Aug. 22, 1961 N. L. WEINBERG 2,997,644

BIAS CIRCUIT

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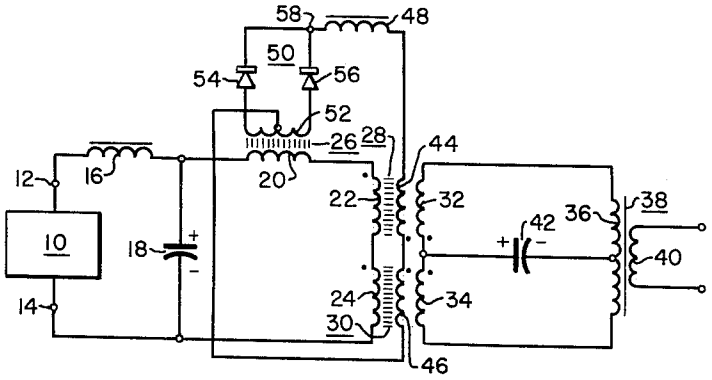


Fig. 1.

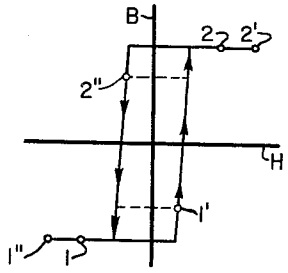


Fig. 2a.

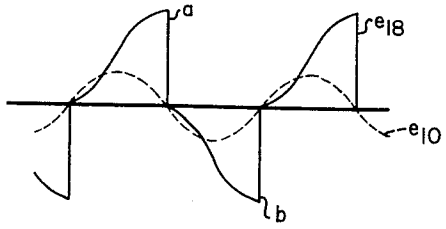


Fig. 2b.



Fig. 2c.

WITNESSES:

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BIAS CIRCUIT

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This invention relates to circuit means for biasing a saturable core transformer or the like and more particularly to a bias circuit of the type described in which the bias voltage is derived from the alternating current supply for the saturable transformer.

Prior to this invention the saturable cores of magnetic amplifiers and magnetic pulse generators were generally biased or reset by means of an external source of direct current voltage which was applied to a bias winding inductively coupled to the core. This method, although workable, has certain disadvantages in that it requires a separate source of bias voltage and a constant current bias circuit.

It is an object of this invention to provide a bias circuit of the type described above which dispenses with the need for an external source of direct current voltage.

More specifically, an object of the invention resides in the provision of means for rectifying a portion of the alternating current driving voltage for a saturable core transformer and for applying the resultant rectified voltage to other cores as a bias voltage.

The above and other objects and features of the invention will become readily apparent from the following detailed description taken in connection with the accompanying drawings which form a part of this specification and in which:

FIGURE 1 is a schematic circuit diagram of one embodiment of the invention shown in conjunction with a magnetic pulse generator;

FIG. 2*a* is an illustration of the rectangular hysteresis curve for the magnetic core material used in the transformers of the circuit shown in FIG. 1; and

FIGS. 2*b* and 2*c* are illustrations of voltage waveforms appearing across various components of the circuit of FIG. 1.

In FIG. 1, the bias circuit of the present invention is shown in conjunction with a magnetic pulse doubling circuit of the type described in copending application Serial No. 564,759 filed February 10, 1956, now Patent No. 2,814,737, issued November 26, 1957, and assigned to the assignee of the present application. It should be understood, however, that the bias circuit may be used with other and different circuitry to suit requirements.

Referring to FIG. 1, the circuit shown includes a source of alternating current voltage **10** having a pair of output terminals **12** and **14**. Connected in series between terminals **12** and **14** are a linear inductor **16** and a capacitor **18**. Capacitor **18** is, in turn, shunted by the primary windings **20**, **22** and **24** of saturable core transformers **26**, **28** and **30**, respectively. The cores of transformers **26–30** are formed from rectangular hysteresis loop material, hereinafter described.

The secondary windings **32** and **34** of transformers **28** and **30** are connected in a closed loop series circuit arrangement with the primary winding **36** of an output transformer **38**. Output signals from the generator are taken from across the secondary winding **40** of the transformer **38**. Connected between the midpoint of winding **36** and the junction of windings **32** and **34** is a capacitor **42**. As will be understood, inductor **16** forms an alternating current charging circuit with capacitor **18** resulting in a line-type magnetic pulser. The inductor **16** also acts as a high impedance to block the flow of energy

from capacitor **18** back into source **10** during discharge of capacitor **18**.

