June 14, 1960 J. J. HESS, JR 2,941,163

MAGNETO-RESISTIVE BRIDGE MODULATOR

Filed June 16, 1954

3 Sheets-Sheet 1

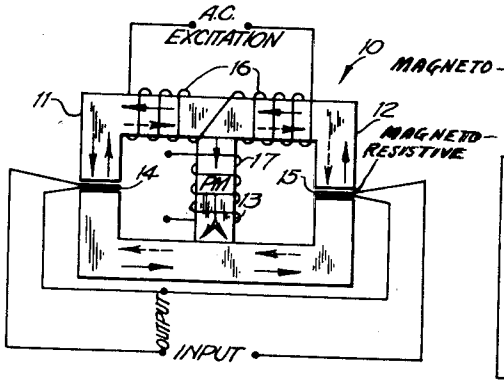


Fig. 1.

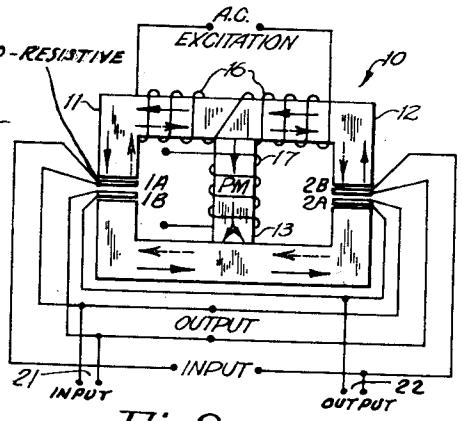
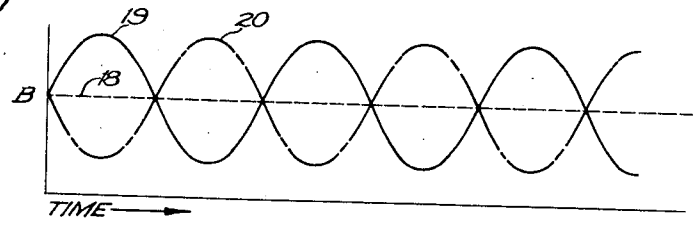


Fig. 2.

Fig. 3.



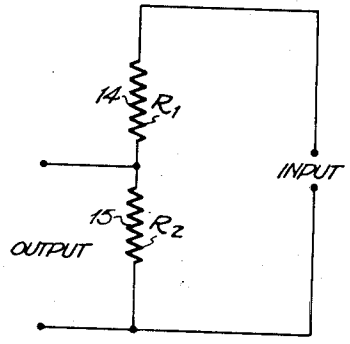


Fig. 4.

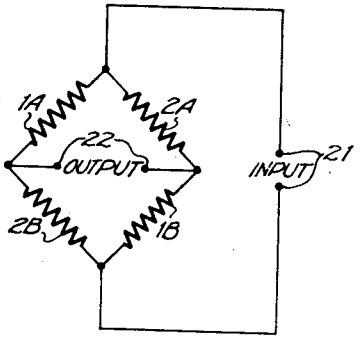


Fig. 5.

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Fig. 6.

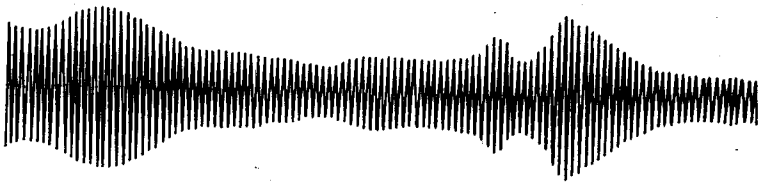


Fig. 7.

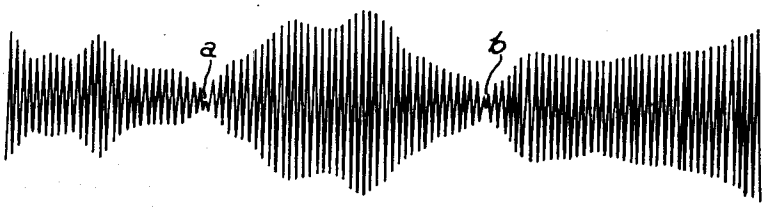


Fig. 8.

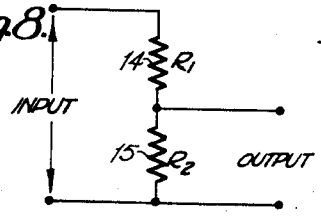


Fig. 11.

