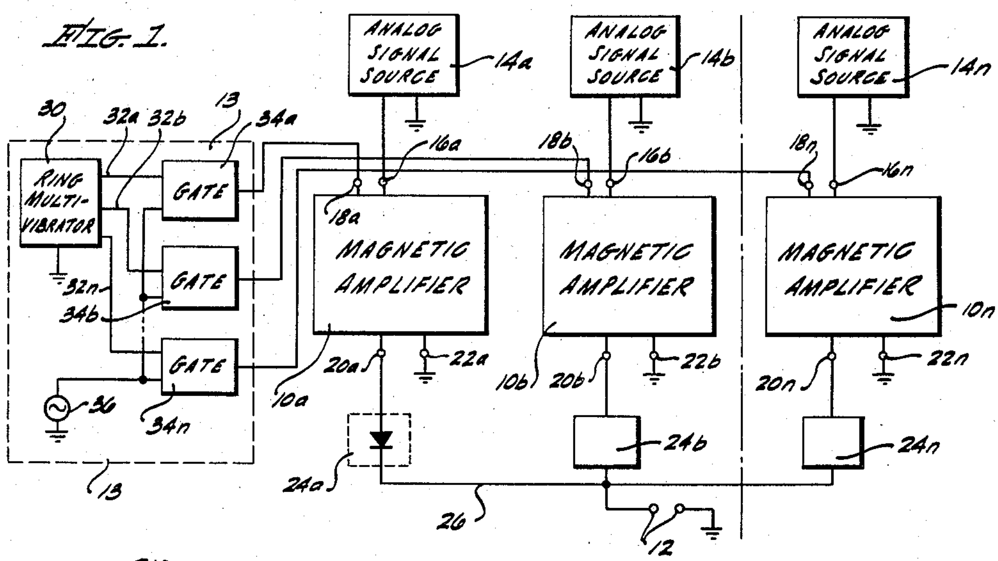
Sept. 2, 1958 J. O. BEAUMONT 2,850,725

ELECTRONIC HIGH SPEED MULTIPLEXING SYSTEM

Filed March 19, 1953

FIG. 1.



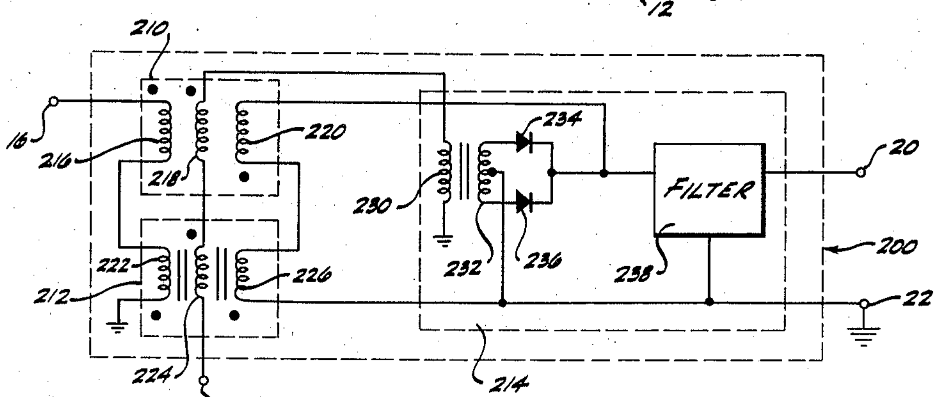


FIG. 2.

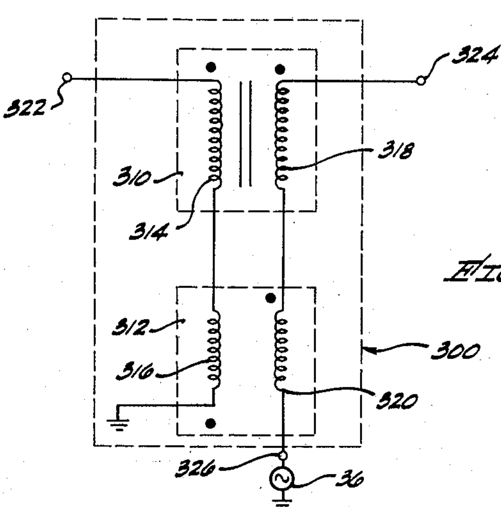


FIG. 3.

