Dec. 20, 1955 M. M. CARPENTER, JR 2,728,028

ELECTRON BEAM DEFLECTION APPARATUS

Filed Aug. 23, 1952

Fig_1

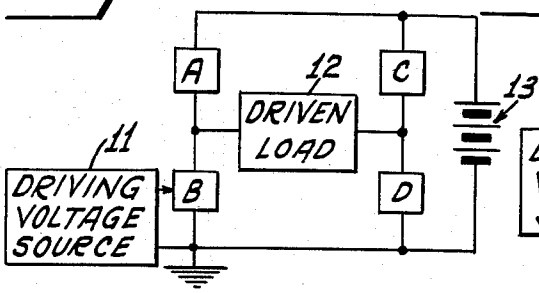


Fig_4

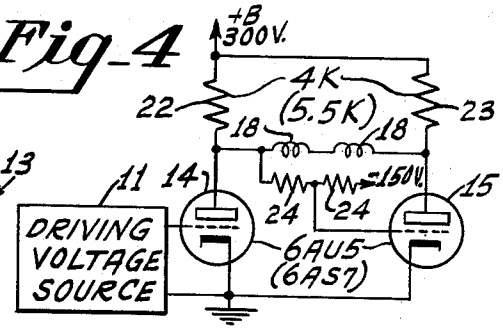


Fig_2

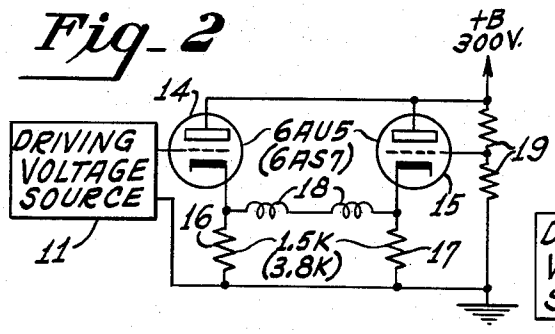


Fig_5

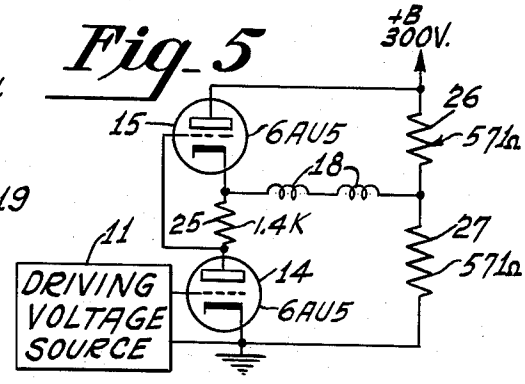


Fig_3

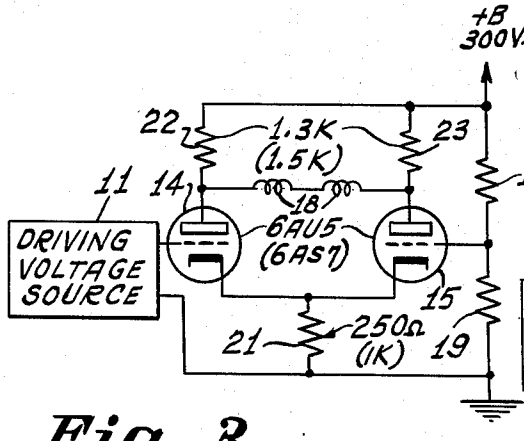
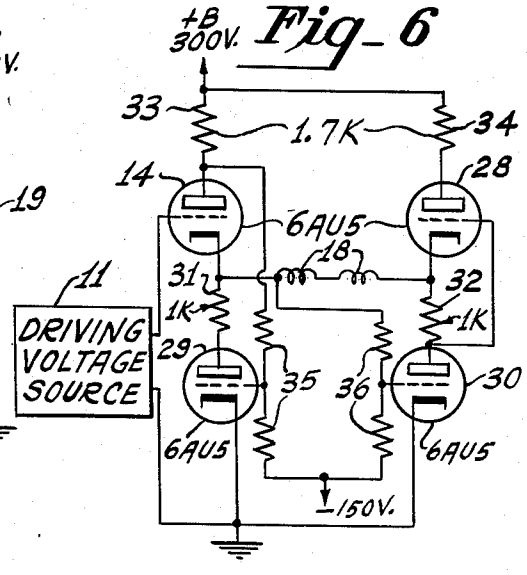


Fig_6



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ELECTRON BEAM DEFLECTION APPARATUS

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9 Claims. (Cl. 315—27)

This invention relates to electron beam deflection systems, and has particular reference to the energization of electromagnetic deflection yokes used in such systems.