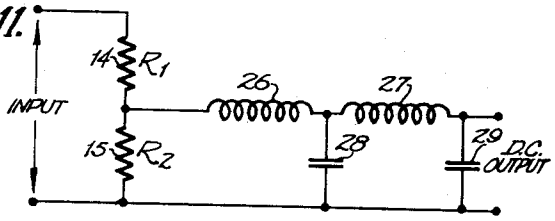
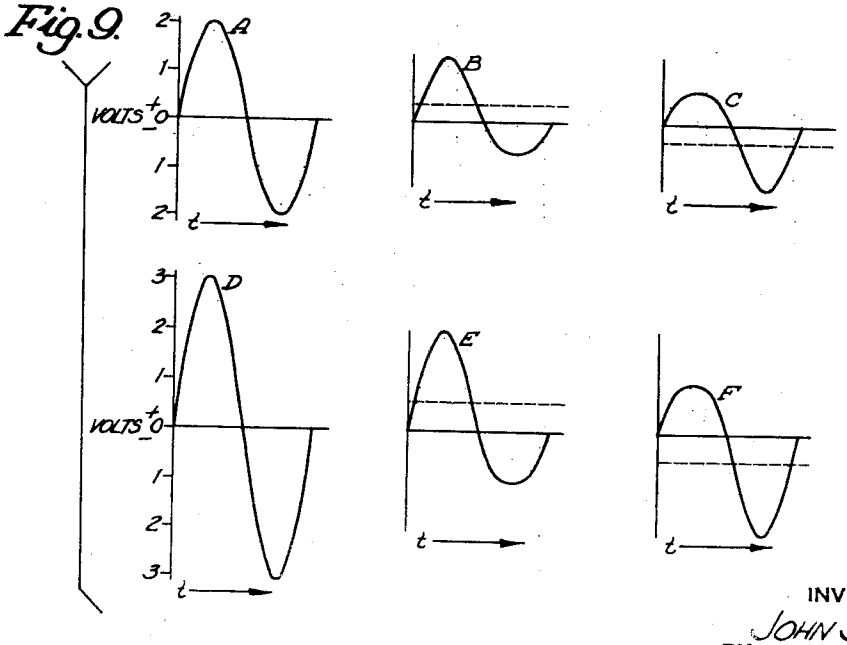


Fig. 9.



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MAGNETO-RESISTIVE BRIDGE MODULATOR

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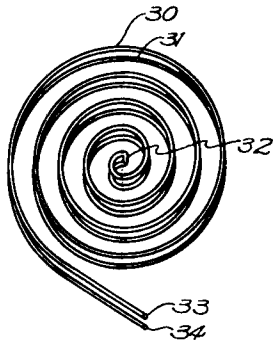

Fig. 12.

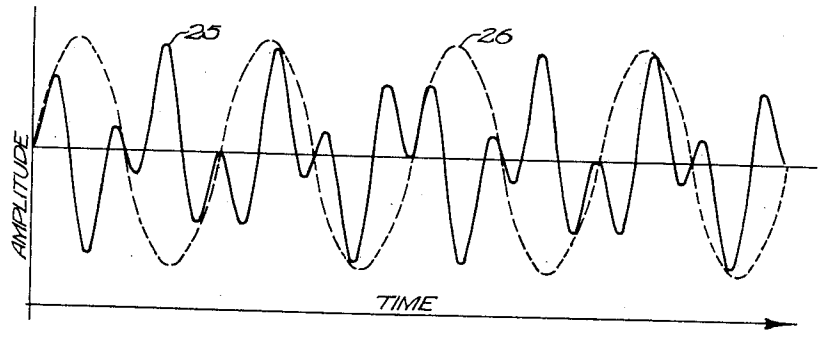

Fig. 10.

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MAGNETO-RESISTIVE BRIDGE MODULATOR

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Filed June 16, 1954, Ser. No. 437,039

15 Claims. (Cl. 332—51)

This invention pertains to a modulating or demodulating device. More particularly, the present invention is concerned with a novel arrangement of electrical conductors placed in magnetic fields so as to be responsive to variations in magneto motive force exerted about them.

Various materials are known which, when placed in a magnetic field of changing flux density, have the property of changing resistive value in response thereto. This magneto-resistive characteristic is found in a number of diamagnetic materials, such as bismuth, for example, and is also found in certain ferromagnetic materials such as "Permalloy."