INVENTOR.

JAMES O. BEAUMONT,

BY

Seymour M. Rosenberg

ATTORNEY.

United States Patent Office

2,850,725

Patented Sept. 2, 1958

2,850,725

ELECTRONIC HIGH SPEED MULTIPLEXING SYSTEM

James Ormond Beaumont, Cupertino, Calif., assignor, by mesne assignments, to Hughes Aircraft Company, a corporation of Delaware

Application March 19, 1953, Serial No. 343,453

4 Claims. (Cl. 340—346)

This invention relates to an electronic high speed multiplexing system and more particularly to a multiplexing system which utilizes magnetic amplifiers for selectively passing one of a plurality of applied electrical analog signals.

In the electronics art it is often desirable to utilize a time-sharing or multiplexing system for selectively passing one of a plurality of applied electrical signals to a common electrical output circuit while simultaneously inhibiting the remaining signals from being applied to the common circuit. For example, in the electronic digital computer art it is common practice to utilize one analog-to-digital converter for converting a plurality of analog signals to corresponding electrical digital signals by sequentially applying each of the analog signals to the converter for counting the signals to their digital equivalents in predetermined time-sharing sequence.

In the prior art, one type of multiplexing system employs electromechanical relays or mechanical commutators for performing the selectivity operations, and therefore is inherently limited to relatively low speed operation and subject to excessive wear and mechanical failure. In addition, the reliability of such systems is decreased still further by such factors as arcing across the contacts, equipment vibration and dust conditions which produce open circuits or unreliable electrical contact.

In other prior art multiplexing systems the relays or commutators are replaced by vacuum tube circuits. Although the speed of operation of these systems is satisfactory, they are inherently limited by the inability of vacuum tube circuits to accurately reproduce direct-current voltage levels present in the applied analog signals, particularly when these voltage levels are of a relatively low order of magnitude. In addition, this type of prior art multiplexing system is subject to relatively frequent failure of its vacuum tube components and must of necessity be relatively expensive if it is desired to obtain even a modicum of fidelity in the reproduced analog signals.

The present invention, on the other hand, eliminates the above and other disadvantages of both types of prior art multiplexing systems while retaining the advantages of each. According to the fundamental concept of the present invention, a multiplexing system selectively passes a plurality of applied electrical analog signals by impressing the signals upon a corresponding plurality of magnetic amplifiers which are rendered operative in a predetermined sequence by applied time-sharing control signals.

More particularly, the multiplexing system of the present invention faithfully and almost instantaneously reproduces any preselected one of a plurality of analog signals by simultaneously applying the analog signals to a corresponding plurality of magnetic amplifiers and selectively energizing the magnetic amplifiers with a corresponding plurality of commutated or time-sharing alternating-current control signals, the sequence of operation of the amplifiers being determined by the commutation sequence of the alternating-current control signals. By utilizing magnetic amplifiers in which the magnitude of the output signal is substantially independent of relatively large variations in the magnitude of the control signal, the multiplexing system of this invention provides high fidelity multiplexing of the input signals under the control of a non-critical control signal. The output terminals of the magnetic amplifiers are then coupled to a common bus through associated isolation networks in order to provide, at any instant, a faithfully-reproduced electrical analog outlet signal corresponding to the analog signal being received by the operative magnetic amplifier.

It is, therefore, an object of this invention to provide a high-speed electronic multiplexing system for selectively and faithfully reproducing a plurality of applied electrical signals in a predetermined sequence.

A further object of this invention is to provide an electronic multiplexing system utilizing magnetic amplifiers for selectively reproducing a plurality of continuously-applied electrical signals as a signal train including a corresponding plurality of time-sharing or time-displaced electrical signals.

Another object of this invention is to provide an electronic multiplexing system which utilizes a plurality of sequentially operable magnetic amplifiers for selectively reproducing a corresponding plurality of applied electrical signals.

It is another object of this invention to provide an electronic multiplexing system which utilizes a plurality of magnetic amplifiers operable in response to a corresponding plurality of time-sharing control signals converting a plurality of applied electrical analog signals to a corresponding time-sharing variable-amplitude electrical output signal.

