Feb. 14, 1967 R. W. McMILLAN 3,304,512

FEEDBACK SYSTEM FOR HIGH SPEED MAGNETIC DEFLECTION

Filed Oct. 29, 1963

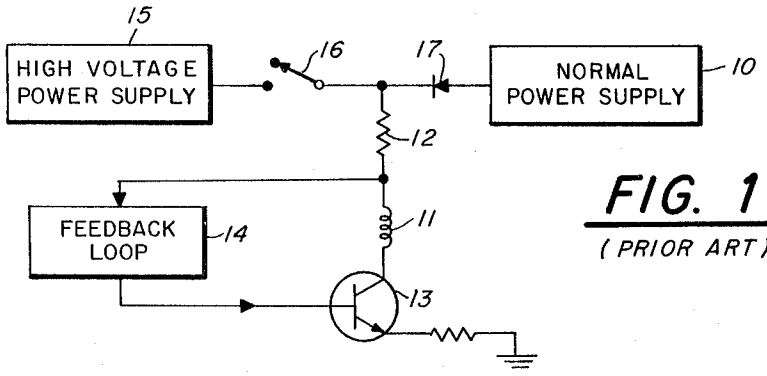

FIG. 1
(PRIOR ART)

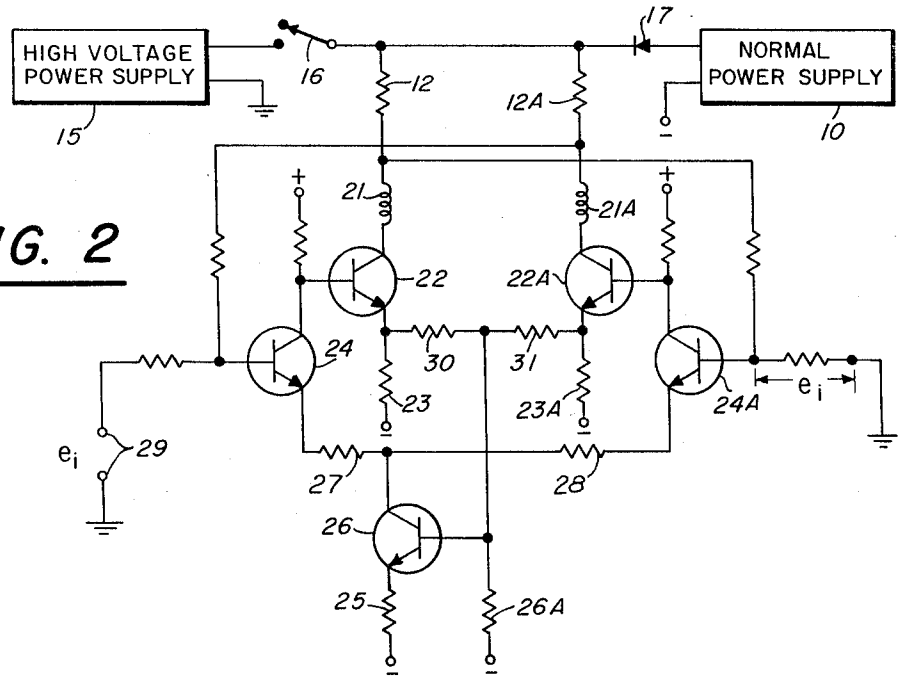

FIG. 2

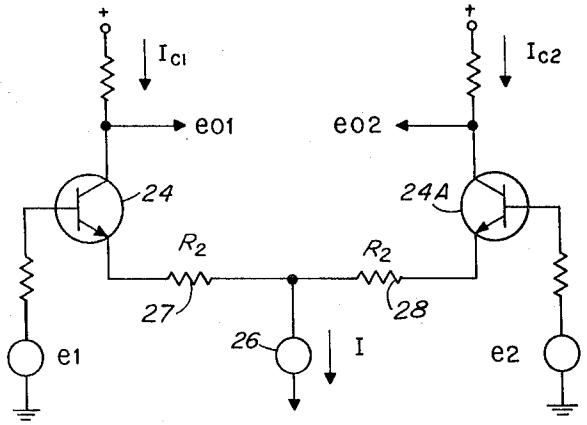

FIG. 3

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United States Patent Office 3,304,512 Patented Feb. 14, 1967

3,304,512

FEEDBACK SYSTEM FOR HIGH SPEED MAGNETIC DEFLECTION

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Filed Oct. 29, 1963, Ser. No. 319,903
3 Claims. (Cl. 330—30)

This invention relates to magnetic deflection systems and is particularly directed to improved means for increasing the fly-back speed.

Heretofore, magnetic deflection yokes have been supplied with a normal power supply for energizing the yoke during normal sweep periods. During the fly-back time, when the direction of the magnetic field must be rapidly reversed, it has been customary to apply an excessive or high voltage to the yoke. Unfortunately, the normal feedback circuit from the yoke to the current control for linearity control is subjected to the excessive voltages, and the first stages of the feedback amplifier are seriously overdriven.

