

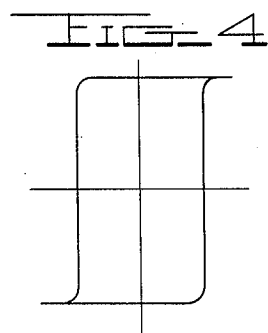
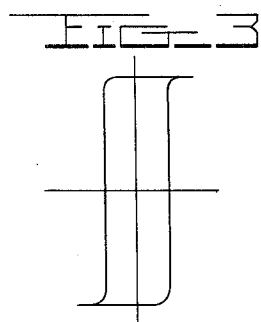
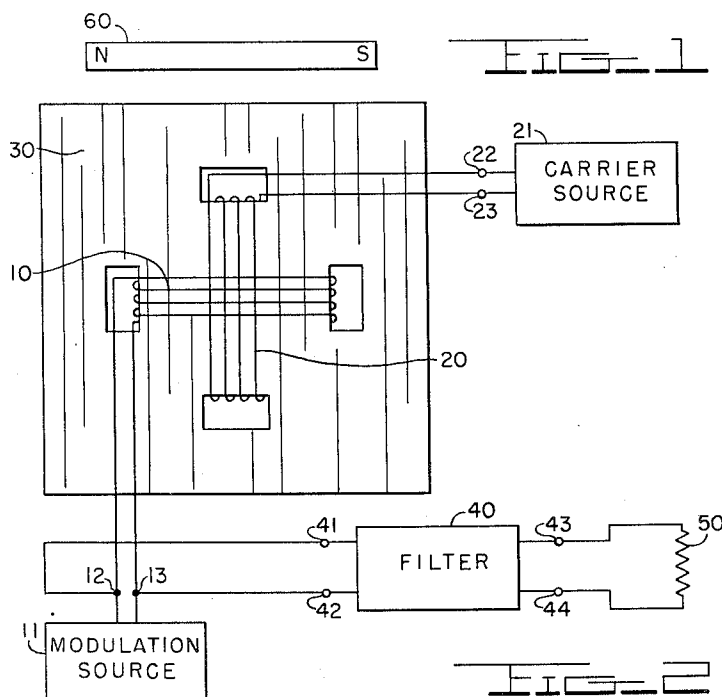
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2,782,376

SUPPRESSED CARRIER MODULATOR

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SUPPRESSED CARRIER MODULATOR

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(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The invention relates in general to magnetic modulation means and in particular to a modulation means for suppressed carrier operation.

Suppressed carrier operation, with which this invention is primarily concerned, is commonly employed where it is desirable to avoid unauthorized monitoring of the communication system. This type of operation involves the elimination of the carrier frequency from the transmitter output when a zero modulation voltage is applied to the carrier. Generally the carrier suppression is accomplished by complex electronic circuitry. For example, as shown in the patent to Duncan No. 1,560,505, issued November 3, 1925, a multi-phase source of carrier frequency oscillations arranged for "in-phase" or "out-of-phase" modulation whereby signaling energy is impressed on the antenna only when the modulation is "in-phase" might be employed. It will be seen that a simplified suppressed carrier modulation system would be highly desirable. Accordingly:

It is an object of this invention to provide a simple magnetic modulation means which permits suppressed carrier operation.

It is still another object of this invention to utilize a non-linear characteristic of grain oriented rolled steel in the modulation of a carrier frequency.

It is still another object of this invention to provide a fast acting means for intermittently mixing two frequencies to produce a sinusoidal product frequency.

Other objects of this invention will become apparent upon a more comprehensive understanding of the invention for which reference is had to the attached specification and drawings.

In the drawings:

Fig. 1 depicts one embodiment of this invention.

Fig. 2 is a graphical showing of the permeability characteristic of grain oriented material.

Fig. 3a and Fig. 3b are graphical showings of the hysteresis curves for a grain oriented material in the direction of grain orientation and in the direction perpendicular to the grain orientation, respectively.