It is an additional object of this invention to provide an electronic multiplexing system utilizing magnetic amplifiers for converting a plurality of applied electrical analog signals into a corresponding plurality of faithfully-reproduced sequential time-displaced signals.

It is also an object of this invention to provide a multiplexing system which includes a plurality of magnetic amplifiers for receiving a corresponding plurality of electrical analog signals and which are operable in response to a corresponding plurality of sequential electrical control signals for producing at a single output circuit a corresponding plurality of time-displaced electrical output signals having magnitudes proportional to the magnitudes of the corresponding applied signals.

The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawings in which one embodiment of the invention is illustrated by way of example. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only, and are not intended as a definition of the limits of the invention.

Fig. 1 is a block diagram of the electronic multiplexing system, according to the present invention;

Fig. 2 is a schematic diagram of one form of magnetic amplifier suitable for use in the circuit of Fig. 1; and

Fig. 3 is a schematic diagram of one form of magnetic amplifier suitable for use as a gating circuit in the multiplexing system of Fig. 1.

Referring now to the drawings, there is shown in Fig. 1 an electronic multiplexing system, according to the present invention, which includes a plurality of magnetic amplifiers **10***a*, **10***b*, . . . **10***n* which are operable under the control of electrical control signals from a control signal source 13 for selectively and sequentially reproducing a plurality of electrical analog input signals, applied to the magnetic amplifiers from a plurality of analog signal sources 14*a*, 14*b*, . . . 14*n*, respectively, as a corresponding plurality of time-sharing or time-displaced electrical analog signals at a pair of output terminals 12.

Each of the magnetic amplifiers includes at least one input terminal 16, a control terminal 18 and two output terminals 20 and 22, respectively, these terminals of magnetic amplifiers 10*a*, 10*b*, . . . 10*n* being designated by the suffix letters *a*, *b*, . . . *n*, respectively. Input terminal 16 of each magnetic amplifier is connected to one output terminal of its associated analog signal source, another output terminal of each analog signal source being grounded. Similarly, output terminals 20*a*, 20*b*, . . . 20*n* of the magnetic amplifiers are connected to the input terminals of a corresponding plurality of respectively associated isolation networks 24*a*, 24*b*, . . . 24*n*, while output terminals 22*a*, 22*b*, . . . 22*n* are grounded. Each of isolation networks 24*a*, 24*b*, . . . 24*n* also include at least one output terminal which is connected to one terminal of output terminal pair 12 by a common bus 26, the other terminal of output pair 12 being grounded.

Each of magnetic amplifiers 10*a*, 10*b*, . . . 10*n* may be any of several suitable direct-current voltage to direct-current voltage magnetic amplifiers known to the art which are operable under the control of an alternating-current control signal for producing at their associated output terminals an output signal having an amplitude directly proportional to the amplitude of an applied signal. It will be recognized by those skilled in the art that the magnitude of the alternating-current control signal is not a critical parameter in the operation of magnetic amplifiers of this type. A more complete description of the operation of a typical direct-current voltage to direct-current voltage magnetic amplifier will be undertaken below in connection with Fig. 2.

Each of isolation networks 24*a*, 24*b*, . . . 24*n* may also be any of several suitable isolation circuits known to the art. For example, as illustrated by isolation network 24*a*, each isolation network may merely include a unidirectional current device such as a crystal rectifier having an anode connected to output terminal 20 of the associated magnetic amplifier and a cathode connected to output bus 26.

Control signal source 13 may be any suitable electrical circuit which is capable of producing a plurality of sequential time-sharing alternating-current signals for controlling the operation of magnetic amplifiers 10*a*, 10*b*, . . . 10*n*. As illustrated in Fig. 1, for example, control signal source 13 may include a ring multivibrator 30 having a plurality of output conductors 32*a*, 32*b*, . . . 32*n*, corresponding to magnetic amplifiers 10*a*, 10*b*, . . . 10*n*, respectively, upon which appear sequential time-sharing electrical square-wave signals. Ring multivibrator 30 also includes an associated control circuit, not shown, for controlling its sequence of operation.