The effect of a change in flux density upon the resistive value of a material placed in a magnetic field is well known and has been utilized in a variety of ways. The term magneto-resistive is used herein to described such characteristic and also to designate materials possessing that characteristic.

Employing the magneto-resistive response of that type of material, the present invention contemplates effecting either modulation or demodulation in accordance with the form of input impressed upon the device and the output desired therefrom. Moreover, in addition to affording a means of producing an alternating current output of selectable frequency modulated in accordance with the amplitude of a direct current input signal (which is a usual requirement of modulators), the present invention may also be used to produce an alternating current output of a first selectable frequency modulated in accordance with a second input alternating signal.

The principal object of the present invention is to effect fail-safe modulation or demodulation of an input signal.

This and other objects and features of the invention will appear more fully from an understanding of the operation of the embodiments illustrated in the drawings in which:

Fig. 1 is a schematic illustration of a preferred embodiment of the present invention;

Fig. 2 is a schematic illustration of a preferred bridge-connected embodiment of the present invention;

Fig. 3 is a diagram illustrating the flux density, B, which acts upon the magneto-resistive elements in a typical embodiment of the present invention;

Fig. 4 is a schematic representation of an arrangement of magneto-resistive elements which may be used in an embodiment of the present invention;

Fig. 5 is a schematic representation of a bridge arrangement of magneto-resistive elements which may be used in an embodiment of the present invention;

Fig. 6 is an illustration of one typical output waveform of the present invention when it is used as a modulator;

Fig. 7 is an illustration of another typical output waveform of the present invention when used as a modulator showing the suppressed carrier modulation;

Fig. 8 is a schematic diagram of an arrangement of magneto-resistive elements in an embodiment of the present invention when used as a demodulator;

Fig. 9 is an illustrative example of the waveforms applied to and developed by the magneto-resistive elements of Fig. 8;

Fig. 10 is an illustrative example of a first alternating current input as modulated by a second alternating current input of different frequency when applied to apparatus operating in accordance with the present invention;

Fig. 11 is an illustration of a form of filter which may be employed with the present invention when it is used as a demodulator; and

Fig. 12 is a perspective view of a form of non-inductive, bifilar coil of magneto-resistive material which may be used in an embodiment of the present invention.

The resistivity of a magneto-resistive material will change considerably when it is in a magnetic field in which the flux density is changing. There is a predictable correlation between the change in flux density and the change of resistivity of a magneto-resistive material, and in the disclosure which follows, reference will be made to a preferred embodiment of the present invention wherein the metal bismuth may be employed as the magneto-resistive material. The practice of the present invention, however, is in no sense limited to the use of bismuth as the magneto-resistive material, but any suitable element or substance having similar characteristics may be employed depending upon the requirements of the particular application.

Referring now to Fig. 1, it may be seen that in the preferred embodiment illustrated there are two magnetic paths having a portion in common. These paths are comprised of a core **10** having outer legs **11** and **12** and a central leg **13** disposed as illustrated. Magneto-resistive conductors **14** and **15** are positioned in each of the magnetic paths and these conductors are connected so as to receive the input and produce the output of the device when it is used as either a modulating or demodulating device. It will be noted that the central leg **13** of the embodiment of Fig. 1, which comprises the common portion of the two magnetic paths, is indicated to be composed of a permanently magnetized material.

Alternating current excitation is applied to the two paths by an appropriate winding **16**. The solid arrows on the outer core structure indicate the direction of flux produced by one half-cycle of the alternating current excitation, and the dash-line arrows represent the direction of flux generated in the outer portion of the core by alternate half-cycles of the alternating current excitation. The directions of the fluxes are arbitrarily chosen for purposes of illustration and are not to be understood to be limitations upon the signals which may be applied to the device nor its operation in accordance with principles and objects of the present invention.

In the central leg of the structure of Fig. 1, the solid arrows indicate the unidirectional flux generated by the permanent magnetization of that portion of the core. The permanent magnet may of course be readily replaced by a simple core element which is excited by other means so as to generate a unidirectional magnetic flux. An appropriate winding **17** connected to a source of direct current, for instance, may accomplish this end.

It will be seen from Fig. 1 that the flux which originates in the central leg of the structure, because of its unidirectional nature, divides as indicated by the split arrows and passes through each of the two magnetic paths to return to its origin. Thus, in the example illustrated, the flux which originates in the central leg will pass through both of the outer legs in an upward direction. The alternating current excitation flux, however, will pass only through

the outer portion of the structure and will change direction each half-cycle.