When it is desired to effect the deflection of the electron beam of a cathode ray device at low frequencies, such as 10 cycles per second or lower, for example, it is not feasible to use an output transformer between the driving voltage source and the deflection yoke constituting a driven load. It is necessary in such cases to use what is commonly referred to as a direct drive. In addition it is usually desirable to achieve as high an operating efficiency of such a circuit as possible.

Accordingly, it is one of the objects of this invention to provide improved driving aparatus by which to energize a driven load such as an electromagnetic beam deflection yoke.

Another object of the invention is to provide an improved low frequency electromagnetic deflection yoke energization by a single-sided driving apparatus.

Still another object of the invention is to provide an improved low frequency electromagnetic deflection yoke driving apparatus which operates so as to draw substantially constant average current from a power supply and to furnish substantially zero output current.

A further object of the invention is to provide an improved low frequency electromagnetic deflection yoke driving apparatus which is adapted to have introduced therein electron beam-centering currents.

In accordance with the present invention, the driving apparatus for energizing a load device such as an electromagnetic beam deflection yoke comprises a bridge circuit including an impedance device in each leg thereof. At least one of these impedance devices is of an active character and any remainder are passive. The load device is connected between one pair of conjugate points of the bridge circuit, and a source of unidirectional energy is connected to the other pair of conjugate bridge points. A driving voltage source providing a periodic wave, which may be of low frequency, is coupled to the active impedance device so as to vary the impedance thereof and thereby to control the energy which is supplied from said energy source to the load device. The basic bridge circuit, in accordance with the present invention, may be varied in many ways. More than one leg of the bridge circuit may include an active impedance element such as an electron tube. In one particularly successful device of the character described, the bridge circuit includes an active impedance element in the form of an electron tube in all four legs thereof. In any case, the driving voltage source is connected to only one of the active impedance devices. The remaining active impedance devices, if any, are coupled to the active impedance device and/or to one another in such a manner that they are effectively operated as slave units to produce the desired result.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings.

In the drawing:

Figure 1 is a block diagram of the basic structure in accordance with the present invention;

Figure 2 is an embodiment of the invention in which two of the active impedance elements are electron tubes and the load is coupled to the cathodes of the tubes;

Figure 3 is another embodiment of the invention in which two electron tubes comprise two active impedance elements, and the load is connected to the anodes of the tubes;

Figure 4 is still another embodiment of the invention in which two electron tubes comprise the active impedance elements, and the load is connected to the anodes of the tubes, and in which the drive for the slave tube is derived from a bleeder circuit associated with the anode of the driving tube;

Figure 5 is a further embodiment of the invention employing still another arrangement of two electron tubes forming the active impedance elements of the bridge circuit, and in which the drive for the slave tube is derived directly from the anode of the driving tube; and,

Figure 6 is an embodiment of the invention in which all four legs of the bridge circuit include electron tubes forming the active impedance elements.

Reference first will be made to Figure 1 of the drawing for a description of the general arrangement of the driving apparatus in accordance with the invention. The bridge circuit consists of four legs including, respectively, elements A, B, C, and D which it will be understood are impedance devices. In this case, the element B is an active impedance device having its input circuit connected to a driving voltage source **11** so that the impedance of the element B may be varied in correspondence with a periodic voltage wave, which may be of low frequency, derived from the source **11**. The load **12** which is to be driven is connected as shown between one pair of conjugate points of the bridge network. Also a source of unidirectional energy **13** is connected to the other pair of conjugate points of the network.

It is seen that such an arrangement provides a single-sided drive which is represented by the element B. Even though all of the other elements A, C, and D are of a passive character, the energy which is derived from the source **13** is caused to flow through the network in such a manner as to energize the drive load **12** in substantial accordance with the wave derived from the driving voltage source **11**. Also, as will be more apparent from other forms of the invention to be described subsequently, the average current through the load **12** is substantially zero. It has been found that with an electron tube such as a 6AS7 employed as the active impedance element B in the network of Figure 1 and the other circuit constants arranged in such a way to drive a current of approximately 70 milliamperes peak-to-peak through a load of approximately 1500 ohms, an efficiency ratio of 6.94 was obtained. In computing this efficiency ratio, the maximum current drawn from the source **13** is divided by the peak load current. In comparing the performance of the other arrangements of this invention, this efficiency ratio also will be employed.