Briefly, the invention comprises a unique inductive field interaction between two coils which are wound in crosswise manner on a metallic form. One of the coils is energized at the carrier frequency and the other is energized at the modulation frequency. In a preferred embodiment the output is taken through a high pass filter connected in parallel with the coil being energized at the modulation frequency. By winding the two coils on a grain oriented material and introducing an additional magnetic field the non-linear hysteresis characteristic of the grain oriented material is utilized as the essential non-linear characteristic in the frequency mixing process to produce a modulated output. In the invention

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both coils must be energized for inductive interaction. In the preferred embodiment, there is no output when modulation ceases—in typical suppressed carrier fashion.

Referring now to the drawings:

Fig. 1 depicts a structural arrangement of one embodiment of the invention wherein coil 10 and coil 20 are wound on metallic form 30 such that the axis of the coils are in orthogonally disposed relation.

A low frequency source 11 capable of producing, for example, a 2 kc. modulation signal is connected across the two terminals, 12 and 13, of the coil 10. A high frequency source 21 capable of producing, for example, a 60 kc. carrier frequency is connected across the two terminals, 22 and 23, of the coil 20. The output circuit comprises a filter 40 whose input terminals, 41 and 42, are connected across terminals 12 and 13, and whose output terminals, 43 and 44, are connected across the output load 50. As will be seen, filter 40 is provided merely to isolate the modulation source 11 from the output. Thus the only critical requirement of this filter in the embodiment of Fig. 1 is that it be capable of passing a band of frequencies in the region of the carrier frequency.

An additional magnetic field producing means 60 is disposed in parallel relation to the axis of the coil 20 to permit interaction between the field produced by the energized coil 20 and that produced by the energized means 60. As depicted in the drawings, means 60 may be a bar magnet, or alternatively, an electromagnetic means might be employed.

As is well known, the modulation of one frequency with another is a product sinusoidal function which requires a processing of the two sinusoidal waves through a non-linear medium. For example, in a balanced modulator the non-linear g_m characteristic of the tubes is utilized in the processing of the sinusoidal waves by critically biasing the tubes in the non-linear region of the g_m curve.

In the device of this invention the non-linear characteristic required in the processing of the sinusoidal waves is provided by saturably biasing grain oriented material in one direction.

In more detailed explanation, a grain oriented material is employed as the metallic form 30 on which the coils 10 and 20 are cross-wound. The grain oriented material utilized in this invention is normally produced by a cold rolling procedure on silicon iron, generally with a silicon content up to 3.5%. This manufacturing procedure provides a magnetically anisotropic sheet in which the crystalline structure seems to take up a preferred orientation and the finished sheet has directional magnetic properties similar to those for a single crystal. As indicated in Fig. 2, the direction of highest permeability is in the rolling direction. Likewise, as seen in Figs. 3a and 3b, the lowest hysteresis loss is also in the rolling direction. Such materials are commercially known as Hypersil, Trancor 3x, etc.

In accordance with the invention, the coils 10 and 20 are so disposed on the metallic form 30 that the magnetomotive force of coil 10 is in the direction of grain orientation and the magnetomotive force of coil 20 is in a direction perpendicular thereto. In addition, a unidirectional source 60 is disposed to produce a magnetomotive force in the same plane as that of the coil 20.

This additional magnetomotive force has the effect of partially saturating the magnetically anisotropic sheet in the direction perpendicular to the direction of grain orientation.

In simplified analysis, the anisotropy of the frame material affords a mutual coupling between the two coils when both the carrier signal and the modulation signal are present and the extent of this coupling is a function

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of the non-linearity of the hysteresis loop of the magnetically anisotropic material. With the addition of the magnetomotive force of source 60 the material is partially saturated in one direction causing the carrier to operate in a non-symmetrical manner about the hysteresis loop. The resultant effect is then the desired mixing of the carrier frequency and the modulation to produce a modulated output.