Output conductors 32*a*, 32*b*, . . . 32*n* are connected to a first input terminal of each of a corresponding plurality of gating circuits 34*a*, 34*b*, . . . 34*n*, respectively, each gating circuit having a second input terminal connected to a common output terminal of an alternating-current signal source 36. In addition, each of the gating circuits includes at least one output terminal which is connected to control terminal 18 of the associated magnetic amplifier, while source 36 includes another output terminal which is grounded.

Each of gating circuits 34*a*, 34*b*, . . . 34*n* may be any suitable electronic gating device operable under the control of a two-level or square-wave signal from ring multivibrator 30 for selectively passing the alternating-current signal from source 36 to produce a corresponding alternating-current signal at its output terminal. Since the

magnitude of the alternating-current control signals applied at control terminals 18*a*, 18*b*, . . . 18*n* is not a critical parameter in the operation of the multiplexing system of the present invention, the gating circuits may merely include conventional vacuum tube or crystal rectifier circuits. On the other hand, the gating circuits may, if desired, include a different type of magnetic amplifier as will be described later in connection with Fig. 3.

In order to most clearly describe the operation of the multiplexing system shown in Fig. 1, it will be assumed that the square-wave signals which appear on output conductors 32*a*, 32*b*, . . . 32*n* from ring multivibrator 30 are normally at a relatively low-level voltage and that each signal, in the desired sequence, swings to its relatively high-level voltage and then back to its low-level voltage. In addition, it will be assumed that gating circuits 34*a*, 34*b*, . . . 34*n* are operable in response to a high level voltage from multivibrator 30 for passing to its associated output terminal the alternating-current signal applied from source 36.

Assume now that each of analog signal sources 14*a*, 14*b*, . . . 14*n* applies an electrial analog signal to the associated magnetic amplifier and that it is desired to multiplex these signals in sequence through magnetic amplifiers 10*a*, 10*b*, . . . 10*n* to produce at output terminal pair 12 a signal train including a corresponding plurality of sequential time-sharing or time-displaced electrical output signals having magnitudes directly proportional to the magnitudes of the corresponding analog input signals, respectively.

In operation, gating circuit 34*a* will pass the alternating-current signal from source 36 in response to a high-level voltage on output conductor 32*a*. Magnetic amplifier 10*a* is thereby rendered operative to produce at output terminal 20*a* an output signal having a magnitude directly proportional to the magnitude of the analog signal applied to magnetic amplifier 10*a* from analog signal source 14*a*. Since the square-wave signals applied to conductors 32*b*, . . . 32*n* are at their low-level voltage when the signal on conductor 32*a* is at its high-level voltage, it is clear that gating circuits 34*b*, . . . 34*n* will inhibit the alternating-current control signal from passing therethrough, thus maintaining magnetic amplifiers 10*b*, . . . 10*n* inoperative. Accordingly, it may be seen that an output signal will appear only at output terminal 20*a* of magnetic amplifier 10*a*.

Consider now the functioning of isolation networks 24*a*, 24*b*, . . . 24*n* when an output signal is produced by magnetic amplifier 10*a*. It will be shown later that depending upon the internal electrical connections, the magnetic amplifiers may produce an output signal which is either positive or negative with respect to ground. However, when the polarity of the unidirectional devices or diodes in the isolation networks is as shown in network 24*a*, it will be assumed that the magnetic amplifiers are connected to produce positive output signals when rendered operative.

As the voltage at output terminal 20*a* rises above ground potential, the diode in isolation network 24*a* is front biased, thereby raising the potential of bus 26 accordingly. Simultaneously the diodes in isolation networks 24*b*, . . . 24*n* are back biased to ground through the output circuits of their respective magnetic amplifiers, and thus present a high impedance to the output signal from magnetic amplifier 10*a*. Accordingly, it may be seen that the output impedance of the multiplexing system or, in other words, the impedance looking into output terminal pair 12, is substantially equal to the forward impedance of isolation network 24*a* plus the output impedance of magnetic amplifier 10*a*. It is clear, therefore, that the multiplexing system of the present invention provides an electrical output signal which is not attenuated or distorted by the impedance of the unenergized multiplexing channels, thereby preserving in the multiplexing system the inherent linearity and fidelity of reproduction of a single magnetic amplifier.