In a magnetic sense the points where the central portion of the more meet the outer portion of the core may be said to be at zero alternating current magneto motive force, and therefore, no alternating flux will flow through the central leg though the unidirectional flux does so. So far as the alternating flux is considered, the two points where the central leg meets the outer core structure may be thought of as having equal alternating magneto motive force at all times.

Thus, on one half-cycle the alternating current flux represented by the solid arrow on the left-hand portion of the structure will oppose the unidirectional flux originating in the central portion of the core. In the right-hand portion of the structure, the alternating current flux represented by the solid arrow aids the unidirectional flux orignated in the central portion of the core. It is therefore evident that during one half-cycle, a magnetic field of decreased intensity exists in the left-hand portion of the structure, while the magnetic field in the right-hand portion of the structure is increased in intensity. On alternate half-cycles the converse is true, and the alternating current flux in the left-hand portion of the structure aids the unidirectional flux while the alternating current flux in the right-hand part of the structure opposes the unidirectional flux.

In response to these changes in flux intensity, magneto-resistive conductors placed in either of the two magnetic paths will have alternating or push-pull resistive values, and it is therein that some of the most desirable features and aspects of this invention are originated and realized.

The illustration of Fig. 3 shows the manner in which the flux density of each of the magnetic paths of a preferred embodiment of the present invention will vary during typical operation. The straight dash line **18** represents the unidirectional flux which originates in the central leg of the structure. The solid sinusoidal waveform **19** represents the resultant flux in one of the magnetic paths due to the alternating current excitation, while the broken line sinusoidal waveform **20** illustrates the resultant flux in the other magnetic path due to the alternating current excitation. This diagram is intended to graphically depict the ideal push-pull variation of the magnetic field in accordance with the concept and objects of the present invention.

If a unidirectional flux were not used, the alternating current flux would cause a change of flux density at twice the frequency of the alternating current excitation source, and push-pull operation could not be achieved. This is so because the magneto-resistive conductors are insensitive to the direction of the flux and respond only to the flux density. Thus a unidirectional flux is provided which establishes a sufficient bias as a quiescent operating point about which the alternating current excitation will cause a flux to alternately change in flux density. It is also important that the unidirectional flux bias be of sufficient magnitude so that the alternating current flux does not completely cancel the unidirectional flux to cause a change of direction of net resultant flux.

When a permanently magnetized material is used to generate the unidirectional flux, the direction of such flux is fixed. However, if a direct current winding is used to generate unidirectional flux, a change in the polarity of the direct current will cause a flux to be generated of opposite direction with the result that the output of the modulator will be changed 180° in phase.

It is also possible to utilize a direct current winding on a permanently magnetized central leg of a device such as that illustrated at **17** in Fig. 1. A means is thus afforded by which the magnetic bias of the device may be changed by external control. If, for instance, an unregulated alternating current excitation source is used and it also is desired to insure that the excitation alternations will not exceed the magnetic bias, a portion of excitation source may be rectified and applied to an auxiliary bias winding to assure sufficient bias level at all times. This arrangement effects an automatic self-regulation of magnetic bias.

Another use of such an auxiliary winding is the adjustment of gain of the device to compensate for temperature changes which effect the magneto-resistive characteristics of the conductors placed in the magnetic paths.

Assuming that only the permanently magnetized central leg of the device illustrated in Fig. 1 is used as a source of unidirectional flux, if one magneto-resistive conductor is placed in each of the two magnetic paths, they may be arranged and connected as shown schematically in Fig. 4 in which the resistances R_1 and R_2 represent magneto-resistive conductors. With such an arrangement, it may be seen that if a direct current potential is applied across the input terminals, it will normally divide equally between the two resistances R_1 and R_2 if those resistances are of equal value. Assuming that these resistances R_1 and R_2 are normally of equal value when not subject to any extraneous effect, an input signal of ten volts, for instance, will cause a voltage drop of five volts across each of the resistances. If, however, these resistances are in the form of magneto-resistive conductors and are placed in two magnetic paths of a core structure such as that shown in Fig. 1, an alternating current excitation applied in accordance with the teaching of the present invention will change the magnetic fields in intensity at the frequency of the alternating current excitation and the resistive values of the two diamagnetic conductors will be caused to change in push-pull fashion.