Since the two coils, 10 and 20, are in orthogonal arrangement in this invention it will be seen that in the absence of either the carrier or the modulation frequency, no inductive coupling between the coils 10 and 20 is possible. As previously mentioned the output is taken across the coil 10 in the embodiment shown. Thus, in the absence of the modulation signal, the carrier signal will not reach the input of filter circuit 60 and there will be no carrier signal output.

The invention described herein provides a new and simplified carrier suppressed modulation system which does not employ vacuum tubes or complex circuitry and thus overcomes many of the inherent disadvantages of prior known systems.

It is understood, of course, that the invention which has been exemplarily described herein, may be readily employed in other modulation systems wherein suppressed carrier operation is not required by taking the output across the terminals 22, 23 of coil 20. Finally, it is understood that the invention is to be limited only by the scope of the appended claims.

What is claimed is:

1. A magnetic modulation means comprising a first signal source for producing a modulation frequency, a second signal source for producing a carrier frequency to be modulated, first and second coil windings connected to said first and second signal sources, respectively, said first and second coil windings being wound in crosswise manner on a form of magnetically anisotropic material having a determined grain orientation such that the magnetomotive force of said first coil winding is in the direction of grain orientation of said material and the magnetomotive force of said second coil winding is in a direction perpendicular thereto, unidirectional magnetic means for producing a magnetomotive force in a direction perpendicular to the direction of grain orientation of said magnetically anisotropic material and in the same plane as the magnetomotive force of said second coil winding, and filtering means capable of passing frequencies in the region of said second frequency source connected across said first coil winding for obtaining a modulated output signal therefrom.

2. A magnetic modulation means comprising a first signal source for producing a modulation frequency, a second signal source for producing a carrier frequency to be modulated, first and second coil windings connected to said first and second signal sources, respectively, said first and second coil windings being wound in crosswise manner on a form of magnetically anisotropic material having a determined grain of orientation such that the magnetomotive force of said first coil winding is in the direction of grain orientation of said material and the magnetomotive force of said second coil winding is in a direction perpendicular thereto, permanent magnet means for producing a magnetomotive force in a direction perpendicular to the direction of grain orientation of said magnetically anisotropic material and in the same plane as the magnetomotive force of said second coil winding, and filtering means capable of passing frequencies in the region of said second frequency source connected across said first coil winding for obtaining a modulated output signal therefrom.

3. A magnetic modulation means comprising a first signal source for producing a modulation frequency, a second signal source for producing a carrier frequency to be modulated, first and second coil windings connected to said first and second signal sources, respectively, said

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first and second coil windings being wound in crosswise manner on a form of magnetically anisotropic material having a determined grain orientation such that the magnetomotive force of said first coil winding is in the direction of grain orientation of said material and the magnetomotive force of said second coil winding is in a direction perpendicular thereto, unidirectional magnetic means for producing a magnetomotive force in a direction perpendicular to the direction of grain orientation of said magnetically anisotropic material and in the same plane as the magnetomotive force of said second coil winding, and high pass filter means connected across said first winding for obtaining a modulated output signal therefrom.

4. A magnetic modulation means comprising a first signal source for producing a modulation frequency, a second signal source for producing a carrier frequency to be modulated, first and second coil windings connected to said first and second signal sources, respectively, said first and second coil windings being wound in crosswise manner on a form of magnetically anisotropic material having a determined grain orientation such that the magnetomotive force of one of said coil windings is in the direction of grain orientation of said material and the magnetomotive force of the other of said coil windings is in a direction perpendicular thereto, unidirectional magnetic means for producing a magnetomotive force in the same direction and plane as the magnetomotive force of the coil winding connected to said second signal source, and filtering means capable of passing frequencies in the region of said second frequency source connected across one of said coil windings for obtaining a modulated output signal therefrom.