Figure 2, to which reference will now be made, shows a somewhat more practical form of the invention. In this case, the bridge network includes a pair of electron tubes **14** and **15** connected in two legs thereof, and resistors **16** and **17** in the other two legs thereof. The driven load in this case is represented by the coils **18** of the deflection yoke windings for use with a cathode ray tube. The driving voltage source **11** is coupled to

the grid, or current-controlling circuit of the input, or driving, tube 14. The source of unidirectional energy is indicated at +B, it being understood that the negative terminal of the source is grounded. In this form of the invention, the driven, or slave tube, 15 is driven from the driving tube 14 by an exchange of current through the bridge leg resistor 17 which in this arrangement is effectively the cathode resistor for the slave tube. The grid of the slave tube is suitably biased by a connection to a bleeder, or voltage divider, resistor network 19 connected to the energy source. The biasing of the grid of the slave tube 15 is of such a character that the tube will be completely cut off when the driving tube 14 is driven to full current conduction in response to the driving voltage from the source 11.

In this form of the invention, as well as in all others to be described subsequently, it is desirable that each of the electron tubes have high transconductance and low plate resistance. Accordingly, in the described illustrative embodiments of the invention included here in accordance apparatus which has been successfully operated, these tubes may be either 6AS7 or 6AU5 types connected as triodes. Such designations are given in the drawings together with the values of the other critical circuit components for use therewith. For example, in Figure 2, when the tubes 14 and 15 respectively are 6AU5, the resistors 16 and 17 have a value of 1500 ohms. Similarly, when the tubes 14 and 15 are 6AS7, indicated in parenthesis, then the resistors 16 and 17 have values of 3800 ohms, also indicated in parenthesis.

Using the same operating conditions as previously referred to with reference to the apparatus of Figure 1, the apparatus of Figure 2 has been found to work in a generally satisfactory manner. When a 6AU5 type of tube is used for the electron tubes 14 and 15, the operating efficiency ratio was found to be 5.57. When these tubes are of the 6AS7 type, the efficiency ratio is 3.6.

Another form of the invention is shown in Figure 3, to which reference now will be made. This embodiment of the invention also includes a driver electron tube 14 and a slave or driven electron tube 15. In this case, the slave tube 15 is driven in response to the current flow through a cathode resistor 21 which also is connected to the cathode of the driver tube 14. The load comprising the yoke 18 in this type of circuit is connected between the pair of conjugate bridge circuit points appearing respectively at the anodes of the tubes 14 and 15. The other two passive legs of the bridge circuit are constituted by the plate load resistors 22 and 23 connected respectively to the tubes 14 and 15. This circuit has been found to have an operating efficiency ratio of 4.8, when using 6AU5 type of tube, and 3.9 when using 6AS7 type of tube.

Figure 4 illustrates still another embodiment of the invention in which the bridge circuit is similar to that shown in Figure 3, but in which the biasing and driving of the slave tube 15 is somewhat different. In this case, the control grid of the slave tube 15 is biased for operation by means of a connection to a voltage divider network 24 connected between a source of negative voltage as indicated and the anode of the driving tube 14. It is seen that, by virtue of the connection of this network to the anode of the driving tube, the slave tube is suitably driven to effect the desired energization of the yoke 18. The operating efficiency ratio of this embodiment of the invention, when using a 6AU5 type of tube was found to be 2.66. A 6AS7 type of tube produced an operating efficiency ratio of 2.57. In general it was found that this was about the most efficient arrangement of a bridge circuit in accordance with this invention when using only two electron tubes.

Another two-tube form of a bridge network in accordance with this invention is shown in Figure 5 to which reference now will be made. In this case, the anode of the driving tube 14 is connected through a plate load resistor 25 to the cathode of the driven or slave tube 15. The control grid of the slave tube is connected as shown to the anode of the driving tube 14. The slave tube 15, accordingly, is driven by the load current for the tube 14 flowing through the resistor 25. In this case the load comprising the deflection yoke 18 is connected between a bridge network point which is common both to the cathode circuit of the driven tube 15 and to the anode circut of the driving tube 14. The other terminal of the yoke is connected to a conjugate point of the bridge circuit formed by the junction of the two passive impedance elements comprising resistors 26 and 27. The operating efficiency ratio of this form of the invention with a 6AU5 type of tube, under the same operating conditions as previously set forth, was found to be 8.26.