Assuming that during one alternation of the alternating current excitation flux, the resistance of conductor R_1 will be increased by 10 percent and the resistance of conductor R_2 will be decreased by 10 percent, the voltage drop of 5.0 volts across conductor R_1 will be increased by 10 percent to approximately 5.5 volts, while that of resistance R_2 will be decreased by 10 percent to approximately 4.5 volts. Output terminals connected across either of the two resistors R_1 or R_2 will reflect a changing output which will alternate in response to the alternating current excitation applied to the device and which will have an amplitude in accordance with the amplitude of the applied input. It is evident of course that the instantaneous total voltage drop across both the conductors R_1 and R_2 is always equal to the instantaneous total potential of the input.

The embodiment illustrated in Fig. 2 is a bridge circuit in which four magneto-resistive conductors are used. Portions of this embodiment which are analogous to those of Fig. 1 bear the same numerical identification as in Fig. 1. Fig. 5 schematically shows the arrangement and interconnection of the bridge. In this embodiment conductors **1A** and **1B** are placed in one of the two magnetic paths, and conductors **2A** and **2B** are placed in the other magnetic path. As indicated in Fig. 5, the input is applied across input terminals **21** which are in turn connected to opposite junctions of the bridge. The output is derived from the remaining two opposite junctions from the bridge at output terminals **22**. This arrangement affords an enhanced push-pull output in accordance with the present invention by which the resistive values of conductors **1A** and **1B** may be caused to increase while the resistive values of conductors **2A** and **2B** are simultaneously caused to decrease. An output is thus realized which is responsive to the frequency and amplitude of the applied alternating current excitation and dependent upon the amplitude of the input signal as well.

Fig. 6 illustrates the waveform of the output realized in a typical application of an embodiment of the present invention. In this case the input is a randomly changing direct current signal and the alternating current excitation may be of 400 cycle frequency, for example. The output which will be realized is thus a 400 cycle waveform

which takes a form not unlike a "carrier" which is amplitude modulated in response to the direct current input signal.

Fig. 7 illustrates an output much the same as that of Fig. 6 in that it also may be of 400 cycle frequency. However, it should be noted that the output waveform is modulated beyond the zero modulation level and this is indicated by a 180° change of phase of the "carrier" as the zero modulation level is exceeded. This is illustrated graphically at points *a* and *b* of Fig. 7 and is known as suppressed carrier modulation in the art.

Fig. 10 is an illustration of the output waveform realized from two alternating current inputs such as 1000 and 400 cycle frequencies, for instance. This latter figure is drawn to a different scale from that of Figs. 6 and 7 to more clearly illustrate the relationship between the two frequencies. The solid-line waveform **25** represents the 1000 cycle frequency as modulated by the lower frequency and the dash-line waveform **26** indicates the 400 cycle modulation envelope. From this illustration it may be seen that the present invention is not limited to accepting one alternating potential as an excitation source and one direct current signal as applied to the input terminals. The alternating excitation may be applied to either pair of terminals which have hereinbefore been referred to as the input terminals or the excitation terminals. The remaining pair of terminals may be connected to receive yet another alternating signal and the output produced will be a form of the higher frequency alternating signal modulated in accordance with the lower frequency alternating signal. In a similar manner two input signals of the same frequency may be applied to apparatus operating in accordance with the present invention so as to produce an output correlated to the amplitude and phase relation of the inputs. The device thus has the desirable feature of adaptability and versatility in use.

As is the case with many modulator devices, typical embodiments of the present invention may be employed to operate as a demodulator as well as a modulator. The concept of the present invention embraces the converse use effecting efficiency and reliability comparable to modulator operation. Fig. 8 illustrates the arrangement and connection of conductors R_1 and R_2 in a two-conductor embodiment of the present invention when it is used as a demodulator. It will be noted that this arrangement is precisely the same as that of Fig. 4 which illustrates the arrangement and connection of a device constructed in accordance with the present invention when it is to be used as a modulator.

Fig. 9 illustrates the waveforms developed during the operation of the present invention when employed as a demodulator. The waveforms utilized in Fig. 9 are single waveforms extracted from what would normally be a continuous series of such waveforms and this has been done to simplify the explanation of the operation of the present invention as a demodulator.

Assuming that an amplitude modulated alternating current signal is applied across the conductors R_1 and R_2, one cycle of this alternating current signal is extracted from the continuous wave and illustrated by waveform A of Fig. 9. The peak voltage of this particular single cycle wave may be two volts, for instance, as illustrated in the scalar relationship of Fig. 9.