Inductively coupled to the cores of transformers **28** and **30** are tertiary bias windings **44** and **46**, connected in series as shown with an inductive choke **48** and a full-wave rectifier circuit, generally indicated at **50**. The rectifier circuit **50** comprises the secondary winding **52** of transformer **26** which has its midpoint connected to one end of the series-connected bias windings **44** and **46**, and its opposite ends connected through rectifiers **54** and **56** and choke **48** to the other end of the series-connected bias windings.

In the drawing the manner in which the windings of the transformers are wound about their associated cores is indicated by dots which represent points of like instantaneous polarity. Thus, if the dots are on the same end of the transformer core, the windings are wound around the core in the same direction; whereas, if the dots are on opposite ends of the core the windings are wound in opposite directions. It can be seen that windings **22** and **24** are wound so that the polarities at corresponding ends of the windings will coincide, whereas secondary windings **32** and **34** are wound so that the polarities at the corresponding ends of the windings will differ. Further, it should be noted that bias windings **44** and **46** are wound in opposite directions to bias the cores of transformers **28** and **30** oppositely.

Operation of the circuit shown in FIG. 1 may best be understood by reference to FIGS. 2*a*–2*c*. In FIG. 2*a* the rectangular hysteresis curve of the core material used in transformers **26–30** is shown. In accordance with well known magnetic theory, the quantity H represents the field intensity at any instant and is measured in ampere-turns per unit of core length. The quantity B represents the flux density at any instant and is measured in webers per square unit of core area. It can be seen that the core material presents a sharp cutoff point between conditions of saturation (i.e., low rate of increase of B as H increases) and unsaturation. When a reactor is saturated, it will experience a very great reduction in permeability and, consequently, in inductance; and the impedance across its windings will be greatly reduced. If an alternating current voltage is applied to the reactor, it may advance from point **1** on the charging cycle of FIG. 2*a* along the path of the arrows to point **2** and then back down the other side of the curve to point **1**. The cycle from point **1** to point **2** and back to point **1** represents one 360° cycle of the applied alternating current voltage. The location of points **1** and **2** depends upon the amplitude of the applied voltage. Consequently, if the amplitude of the applied voltage is small enough, saturation may never take place.

The field intensity H varies in direct proportion to ampere-turns which are, in turn, dependent upon applied voltage. Therefore, by applying a bias voltage of a particular value to a winding on the core member, it can be made to reach saturation in only one direction. Thus, if a direct current bias voltage of one polarity is applied to a winding on a core member, points **1** and **2** will be shifted to the right as indicated by the numerals **1'** and **2'**. Under these conditions the flux density will never reach saturation in the negative direction, provided the applied alternating current voltage is not increased in magnitude, but will follow the dotted line adjacent point **1'**. If a direct current bias voltage of the opposite polarity is applied, the core will saturate in the negative direction only as indicated by the points **1''** and **2''**. Obviously, the point in the cycle at which the core saturates will depend upon the magnitude of the applied bias voltage.

The bias voltages applied to the windings **44** and **46** have opposite polarities as shown, so that on one half cycle of the applied voltage from source **10**, the core of

transformer 28 will saturate while on the other half cycle the core of transformer 30 will saturate. Assuming that the polarity of voltage source 10 is such as to charge capacitor 18 with the polarity indicated, a point will be reached at which the core of transformer 26 will saturate to permit capacitor 18 to discharge into windings 22 and 24. The point in the charging cycle at which transformer 26 saturates will depend, in known manner, upon the magnitude of the applied voltage from source 10 and the time during which that voltage is applied.

Referring to FIG. 2*b*, showing the voltage waveform e_{18} across capacitor 18, it can be seen that at point (*a*) transformer 26 will saturate and will allow capacitor 18 to discharge into windings 22 and 24 to charge capacitor 42 with the indicated polarity. Since, during this part of the cycle, the voltages on the primary and bias windings of transformer 30 are additive, the transformer 30 will saturate before transformer 28 and allow capacitor 42 to discharge into the lower half of winding 36 to produce an output pulse across winding 40. On the next half cycle of the applied voltage source, capacitor 18 will be charged with a polarity opposite to that indicated in FIG. 1. At point (*b*) transformer 26 will again saturate and will permit capacitor 18 to discharge into windings 22 and 24 to charge capacitor 42 with the polarity opposite to that indicated in the drawing. During this half cycle, however, the voltages on the primary and bias windings of transformer 28, rather than transformer 30, are additive. Consequently, the transformer 28 will now saturate to permit capacitor 42 to discharge into the upper half of winding 36.