The object of this invention is to provide means for rapid fly-back without overdriving the deflection control amplifier.

The objects of this invention are obtained by employing a double yoke or split winding connected in push-pull with a differential amplifier. The constant current collector circuits of two transistors are connected respectively in circuit with the two windings of the yoke, and the push-pull or two phase-opposed signals of differential amplifiers are in turn applied directly to the control electrodes of the two transistors. For linearity control, the usual cross-connected feedback connections are made between one terminal of each yoke to the control electrodes of one amplifier of the differential amplifier. A second feedback circuit which is symmetrical with respect to the two constant current transistors feeds energy back symmetrically as common bias to the differential amplifier. When the high voltage or rapid flyback is amplified, it is found that the two differential amplifiers are not overdriven as heretofore.

Other objects and features of this invention will become apparent to those skilled in the art by referring to the specific embodiments described in the following specification and illustrated in the accompanying drawing in which:

FIG. 1 shows schematically a prior art circuit for deflection control;

FIG. 2 shows a schematic circuit diagram of one embodiment of this invention; and

FIG. 3 is a skeletonized diagram of the principal circuits of the embodiment of FIG. 2, to illustrate the mode of operation.

The well-known prior art driving circuit for a deflection yoke shown in FIG. 1 comprises the normal power supply **10** connected in series with the deflection yoke **11** through the current sensing resistor **12** and the current control amplifier **13**. The current through the yoke is sensed by the voltage drop across the resistor **12** and is applied through the feedback loop, shown diagrammatically at **14**, to regeneratively control the effective resistance of the amplifier **13**, all for the purpose of obtaining linearity of the sweep of the beam to be deflected by the yoke. During retrace or flyback, it is customary to apply a high voltage power supply **15** through the switch mechanism **16**, of either mechanical or electrical configuration, to the deflection circuit. To isolate the two power supplies the polarized diode **17** may be employed. The use of the high voltage power supply switching to obtain fast rise time or quick flyback in the magnetic deflection amplifier, creates difficulty in the design of the feedback network

14. When the high voltage power supply switch is open, the voltage fed back is a function of the current flowing through the deflection yoke. However, when the high voltage switch is closed, substantially all of the high voltage appears across the yoke and a pulse is fed back that is not necessarily a function of the yoke current. Since this pulse may exceed in amplitude the capacity of the feedback loop, the first or low level stages of the feedback amplifier are heavily overdriven.

In order to overcome this problem, a push-pull output stage driven by a differential amplifier with single-ended input is employed as shown in FIG. 2. In FIG. 2, the deflection yoke comprises two windings **21** and **21A**. The current through winding **21** is controlled by the collector circuit of transistor amplifier **22**. The current through winding **21A** is controlled by the collector circuit of transistor amplifier **22A**. The circuits for the deflection current is completed through the emitter resistances **23** and **23A** as shown.

According to an important feature of this invention, the currents through amplifiers **22** and **22A** are differentially controlled by the output of the differential amplifier including transistors **24** and **24A**. The common emitter circuit for the differential amplifiers comprises the resistance **25** in series with the collector-emitter circuit of the control transistor **26**. The current limiting resistors **27** and **28** are connected respectively in the emitters of differential by coupled transistors. The synchronizing pulses for operating the sweep circuit are applied to input terminals **29** and hence directly to the base of transistor **24** and indirectly through the common emitter resistance **25**, **26** to the emitter-base of transistor **24A**. In operation, the currents through **24** and **24A** rise and fall complementarily under the control of the resistance in the common emitter circuit. That is, the signal current due to e_i, in one amplifier rises while the signal current in the other amplifier drops. Since the bases of the current control transistors **22** and **22A** are connected directly to the collectors, respectively, of the differential amplifiers **24** and **24A**, it follows that the currents through the two deflection yokes are complementary. The proper phase relations are obtained for regenerative feedback by connecting the base of transistor **24** to the load circuit of yoke **21A** while the base of amplifier **24A** is connected to the load circuit of yoke **21**.

It will be noted that the high voltage switching pulse obtained when switch **16** is closed is applied in phase to both sides of the push-pull yoke. Since transistors **22** and **22A** are essentially constant current sources, the increase in collector voltage causes very little change in the yoke current. The yoke current is further stabilized by feedback from the emitter circuits of transistors **22** and **22A** to the base of constant current transistor **26**. The transient voltage caused by the closure of switch **16** produces like voltages or in-phase voltages at the emitter terminals of transistors **22** and **22A**. These in-phase voltages are added through resistors **30** and **31** and are applied across coupling resistance **26A** to the base of transistor **26**. The collector-emitter resistance of transistor **26** changes to vary the total emitter resistance of transistors **24** and **24A** to degeneratively change the signal on the base electrodes of transistors **22** and **22A** to, in turn, minimize the disturbance of the transient voltage from switch **16**. Since the same high voltage pulse for transient is applied to both sides of the yoke, and therefore to both sides of the input differential amplifier, no change in drive to the two output transistors **22** and **22A** results from the application of the high voltage switching pulse.