When operating as a demodulator, the alternating current excitation applied to the two magnetic paths of the apparatus should be of the same frequency as that of the signal to be demodulated. Preferably the magnetic flux alternations resulting from said excitation should be in phase with the electrical alternations of the input signal. Assuming the existence of these conditions for purposes of illustration, it may be seen that during one half-cycle of operation, the flux due to alternating current excitation will increase the flux density of one magnetic path while decreasing the flux density of the other magnetic path. During the subsequent half-cycle of operation, the converse is true. For a full cycle of operation with a waveform A applied as the input signal, the individual magneto-resistive conductors therefore develop alternating potentials of substantially the respective waveforms B and C. It should be borne in mind that the waveforms A, B and C of Fig. 9 are all coincident in time. It is also important to note that a change of phase relationship between the alternations of flux due to the excitation and the alternating input signal which is to be demodulated, will result in a correlated change in the output signal developed.

It is to be noted also that the instantaneous values of waveforms B and C when added together are equal to the instantaneous value of waveform A. This is perhaps most clearly demonstrated by simply summing those peak values of waveforms B and C which are coincident in point of time. This shows that the instantaneous potential of waveform A is divided across the two magneto-resistive conductors in the form of waveforms B and C.

Waveform A is seen to have an average voltage of zero because it is purely an alternating current signal. However, waveforms B and C each have an average potential other than zero. As shown, waveform B has an average voltage of approximately +⅜ volt, and waveform C has an average voltage of approximately —⅜ volt. Thus a waveform which is taken from either of the two magneto-resistive conductors in the arrangement of Fig. 8 will have an average value which may be realized in the form of a direct current signal. This value is dependent upon the amplitude of the input signal which will be explained in connection with waveforms D, E and F of Fig. 9.

Assuming for purposes of illustration that a waveform generally of the shape of waveform A is modulated so as to be increased to a peak value of three volts as shown by waveform D illustrated in Fig. 9, a proportionate division of voltage drops across two magneto-resistive conductors will result in the development thereacross of potentials having amplitudes substantially as shown by waveforms E and F. Here again, it may be seen that the instantaneous values of waveforms E and F when added together are equal to the instantaneous values of waveform D. The average value of waveform E and F, however, is equal to approximately 9/16 of a volt so that in the illustrative example, it may be seen that a change in amplitude of the peak voltage of waveform A by an increase of one volt to the amplitude of waveform D will produce an output having a direct current component which is increased by 9/16 of a volt in the same sense. This resultant output effect is equally true of a constantly modulated alternating current input so as to produce a continuously modulated average or direct current output component correlated to the amplitude of input. This may be best illustrated by a simple mathematical analysis of the demodulator action as follows:

$$R_1 = R_0(1 - a \sin wt)$$

$$R_2 = R_0(1 + \sin wt)$$

where R_0 is the steady state or quiescent value of both R_1 and R_2 as shown in Fig. 4

$$R_1 + R_2 = 2R_0$$

$$E = E_0 \sin wt$$

$$\therefore I = \frac{E_0 \sin wt}{R_1 + R_2} = I_0 \sin wt$$

$$E_2 = IR_2 = R_0 I_0 (1 + a \sin wt) \sin wt$$

$$= R_0 I_0 (\sin wt + a \sin^2 wt)$$

$$E_{2av} = \frac{w}{2\pi} \int_0^{\frac{2\pi}{w}} E_2 dt$$

$$= \frac{w}{2\pi} R_0 I_0 \int_0^{\frac{2\pi}{w}} (\sin wt + a \sin^2 wt) dt$$

but

$$\int_0^{\frac{2\pi}{w}} \sin wt dt = 0$$

$$\therefore E_{2av} = \frac{w}{2\pi} R_0 I_0 \int_0^{\frac{2\pi}{w}} (+a \sin^2 wt) dt$$

$$= +\frac{w}{2\pi} R_0 I_0 a \int_0^{\frac{2\pi}{w}} \frac{1 - \cos^2 wt}{2} dt$$

$$= +\frac{w R_0 I_0 a}{2\pi} \left[\frac{t}{2} - \frac{\sin^2 wt}{4w} \right]_0^{\frac{2\pi}{w}}$$

$$= +\frac{w R_0 I_0 a}{2\pi} \left[\frac{1}{2} \frac{2\pi}{w} \right]$$

$$= +I_0 R_0 \frac{a}{2}$$

$$E_{2av} = +\frac{a E_0}{4}$$

Fig. 11 illustrates a conventional type filter which may be connected to the output of a demodulator arranged and connected as shown so as to filter the alternating current components of the output and produce a direct current signal corresponding to the modulation envelope of the alternating current input. It is comprised of two inductances **26** and **27** connected in series with said demodulator output and two capacitances **28** and **29** connected across the demodulator output.