After magnetic amplifier **10a** has produced an output signal for a predetermined time interval, ring multivibrator **30** functions to lower the potential of the signal on conductor **32a** to its normal or low-level value, and raises the potential of the signal on conductor **32b** to its high-level value. At this instant, the control signal is removed from control terminal **18a** of magnetic amplifier **10a** and applied to control terminal **18b** of magnetic amplifier **10b**. Accordingly, a time-sharing or time-displaced electrical output signal, corresponding in amplitude to the signal presented by analog signal source **14b**, will appear at output terminal pair **12**.

It is clear, therefore, that as ring multivibrator **30** sequentially switches from one conduction state to the succeeding conduction state, the signal appearing at any instant at output terminal pair **12** will correspond to the analog input signal which is applied to the operative magnetic amplifier. In addition, it is clear that the use of a ring multivibrator or a ring counter in control signal source **13** provides cyclical operation of the multiplexing system, or, in other words, switches the system, at the end of each multiplexing cycle, from magnetic amplifier **10n** back to magnetic amplifier **10a**.

It should be understood, of course, that the component structure of control signal source **13** may include other circuit arrangements than the one shown in Fig. 1 and that the multiplexing system of the present invention is not to be limited to the control circuit which is illustrated.

It may be recalled that each of magnetic amplifiers **10a**, **10b**, . . . **10n** may be any of several suitable direct-current voltage to direct-current voltage magnetic amplifiers known to the art. Referring now to Fig. 2 there is shown a typical magnetic amplifier, generally designated **200**, which may be utilized in the multiplexing system of the present invention.

Magnetic amplifier **200** includes three basic components, namely, two tertiary winding saturable core devices **210** and **212**, respectively, and an output circuit **214**. Saturable core device **210** includes an input winding **216**, a control winding **218** and a feedback winding **220**, these windings having polarities with respect to each other as indicated by the black dots at the ends of the windings. Similarly, saturable core device **212** includes an input winding **222**, a control winding **224**, and a feedback winding **226**, having polarities with respect to each other as shown by the black dots at the ends of the windings. In addition, the wire sizes, number of turns and magnetics paths of the input, control and feedback windings in saturable core device **212** are identical to those of the corresponding windings in saturable core device **210**.

One end of input winding **216** of saturable core device **210** is connected to one end of input winding **222** of saturable core device **212** in series-subtractive as indicated by the dots, the other end of winding **216** being connected to input terminal **16** while the other end of winding **222** is grounded. One end of control winding **218** of saturable core device **210** is connected to one end of control winding **224** of saturable core device **212** in series-additive as indicated by the dots, the other end of winding **224** being connected to control terminal **18** while the other end of winding **218** is connected to ground through a primary winding **230** of an output transformer in output circuit **214**.

The output transformer in output circuit **214** also includes a center-tapped secondary winding **232** which is connected across a full wave rectifying circuit including two unidirectional current devices or diodes **234** and **236**. When diodes **234** and **236** are polarized as shown in Fig. 2, or in other words, have their cathodes connected together, the output signal from magnetic amplifier **200** will have positive polarity. If, on the other hand, the polarity of diodes **234** and **236** is reversed, magnetic amplifier **200** will produce a negative output signal.

The common junction of diodes **234** and **236** is connected to one input circuit of a filter network **238** and in feedback relationship to one end of feedback winding **220** of saturable core device **210**. The other end of winding **220** is connected to one end of feedback winding **226** in saturable core device **212** in series-additive as indicated, the other end of winding **226** being connected to the center tap in secondary winding **232** of the output transformer. The center tap in winding **232** is also connected to another input circuit of a filter network **238** and to output terminal **22**, which, as shown in Fig. 1, is grounded. Output terminal **20**, on the other hand, is connected to the output circuit of filter network **238**.

In operation, the application of an analog input signal at terminal **16** produces a current through primary windings **216** and **222**, thereby producing magnetic flux in their respective saturable cores. The magnitude of the flux in the saturable cores, in turn, controls the impedance of control windings **218** and **224**, the relationship between this flux and the control impedance being substantially linear. Accordingly, the application of an alternating-current control signal at control terminal **18** produces a full-wave rectified signal at the common junction of unidirectional current devices **234** and **236**, the magnitude of this signal being proportional to the effective impedance presented to the applied control signal by control windings **218** and **224**.