Reference to Figure 6 of the drawings is made for a description of an embodiment of the invention which provides a particularly practical form of apparatus for driving a beam deflection yoke at low frequencies. In this case, the bridge network includes, in addition to the driving tube 14 in one leg thereof, electron tubes 28, 29, and 30 in the other legs. Consequently, this bridge network comprises one driving tube as an active impedance element and three driven or slave tubes as passive impedance elements. The cathode-to-anode connection of the tube 14 and the driven tube 29 through a load resistor 31 for the tube 29 is substantially similar to the corresponding arrangement shown in Figure 5. In a like manner, the cathode of the driven tube 28 is coupled to the anode of the driven tube 30 by means of a plate load resistor 32 for the tube 30. Also, the control grid of the driven tube 28 is connected as shown to the anode of the driven tube 30 as in the corresponding arrangement of Figure 5. Consequently, the cathodes of the tubes 14 and 28 effectively constitute one pair of conjugate bridge circuit points between which the deflection yoke 18 is coupled as a load.

The anodes of the respective tubes 14 and 28 are connected through load resistors 33 and 34 to a positive terminal of a source of unidirectional energy. This common point is one of the other pair of conjugate points of the bridge network of which the grounded cathodes of the tubes 29 and 30 comprise the other. As in preceding embodiments of the invention, the driving voltage source 11 is coupled to the control grid of the driving tube 14.

The biasing and driving circuit for the driven tube 29 includes a voltage divider resistive network 35 connected between a negative potential point as indicated and the anode of the driving tube 14. It is seen that this arrangement is somewhat similar to that provided in the embodiment of the invention shown in Figure 4. A similar arrangement is made for the driving of the tube 30 by means including a voltage divider resistive network 36 connected between a negative potential point and the cathode of the driving tube 14. The driven tube 28 is operated by reason of the coupling to the cathode of the driving tube 14 in somewhat the same manner as the driven tube is operated in the form of the invention shown in Figure 2.

It has been found that, when the embodiment of the invention such as that shown in Figure 6, includes a 6AU5 type of tube for the bridge network elements, an operating efficiency ratio of 1.26 was obtained. This, it will be noted, is the most efficient of all of the disclosed devices. Apparently, one of the reasons for the relatively high efficiency is the provision of the variable impedance devices in all four legs of the bridge network and the control of the respective impedances from a single element such as the driving electron tube. It also is found that this form of the invention places a minimum current drain upon the power supply. Also, a minimum variation of the current drawn from the power supply was noted.

It will be understood that other arrangements of a bridge network in accordance with the above described

principles may be made without departing from the scope of the present invention. Also, other arrangements may be made such as by replacing the resistive elements in the passive legs of the bridge circuit with constant current devices such as pentode electron tubes in order to achieve an even greater supply current economy. It also will be understood that the improved driving apparatus, in accordance with the present invention, may incorporate feedback in accordance with well known principles in order to improve any fluctuation in linearity by making the output current waveform follow the input voltage waveform. It also will be appreciated that any of the other known arrangements for effecting grid drive for the slave tubes may be employed without departing from the scope of the invention.

Accordingly, it will be seen that driving apparatus in accordance with the present invention provides a highly efficient device as considered from the standpoint of total or maximum supply current in relation to the peak load current. This is particularly true with reference to the form of the device shown in Figure 6. This high efficiency is achieved by virtue of the fact that the legs of the bridge network which are not required to carry load current are cut off. Such a direct drive for electron beam deflection apparatus is particularly useful where transformers may not be used, such as in the case where the deflection frequencies are of a relatively low order of magnitude.

The nature of the invention may be ascertained from the foregoing description of several illustrative embodiments thereof. The scope of the invention is pointed out in the appended claims.

What is claimed is:

1. Driving apparatus for energizing an electromagnetic electron beam deflection yoke by a periodic wave, said apparatus comprising a bridge circuit including an impedance device in each leg thereof, at least two of said impedance devices being of an active character and each comprising an electron tube and any remainder of said impedance devices being of a passive character, each of said electron tubes including a cathode, a space current control electrode and an anode, means connecting said deflection yoke between one pair of conjugate points of said bridge circuit, a source of unidirectional energy connected to the other pair of conjugate points of said bridge circuit, a driving voltage source of said periodic wave coupled to the control electrode of only one of said electron tubes to vary the impedance thereof in one sense, means coupling the other of said electron tubes to said one electron tube in a manner to vary the impedance of said other tube in a sense opposite to that of said one tube, and means including a voltage divider resistive network connected to said energy source and to the control electrode of said other tube to bias it so as to be nonconducting when said one tube is at a conducting maximum.