Fig. 12 is an illustration of one configuration of a bifilar coil of magneto-resistive material which is suitable for use in the present invention. A length of magneto-resistive material formed in a configuration having an upper spiral section **30**, a lower congruent spiral section **31**, and joined at **32** to form a continuous electrical path from one end **33** to the other end **34**. This shape affords a relatively high concentration of magneto-resistive material through which a varying magnetic field may pass to cause the desired change in resistance in accordance with the magneto-resistive response of the conductor alluded to hereinbefore. There is substantially zero coupling between such a coil and the alternating component of flux, with the result that the coil is virtually non-inductive and operation of the device is not hampered by transformer action between the coil and the alternating flux.

The present invention therefore affords a compact and reliable modulating or demodulating device which is not dependent for its operation upon electro-mechanical actuation nor electron emission devices. The magnetic operation is accomplished by physically fixed, passive elements which readily lend themselves to ruggedized construction techniques, greatly enhancing the potential value of the invention because of its broadened field of application.

Moreover, the present invention is such that insures fail-safe operation. To explain this feature of the invention, reference may be made to Fig. 4. The purpose of the modulating action of a device operating in accordance with the present invention is usually to convert a direct current signal to an alternating current form so that it may be readily amplified, mixed, etc. The output of the arrangement of magneto-resistive conductors shown in Fig. 4 would therefore be filtered so as to block the direct current component of the output and allow only the modulated alternating current component to pass. A simple capacitor of appropriate value may be employed in a series connection to the output for this purpose.

Assuming that such a conventional and usual practice of blocking the direct current component of the output is followed, the action of a modulator constructed and operating in accordance with the teachings of the present invention may be ascertained. If an open circuit occurs in the input circuit or one of the magneto-resistive elements, current will cease to flow therein, and consequently, no potential will be developed across either of the magneto-resistive conductors with the result that no output will be realized from the modulator. If, on the other hand, one of the magneto-resistive conductors becomes short-circuited, the entire input potential will appear across the remaining conductor so that the push-pull action is lost. Since the value of the series capacitor or direct current blocking device will customarily be such that will allow only the alternating current "carrier" to pass as output, there is no output under either of these two possible conditions of failure or malfunction of the modulator.

Thus it is seen that either an open circuit or a short-circuit in the magneto-resistive conductors will produce a fail-safe zero output indicating the defect without producing a misleading output signal. This is another worth-while aspect and feature of the present invention which is most important in instrument applications, for instance.

It is also interesting to note that embodiments of the present invention can operate as modulators accepting an alternating current excitation signal at the terminals normally designated for direct current input, while receiving a direct current signal at the terminals which usually have the alternating current excitation impressed upon them. In other words, the alternating current excitation and modulating inputs as shown in Figs. 1 and 2 may be interchanged but the output realized will be substantially the same as that produced with the usual arrangement as illustrated.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A modulator comprised of a core structure defining two relatively low reluctance magnetic paths each having a portion common to the other and a portion independent from the other, means for originating a unidirectional flux in the common portion of said paths, at least one magneto-resistive conductor positioned in the magnetic field of each path, means for exciting the independent portions of said paths with an alternating flux so that when said alternating flux opposes said unidirectional flux in one of said paths, it aids said unidirectional flux in the other of said paths, and means for impressing an input signal upon said magneto-resistive conductors connected in series, whereby each of said conductors develops a signal alternating in response to said alternating flux and modulated in accordance with the instantaneous amplitude of said input signal.

2. A modulator comprised of two magnetic paths including a core having a common central leg and two outer legs, a magneto-resistive conductor positioned in each magnetic path, said conductors being serially connected to receive an input signal, means associated with said central leg for producing a unidirectional flux therein, and means for exciting said outer legs with an alternating flux, whereby there is developed across either of said magneto-resistive conductors a signal alternating in response to said alternating flux and modulated in accordance with the instantaneous amplitude of said input signal.