It will be noted that the respective polarities of the input and control windings of saturable core devices **210** and **212** provide a cancellation network to prevent the alternating-current control signal from feeding back into the applied analog signal. In other words, any alternating-current signal induced in input winding **216** of saturable core device **210** will be cancelled out by an induced signal of identical magnitude and opposite polarity in input winding **222** of saturable core device **212**.

It has been stated previously that the magnetic amplifiers utilized in the multiplexing system of the present invention are relatively insensitive to amplitude variations in the applied alternating-current control signal, and are essentially responsive only to the presence of a commutated control signal for selectively reproducing an applied analog input signal. This feature is provided in magnetic amplifier **200** by the magnetic feedback circuit including feedback windings **220** and **226** which coact to compensate for output signal variations due to amplitude variations in the control signal. In this manner, an essentially linear relationship exists between the magnitudes of the input signal to the magnetic amplifier and the output signal therefrom, irrespective of relatively large variations in the magnitude of the control signal.

The rectified signal which appears at the junction of unidirectional current devices **234** and **236** is then filtered by filter circuit **238** to provide at output terminal **20** an electrical analog output signal which varies in accordance with variations in the analog signal applied at input terminal **16**.

It is obvious, of course, that the magnetic amplifiers utilized in the multiplexing system of the present invention may be operated to provide a voltage gain of unity, or, on the other hand, may be utilized to amplify the applied signals by a predetermined scale factor. In applications where the magnitudes of the applied analog input signals are relatively low, it often has been found preferable to utilize the amplification characteristics of the magnetic amplifiers in this manner. It is to be expressly understood, however, that the magnetic amplifier shown in Fig. 2 is merely illustrative of numerous magnetic amplifiers which are suitable for the multiplexing system of this invention, and should not be construed as limiting the scope of this invention.

It may be recalled that gating circuits **34a**, **34b**, . . . **34n** in control signal source **13** may also employ magnetic amplifiers, if desired, to produce commutated or time-sharing alternating-current control signals under the control of the square-wave signals applied over conductors 32*a*, 32*b*, . . . 32*n* from ring multivibrator 30. Referring now to Fig. 3, there is shown a magnetic amplifier, generally designated 300, which may be employed as a gating circuit in control signal source 13.

Magnetic amplifier 300 includes two saturable-core devices 310 and 312, respectively, comprising input windings 314 and 316, respectively, and output windings 318 and 320, respectively. The number of turns, wire sizes and magnetic paths of windings 314 and 318 in saturable core device 310 are identical to those of the corresponding windings in saturable core device 312.

One end of winding 314 of saturable core device 310 is connected to a control terminal 322 for receiving a square-wave control signal, the other end of winding 314 being connected to one end of winding 316 of saturable core device 312. The other end of winding 316 is, in turn, grounded. Similarly, one end of output winding 318 of saturable core device 310 is connected to an output terminal 324, the other end of winding 318 being connected to one end of output winding 320 of saturable core device 312. The other end of winding 320 is, in turn, connected to an input terminal 326 for receiving the alternating-current signal from source 36, which corresponds to the similarly designated alternating-current signal source illustrated in Fig. 1. In addition, when the windings of saturable core devices 310 and 312 are connected as illustrated and described, their relative polarities are as indicated in the drawings by the black dots at the ends of the windings.

Assume now that the square-wave signal received at control terminal 322 swings between ground potential and a relatively high-level voltage. In operation, when the control signal is at its low-level value, or, in other words, when control terminal 322 is grounded, output windings 318 and 320 present a relatively high impedance to the passage of the alternating-current input signal applied at input terminal 326. On the other hand, when the square-wave signal applied at control terminal 322 swings to its high-level value, the resultant flux in the magnetic cores of devices 310 and 312 produces a concomitant decrease in the effective impedance of output windings 318 and 320, thereby permitting the applied alternating-current input signal to pass relatively unattenuated. Accordingly, it is clear that magnetic amplifier 300 selectively passes or inhibits the applied alternating-current signal in accordance with the instantaneous voltage level of the applied square-wave control signal.

It will be recognized, of course, that magnetic amplifier 300 is merely illustrative and that numerous other electronic circuits utilizing vacuum tubes, crystal rectifiers, or different forms of magnetic amplifiers may be employed in the gating circuits of control signal source 13.