5. A magnetic modulation means comprising a first signal source for producing a modulation frequency, a second signal source for producing a carrier frequency to be modulated, first and second coil windings connected to said first and second signal sources, respectively, said first and second coil windings being wound in crosswise manner on a form of magnetically anisotropic material having a determined grain orientation such that the magnetomotive force of one of said coil windings is in the direction of grain orientation of said material and the magnetomotive force of the other of said coil windings is in a direction perpendicular thereto, unidirectional magnetic means for producing a magnetomotive force in the same direction and plane as the magnetomotive force of the coil winding connected to said second signal source, and filtering means capable of passing frequencies in the region of said second frequency source connected across the coil winding connected to said first signal source for obtaining a modulated output signal.

6. A magnetic modulation means comprising a first signal source for producing a first frequency; a second signal source for producing a second frequency to be modulated with said first frequency; first and second coil windings connected to said first and second signal sources, respectively; said first and second coil windings being wound in crosswise manner on a form of magnetically anisotropic material having a determined grain orientation such that the magnetomotive force of said first coil winding is in the direction of grain orientation of said material and the magnetomotive force of said second coil winding is in a direction perpendicular thereto, unidirectional magnetic means for producing a magnetomotive force in a direction perpendicular to the direction of grain orientation of said magnetically anisotropic material and in the same plane as the magnetomotive force of said second coil winding; and output means connected across said first coil winding for obtaining an output signal therefrom; said output means including a signal rejection means capable of rejecting said first frequency.

7. A magnetic modulation means comprising a first signal source for producing a first frequency; a second signal source for producing a second frequency to be modulated with said first frequency; first and second coil windings

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connected to said first and second signal sources, respectively; said first and second coil windings being wound in crosswise manner on a form of magnetically anisotropic material having a determined grain orientation such that the magnetomotive force of said first coil winding is in the direction of grain orientation of said material and the magnetomotive force of said second coil winding is in a direction perpendicular thereto; permanent magnet means for producing a magnetomotive force in a direction perpendicular to the direction of grain orientation of said magnetically anisotropic material and in the same plane as the magnetomotive force of said second coil winding; and output means connected across said first coil winding for obtaining an output signal therefrom; said output means including a signal rejection means capable of rejecting said first frequency.

8. A magnetic modulation means comprising a first signal source for producing a first frequency; a second signal source for producing a second frequency to be modulated with said first frequency; first and second coil windings connected to said first and second signal sources, respectively; said first and second coil windings being wound in crosswise manner on a form of magnetically anisotropic material having a determined grain orientation such that the magnetomotive force of said first coil winding is in the direction of grain orientation of said material and the magnetomotive force of said second coil winding is in a direction perpendicular thereto; unidirectional magnetic means for producing a magnetomotive force in a direction perpendicular to the direction of grain orientation of said magnetically anisotropic material and in the same plane as the magnetomotive force of said

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second coil winding; and output means connected across one of said coil windings for obtaining an output signal therefrom; said output means including a signal rejection means capable of rejecting the output frequency of the signal source connected in parallel with said output means.

9. A magnetic modulation means comprising a first signal source for producing a first frequency, a second signal source for producing a second frequency to be modulated with said first frequency; first and second coil windings connected to said first and second signal sources, respectively; said first and second coil windings being wound in crosswise manner on a form of magnetically anisotropic material having a determined grain orientation such that the magnetomotive force of said first coil winding is in the direction of grain orientation of said material and the magnetomotive force of said second coil winding is in a direction perpendicular thereto; permanent magnet means for producing a magnetomotive force in a direction perpendicular to the direction of grain orientation of said magnetically anisotropic material and in the same plane as the magnetomotive force of said second coil winding, and output means connected across one of said coil windings for obtaining an output signal therefrom, said output means including a signal rejection means capable of rejecting the output frequency of the signal source connected in parallel with said output means.

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