3. The modulator of claim 2 in which the means associated with said central leg is permanent magnetization and a winding thereabout connected to a direct current source.

4. A modulator comprised of two magnetic paths including a core with a common central leg and two outer legs, said outer legs having gaps therein, a pair of magneto-resistive conductors positioned in each of said gaps, said conductors being connected in a bridge circuit, each pair of conductors forming opposite sides of said bridge circuit, means for exciting said outer legs with an alternating flux, means associated with said central leg for producing a unidirectional flux therein, and means for impressing an input signal across two opposite junctions of said bridge circuit, whereby there is developed across the remaining two opposite junctions of said bridge a signal alternating in response to said alternating excitation and modulated in accordance with the instantaneous amplitude of said input signal.

5. The modulator of claim 4 in which the means associated with said central leg for producing a unidirectional flux thereon is a winding about said central leg connected to a direct current source.

6. The modulator of claim 4 in which the central leg is characterized by being permanently magnetized.

7. A demodulator comprised of a core structure defining two relatively low reluctance magnetic paths each having a portion common to the other and a portion independent from the other, means for originating a unidirectional flux in the common portion of said paths, a magneto-resistive conductor positioned in the magnetic field of each path, said conductors being connected serially to receive an amplitude modulated alternating input signal, and means for exciting the independent portions of said paths with an alternating flux of the same frequency as said input signal, whereby there is developed across either of said conductors a signal having a direct current component modulated in accordance with the amplitude modulation of said input signal.

8. A demodulator comprised of two magnetic paths including a core having a common central leg, and two outer legs, a magneto-resistive conductor positioned in each magnetic path, said conductors being serially connected to receive an amplitude modulated alternating input signal, means associated with said central leg for producing a unidirectional flux therein, and means for exciting said outer legs with an alternating flux of the same frequency as said input signal, whereby there is developed across either of said magneto-resistive conductors a signal having a direct current component modulated in accordance with the amplitude modulation of said input signal.

9. A demodulator comprised of two magnetic paths including a core with a common central leg and two outer legs, said outer legs having gaps therein, a pair of magneto-resistive conductors positioned in each of said gaps, said conductors being connected in a bridge circuit, each pair of conductors forming opposite sides of said bridge circuit, means for producing a unidirectional flux in said central leg, means for impressing an amplitude modulated alternating input signal across two opposite junctions of said bridge circuit, and means for exciting said outer legs of said magnetic paths with an alternating flux of substantially the same frequency as said input signal, whereby there is developed across the remaining

two opposite junctions of said bridge a signal having a direct current component modulated in accordance with the amplitude modulation of said input signal.

10. A demodulator in accordance with claim 9 wherein said means for producing a unidirectional flux in said central leg comprises a winding wound about said leg and connected to receive a direct current.

11. A demodulator in accordance with claim 9 wherein said means for exciting said outer legs with an alternating flux comprises a winding common to both said outer legs connected to receive an alternating current of the same frequency as that of said input signal.

12. A demodulator in accordance with claim 9 wherein the central leg of said core is comprised of permanently magnetized material.

13. A demodulator in accordance with claim 12 including a winding wound about said central leg and connected to receive a direct current.

14. Apparatus comprising means defining first and second magnetic flux paths, a network including first and second magneto-resistive conductors each positioned in a different one of said paths, means for subjecting said paths to substantially steady unidirectional fluxes, means for subjecting said paths to alternating fluxes poled to alternately aid the unidirectional flux in one path while opposing the unidirectional flux in the other path, one end of one of said conductors being coupled to one end of the other conductor, means for connecting an input signal across the other ends of said conductors whereby said conductors develop oppositely swinging signals, and means coupled to said network for deriving an output signal from said oppositely swinging signals.

15. Apparatus comprising means defining first and second flux paths, a network including first and second magneto-resistive conductors each positioned in a different one of said paths, means for subjecting said paths to substantially steady unidirectional fluxes, means including first electric circuit means for subjecting said paths to magnetic forces poled to aid said unidirectional flux in one path while opposing said unidirectional flux in the other path, one end of one of said conductors being coupled to one end of the other conductor, means including second electric circuit means for applying electric energy across the other ends of said conductors whereby said conductors develop oppositely swinging signals when said first and second circuit means are supplied with electrical current and the supply to at least one of said circuit means is alternating in character, and means coupled to said network for deriving an output signal from said oppositely swinging signals.

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