If transistor **26** is considered a constant current source, the schematic diagram of FIG. 2 may be redrawn as shown in FIG. 3.

The total current I comprising the collector currents of transistors **24** and **24A**, is given by:

$$I=Ic1+Ic2 \quad (1)$$

The signal voltages $e1$ and $e2$ applied to the two bases of **24** and **24A** are in phase opposition. Assume now that a change in input voltage, Δe, is applied to both bases simultaneously, in phase. If the transistors are fairly well matched and/or if the resistors R_2 are fairly large, this input change will cause a change in each collector current such that:

$$\Delta Ic1=\Delta Ic2 \quad (2)$$

but since transistor **26** in the common emitter circuit is a constant current source:

$$Ic1+\Delta Ic1+Ic2+\Delta Ic2=I \quad (3)$$

Therefore:

$$\Delta Ic1=\Delta Ic2=0 \quad (4)$$

Since the output voltages e_{01} and e_{02} depend on the collector currents it follows that $\Delta e_{01}=\Delta e_{02}=0$, and the drive to the output stage **22** and **22A** does not change when the high voltage pulse is applied. The change in the input voltage Δe does not appear across the emitter ends of the resistors R_2, R_2, although it does appear across the constant current transistor **26**, which is insensitive to changes in voltage on its collector.

It is important that the collectors of transistors **24** and **24A** not drop below the maximum amplitude of the high voltage switching pulse because the base-collector diodes will conduct and the output voltage will no longer depend on the collector currents.

The feedback system of this invention depends for its operation on the constant current properties of transistors and on the common mode rejection properties of the differential amplifier.

Many modifications may be made in the details of the circuits of this invention without departing from the scope as defined in the appended claims. Whereas NPN type transistors are shown, it is feasible, of course, to employ PNP type transistors with appropriate changes in polarity of biasing sources.

What is claimed is:

1. In combination in a deflection system, two coaxial deflection coils;

a first and a second transistor said transistors having a common emitter circuit with output circuits, respectively, in series with said coils;

a direct current power source of a predetermined normal voltage, the transistor-coil circuits being connected in parallel across said power source;

a differential amplifier comprising third and fourth transistors with a common emitter circuit, a synchronizing pulse source coupled to said differential amplifier;

a feedback circuit connected between each coil and the out-of-phase control electrode of the third and fourth transistors to regulate current through said coils;

a current control transistor, the collector-emitter circuit of said control transistor being connected in the mentioned common emitter circuit of said differential amplifier, the control electrode of said control transistor being connected to the mentioned common emitter circuit of said first and second transistors so that transient voltages applied in phase to said coils does not disturb voltage-wise the conduction through either the transistor-coil circuit or the differential amplifiers.

2. In a high speed deflection system, a push-pull deflection yoke having two windings;

two power transistors, each transistor having an output circuit connected, respectively, in series with one of said windings, the winding-output circuits being connected in parallel across a power supply of predetermined operating voltage, said two power transistors having a common emitter circuit for combining in one circuit the yoke currents flowing in said windings;

a pair of differentially coupled amplifiers, each amplifier having an output circuit coupled, respectively, to the control circuit of one of said power transistors;

feedback circuits coupled between each deflection coil and the out-of-phase control electrode of said differential amplifier for controlling the linearity of the sweep voltage of said deflection system;

said pair of differential amplifiers having a common emitter circuit for differentially controlling the current through the amplifiers said common emitter circuit of the differential amplifier including the collector-emitter path of a current-controlling transistor; and

said current controlling transistor having a controlling electrode and means for applying a voltage to said electrode from said power-transistor common emitter circuit so that the voltage transients appearing in-phase on said yoke windings are degeneratively fed back through said differential amplifier to the control electrodes of said power transistors.

3. A high speed magnetic deflection system comprising two coextensive deflection coils;

a first and a second transistor with a first common emitter circuit and with output circuits, respectively, in series with said coils;

a direct current power source, the transistor-coil circuits being connected in parallel across said power source;

a differential amplifier comprising third and fourth transistors with a second common emitter circuit and with output circuits coupled, respectively, to the control electrodes of said first and second transistors;

two feedback circuits connected, respectively, between each coil and the out-of phase control electrode of the said differential amplifier to linearize current through said coils; and

said second common emitter circuit including the emitter-collector path of a constant current transistor, the base electrode of said constant current transistor being connected to said first common emitter circuit for in-phase feedback so that transient voltages applied to said coils from said voltage source during high speed flyback is balanced in said differential amplifier to prevent over-driving thereof.

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