What is claimed as new is:

1. In an electronic multiplexing system a plurality of magnetic amplifiers each having an input winding, a control winding and a feed back winding, means for applying an analog signal to the input winding of each of said magnetic amplifiers, means for sequentially applying a control signal to the control winding of each of said magnetic amplifiers effective for providing an output signal having an amplitude proportional to the amplitude of the applied analog signal, a corresponding plurality of output transformers each having primary and secondary windings, said primary windings being conductively connected in series circuit relationship with the control winding for the corresponding magnetic amplifier, a full wave rectifying circuit connected across the secondary winding of said output transformer, a filter network coupled to said full wave rectifier to receive the output signal therefrom, circuit connections for said feed back winding intermediate said full wave rectifier and said filter to balance out the variations in the control signal, a common output circuit for said magnetic amplifiers, and isolating means interconnecting said filter networks with said output circuits.

2. In an electronic multiplexing system, a plurality of magnetic amplifiers, each of said magnetic amplifiers comprising a pair of saturable cores each having an input winding and a control winding coupled thereto, said input windings for each of said magnetic amplifiers being connected in series subtractive relationship, said control windings for each of said magnetic amplifiers being connected in series additive relationship, means for applying an analog input signal to the input windings of each of said magnetic amplifiers, means for sequentially applying a control signal to the control windings of each of said magnetic amplifiers, an output transformer for each of said magnetic amplifiers having a primary winding and a secondary winding, the primary winding of said output transformer being connected in series circuit relationship with said control windings, a full wave rectifier connected across said secondary winding of said output transformer, a filter network coupled to said full wave rectifier to receive the output signal therefrom, a common output circuit for said magnetic amplifiers, and circuit means including isolation means coupled between said output circuit and the secondary coil of said output transformer.

3. In an electronic multiplexing system, a plurality of magnetic amplifiers, each of said magnetic amplifiers comprising a pair of saturable cores each having an input winding and a control winding coupled thereto, said input windings for each of said magnetic amplifiers being connected in series-subtractive relationship, said control windings for each of said magnetic amplifiers being connected in series-additive relationship, means for applying an analog signal to the input windings of each of said magnetic amplifiers, means for sequentially applying a control signal to the control windings of each of said magnetic amplifiers, an output transformer for each of said magnetic amplifiers having a primary winding and a secondary winding, the primary winding of said output transformer being connected in series circuit relationship with said control windings, a full wave rectifier connected across said secondary winding of said output transformer, a filter network coupled to said full wave rectifier to receive the output signal therefrom, and a common output circuit coupled to each of said filter networks for said magnetic amplifiers.

4. In an electronic multiplexing system, a plurality of magnetic amplifiers, each of said magnetic amplifiers comprising a pair of saturable cores each having an input winding, a control winding and a feed back winding coupled thereto, said input windings for each of said magnetic amplifiers being connected in series subtractive relationship, said control windings for each of said magnetic amplifiers being connected in series additive relationship, said feed back windings for each of said magnetic amplifiers being connected in series additive relationship, means for applying an analog input signal to the input windings of each of said magnetic amplifiers, means for sequentially applying a control signal to the control windings of each of said magnetic amplifiers, an output transformer for each of said magnetic amplifiers having a primary winding and a tapped secondary winding, the primary winding of said output transformer being connected in series circuit relationship with said control windings, a full wave rectifier connected across said secondary winding of said output transformer, a filter network coupled to said full wave rectifier to receive the output signal therefrom, circuit means coupled to and arranged with said feed back winding between the tap of siad output transformer and a point intermediate said rectifier and said filter network to provide a negative

feedback loop, and a common output circuit coupled to each of said filter networks for said magnetic amplifiers.

References Cited in the file of this patent

UNITED STATES PATENTS

1,946,297	Suits	Feb. 2, 1934
1,962,335	Wensley	June 12, 1934
2,332,300	Cook	Oct. 19, 1943
2,369,662	Deloraine et al.	Feb. 20, 1945
2,615,066	Milne	Oct. 21, 1952
2,640,164	Giel et al.	May 26, 1953
2,644,933	Peterson et al.	July 7, 1953

OTHER REFERENCES

"A Multichannel PAM-FM Radio Telemetering System," Proceedings of the I. R. E., January 1951, pages 36–43.