2. Driving apparatus as defined in claim 1 wherein, said deflection yoke is connected between the cathodes of said electron tubes.

3. Driving apparatus as defined in claim 1 wherein, said deflection yoke is connected between the anodes of said electron tubes.

4. Driving apparatus as defined in claim 1 wherein, said deflection yoke is connected between a point common to the cathode circuit of one of said electron tubes and to the anode circuit of the other of said electron tubes and another point of said bridge circuit conjugate therewith.

5. Driving apparatus as defined in claim 4 wherein, said bridge circuit includes two additional electron tubes forming said respective impedance devices in the other two legs of said bridge circuit, and said other bridge circuit conjugate point is common to the cathode and anode circuits respectively of said two additional electron tubes.

6. Driving apparatus for energizing an electromagnetic electron beam deflection yoke by a periodic wave, said apparatus comprising, a bridge circuit including two electron tubes constituting active impedance devices in two legs of said bridge circuit and each including a cathode, a control grid and an anode, one of said tubes being a driving tube and the other being a driven tube, said bridge circuit also including a pair of resistors constituting passive impedance devices in the other two legs of said bridge circuit and connected respectively from a common junction point to the cathodes of said tubes, a source of unidirectional energy connected between the anodes of said tubes and said resistor junction point, said yoke being connected between the cathodes of said tubes, a driving voltage source of said periodic wave coupled to the control grid of said driving tube, and means including a voltage devider resistive network connected to said energy source and to the control grid of said driven tube to bias it so as to be nonconducting when said driving tube is at a conducting maximum.

7. Driving apparatus for energizing an electromagnetic electron beam deflection yoke by a periodic wave, said apparatus comprising, a bridge circuit including two electron tubes constituting active impedance devices in two legs of said bridge circuit and each including a cathode, a control grid and an anode, one of said tubes being a driving tube and the other being a driven tube, said bridge circuit also including a pair of resistors constituting passive impedance devices in the other two legs of said bridge circuit and connected respectively from a common junction point to the anodes of said tubes, a coupling resistor connected to the cathodes of said tubes, a source of unidirectional energy connected between said resistor junction point and said cathode coupling resistor, said yoke being connected between the anodes of said tubes, a driving voltage source of said periodic wave coupled to the control grid of said driving tube, and means including a voltage divider resistive network connected to said energy source and to the control grid of said driven tube to bias it so as to be non-conducting when said driving tube is at a conducting maximum.

8. Driving apparatus for energizing an electromagnetic electron beam deflection yoke by a periodic wave, said apparatus comprising, a bridge circuit including two electron tubes constituting active impedance devices in two legs of said bridge circuit and each including a cathode, a control grid and an anode, one of said tubes being a driving tube and the other being a driven tube, said bridge circuit also including a pair of resistors constituting passive impedance devices in the other two legs of said bridge circuit and connected respectively from a common junction point to the anodes of said tubes, a source of unidirectional energy connected to said resistor junction point and to the cathodes of said tubes, said yoke being connected between the anodes of said tubes, a driving voltage source of said periodic wave coupled to the control grid of said driving tube, and means including a voltage divider resistive network connected to the anode of said driving tube and to said energy source and having an intermediate point connected to the control grid of said driven tube, thereby to provide a driving circuit for said driven tube and to bias it so as to be non-conducting when said driving tube is at a conducting maximum.

9. Driving apparatus for energizing an electromagnetic electron beam deflection yoke by a periodic wave, said apparatus comprising, a bridge circuit including four electron tubes constituting active impedance devices in the respective legs of said bridge circuit and each including a cathode, a control grid and an anode, one of said tubes being a driving tube and the others being driven tubes, load resistors connected respectively to the anodes of said tubes, the load resistor of a first driven tube being connected to the load resistor of said driving tube at a common junction point, the load resistors of said

second and third driven tubes being connected respectively to the cathodes of said driving and first driven tubes, a source of unidirectional energy connected between said load resistor junction point and the cathodes of said second and third driven tubes, said yoke being connected between the cathodes of said driving and first driven tubes respectively, a driving voltage source of said periodic wave coupled to the control grid of said driving tube, a connection from the anode of said third driven tube to the control grid of said first driven tube, a first voltage divider resistive network connected to the anode of said driving tube and to said energy source and having an intermediate point connected to the control grid of said second driven tube, and a second voltage divider resistive network connected to the cathode of said driving tube and to said energy source and having an intermediate point connected to the control grid of said third driven tube.

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