source (not shown) to which the terminal 3 is connected. The screening grid of the valve 2 is connected at terminal 4 to a source of stable voltage (not

shown), and the cathode 5 is connected to earth through a resistance 6. The control grid of the valve 2 is connected on one hand through a resistance 7 to a known fraction of the cathode ray tube anode potential at the terminal 8 and on the other hand through a resistance 9 to a source of stable voltage at the terminal 10. The stable voltage may be provided by a battery or an artificially stabilised mains rectifier source or a source rectified from a stable alternating current supply which in general is liable to percentage variations which are small compared with the percentage variations to be expected in the high voltage supply feeding the cathode ray tube anode. It will be understood that as the valve 2 is of the pentode type and therefore has a high anode impedance, the current through the coil 1 is substantially independent of small fluctuations of its resistance such as might be caused by temperature variations, the current also being independent of small variations in the potential of the source to which the terminal 8 is connected.

If  $I$  is the current through the coil, then neglecting screen current, the potential at the grid of valve 2 is approximately:

$$v = I(1/g+r) - v' \tag{3}$$

where

$v$  is the potential at the grid of the valve 2,  $g$  is the slope of the valve,  $r$  represents the value of the resistance 9 and  $v'$  is a constant depending on the type of valve and the mean value of  $I$ .

Allowing for screen current and the finite voltage amplification factor between grid and screen, a similar linear equation is obtained with modified constants.

The potential  $v$  at the grid of the valve is made up of a component  $v'$ , which is fixed, being derived from the stabilised source 4 and a variable component, a fraction of the anode supply of the cathode ray tube, say  $V/a$ .

Thus

$$v = \frac{v}{a} + v_1 = I\left(\frac{1}{g} + r\right) - v' \tag{4}$$

The change of current corresponding to a small change of  $V$ ,  $\Delta V$  is therefore

$$\Delta I = \frac{\Delta V}{a\left(\frac{1}{g} + r\right)}$$

$$\therefore \frac{\Delta I}{\Delta V} = \frac{1}{a\left(\frac{1}{g} + r\right)}$$

Substituting the value

$$\frac{\Delta I}{\Delta V}$$

from Equation 2 it will be seen that

$$0.64 \frac{I}{V} = \frac{1}{a\left(\frac{1}{g} + r\right)}$$

By substituting in Equation 4

$$\frac{V}{a} + v' = \frac{V}{0.64a} - v'$$

$$\therefore \frac{V}{a + v_1 + v'} = 0.64 \tag{5}$$

which is the condition required for keeping the tube focused.

In order to provide means for varying the focusing current without altering the relation expressed in the Equation 5, a cathode follower valve 11, a variable potentiometer 12 and resistance 13, large compared with the inverse of the slope of valve 11, connected to a stabilised source of supply at the terminal 14 have been added to the arrangement of Figure 1. The anode of the valve 11 is connected to a stable source of supply at the terminal 4. The potential at the terminal 10 is modified to provide a standing bias for the control grid of the valve 11. Under these conditions the potential at the cathode of the valve 11 is very nearly  $V/a + v'$  with respect to earth. The potential at the terminal 14 is made equal to  $v'$  so that the potential at the cathode with respect to that at the terminal 14 is  $V/a + v_1 + v'$ .

For a given position of the tapping point on the potentiometer the potential at the grid of the valve 2 with respect to that at the terminal 14 is a fraction, say  $b$  of  $V/a + v' + v_1$ , and the potential with respect to earth is therefore

$$v = b(V/a + v_1 + v') - v' = I(1/g+r) - v' \tag{4a}$$

$$\therefore \frac{b}{a} \Delta V = \left(\frac{1}{g} + r\right) \Delta I$$

or

$$\frac{\Delta I}{\Delta V} = \frac{b}{a\left(\frac{1}{g} + r\right)}$$

$$\therefore 0.64 \frac{I}{V} = \frac{b}{a\left(\frac{1}{g} + r\right)} \text{ from (2)}$$

Substituting in (4a)

$$b\left(\frac{V}{a} + v_1 + v'\right) = \frac{bV}{0.64a}$$

whence

$$\frac{V}{\frac{V}{a} + v_1 + v'} = 0.64$$

so that the condition for focus compensation is as in the circuit of Figure 1 and is independent of  $b$ . Thus, the potential at the grid of the valve 2 and hence the current flowing through the focusing coil, can be varied by moving the slider of the potentiometer 12 without altering the law of the compensation.

We claim:

1. In a cathode ray system wherein is provided a cathode ray tube having an electron emitting cathode and an anode for accelerating electrons emitted from said cathode and wherein a magnetic coil is supplied for focusing said electrons into a beam, the method of maintaining focus in spite of spurious fluctuations of anode potential and coil current supply, which comprises feeding current to said coil through a constant current impedance path, adjusting said current to a predetermined value, and altering said predetermined value of current in accordance with fluctuations of the anode potential from a predetermined value of voltage.

2. In a cathode ray system wherein is provided a cathode ray tube having an electron emitting cathode and an anode for accelerating electrons emitted from said cathode and wherein a magnetic coil is supplied for focusing said electrons into a beam, the method of maintaining focus in spite of spurious fluctuations of anode poten-

tial and coil current supply, which comprises feeding current to said coil through a constant current impedance path, adjusting said current to a predetermined value, and altering said predetermined value of current in proportion to fluctuations of the anode potential from a predetermined value of voltage.

3. A cathode ray system comprising a cathode ray tube having at least an electron emitting cathode and an electron accelerating anode, a magnetic focusing coil positioned intermediate said cathode and said anode, means to supply electrical current to said coil through a constant current impedance, means for adjusting said current to a predetermined value, and means for altering said predetermined value of current in accordance with fluctuations from a predetermined value of voltage of potential supplied to said anode.

4. A cathode ray system comprising a cathode ray tube having at least an electron emitting cathode and an electron accelerating anode, a magnetic focusing coil positioned intermediate said cathode and said anode, means to supply electrical current to said coil through a constant current impedance, means for adjusting said current to a predetermined value, and means for altering said predetermined value of current in proportion to fluctuations from a predetermined value of voltage of potential supplied to said anode.

5. A cathode ray system comprising a cathode ray tube having at least an electron emitting cathode and an electron accelerating anode, a magnetic focusing coil having a saturable iron core positioned intermediate said cathode and said anode, means to supply electrical current to

said coil through a constant current impedance, means for adjusting said current to a predetermined value, and means for altering said predetermined value of current in accordance with fluctuations from a predetermined value of voltage of potential supplied to said anode in accordance with the degree of saturation and fluctuations of potentials supplied to the anode from a predetermined value of voltage.

6. A cathode ray system comprising a cathode ray tube having at least an electron emitting cathode and an electron accelerating anode, a magnetic focusing coil positioned intermediate said cathode and said anode, means to supply electrical current to said coil through a thermionic tube having substantially constant anode current, means for adjusting said current to a predetermined value, and means for altering said predetermined value of current in accordance with fluctuations from a predetermined value of voltage of potential supplied to said anode.

7. A cathode ray system comprising a cathode ray tube having at least an electron emitting cathode and an electron accelerating anode, a magnetic focusing coil positioned intermediate said cathode and said anode, means to supply electrical current to said coil through a thermionic tube having substantially constant anode current, means for adjusting said current to a predetermined value, and electrical bridge means for altering said predetermined value of current in accordance with fluctuations from a predetermined value of voltage of potential supplied to said anode.

ALAN DOWER BLUMLEIN.  
FRANK BLYTHEN.