It should be apparent that the voltages appearing across the upper and lower halves of winding 36 during discharge of capacitor 42 are additive. That is, the polarity of the voltage at the top of the upper half of winding 36 when transformer 28 saturates will correspond to the polarity at the midpoint of winding 36 when transformer 30 saturates. A series of output voltage pulses of the same polarity will, therefore, appear across winding 40.

The voltage appearing across the primary and secondary windings of transformer 26 will correspond to that shown in FIG. 2*b*. Consequently, on one half cycle current will flow through rectifier 56 and choke 48 into bias windings 44 and 46; whereas, on the other half cycle current will flow through rectifier 54 and choke 48 into the bias windings. The voltage appearing at point 58 in the drawing is shown in FIG. 2*c*. It can be seen that it is a series of voltage pulses of one polarity. This resultant direct current is filtered by means of choke 48 which presents a high impedance to the alternating current components of the waveform and a low impedance to the direct current component so that the voltage appearing across bias windings 44 and 46 is a substantially constant direct current voltage. It will be noted that the currents through rectifiers 54 and 56 oppose each other in the secondary winding 52 of transformer 26, thus resulting in zero direct current in the transformer 26 as is required for biphase operation.

It can thus be seen that the present invention provides a simple and economical means for deriving a direct current bias voltage for a saturable core transformer from the alternating current driving source for the transformer.

Although the invention has been described in connection with a certain specific embodiment, it will be readily apparent to those skilled in the art that various changes in form and arrangement of parts may be made to suit requirements without departing from the spirit and scope of the invention.

I claim as my invention:

1. In apparatus of the type described, a saturable magnetic core member, first and second windings inductively associated with said core member, a source of alternating current voltage, circuit means including the primary winding of a saturable transformer device for applying said source of voltage across said first winding, and further circuit means for rectifying voltages appearing across the secondary winding of said saturable transformer device and for applying the resultant rectified voltage across said second winding.

2. In combination with a source of alternating current voltage, a saturable magnetic core member, first and second windings inductively associated with said core member, circuit means including the primary winding of a saturable transformer for periodically applying electrical energy from said source across the said one winding to drive said core member toward saturation, and circuit means for rectifying voltages appearing across the secondary winding of said saturable transformer and for applying the resultant rectified voltage across said second winding to bias the core member toward an unsaturated condition.

3. In combination, a saturable magnetic core member, winding means inductively coupled to said core member, circuit means including the primary winding of a saturable transformer for periodically driving said core member toward saturation, a pair of rectifiers in series connecting the opposite ends of the secondary winding of said saturable transformer, an inductive choke connecting the junction of said rectifiers to one terminal of said winding means, and a connection between the other terminal of said winding means and the midpoint of said secondary winding.

4. In combination with a source of alternating current voltage having a pair of output terminals, a capacitor connected across said output terminals, a saturable magnetic core member, first and second windings inductively associated with said core member, a saturable transformer having primary and secondary windings, circuit means connecting the primary winding of said saturable transformer and said first winding in series across the opposite terminals of said capacitor, and circuit means for rectifying voltages appearing across the secondary winding of said saturable transformer and for applying the resultant rectified voltage across said second winding to bias the saturable core member toward an unsaturated condition.

5. In combination with a source of alternating current voltage having a pair of output terminals, a capacitor connected across said output terminals, first, second and third saturable core transformers, primary and secondary windings for each of said transformers, circuit means connecting the primary windings of each of said transformers in series across said output terminals, tertiary bias windings for said second and third saturable core transformers, means for rectifying voltages appearing across the secondary winding of said first saturable transformer and for applying the resultant rectified voltage across the tertiary bias windings of said second and third saturable transformers, an output transformer having primary and secondary windings, means connecting the secondary windings of said second and third transformers in a closed loop series arrangement with the primary winding of said output transformer, and a capacitor connecting the midpoint of the primary winding of said output transformer to a point intermediate the secondary windings of said second and third saturable transformers.

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