March 1, 1955 H. J. McCREARY 2,703,388

MAGNETIC CROSS VALVE CIRCUITS

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FIG. 1

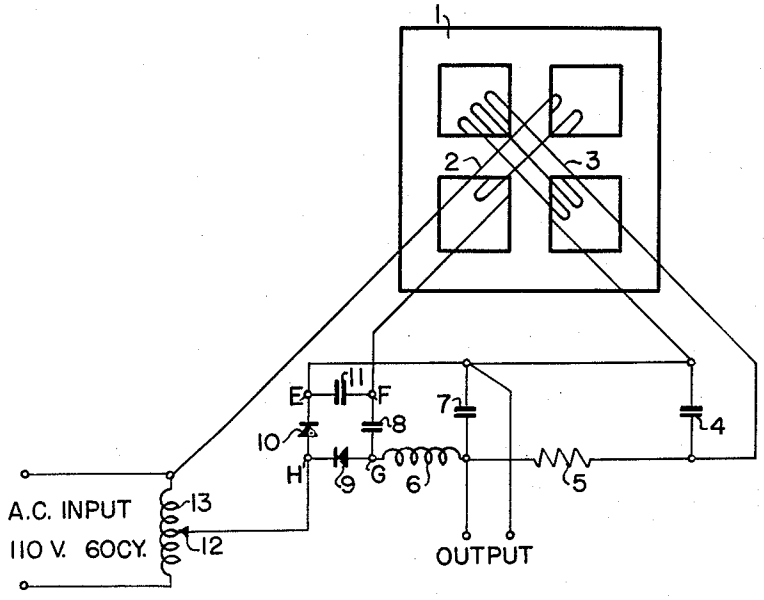
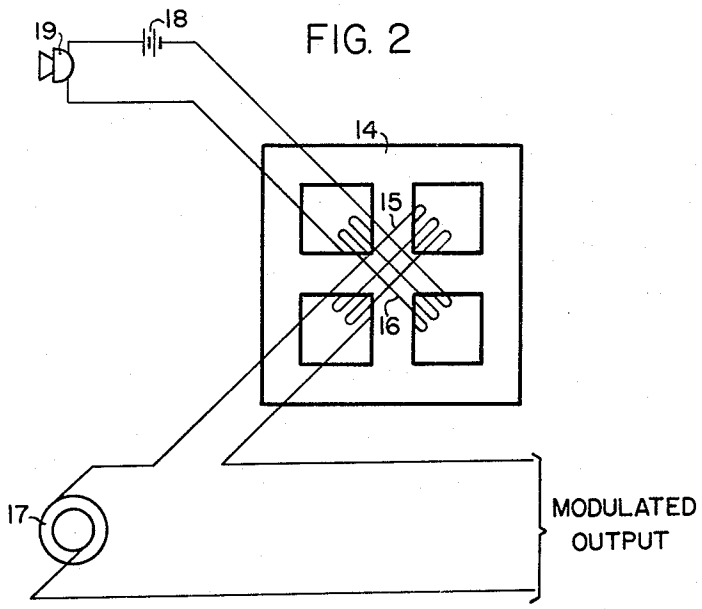


FIG. 2



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FIG. 3

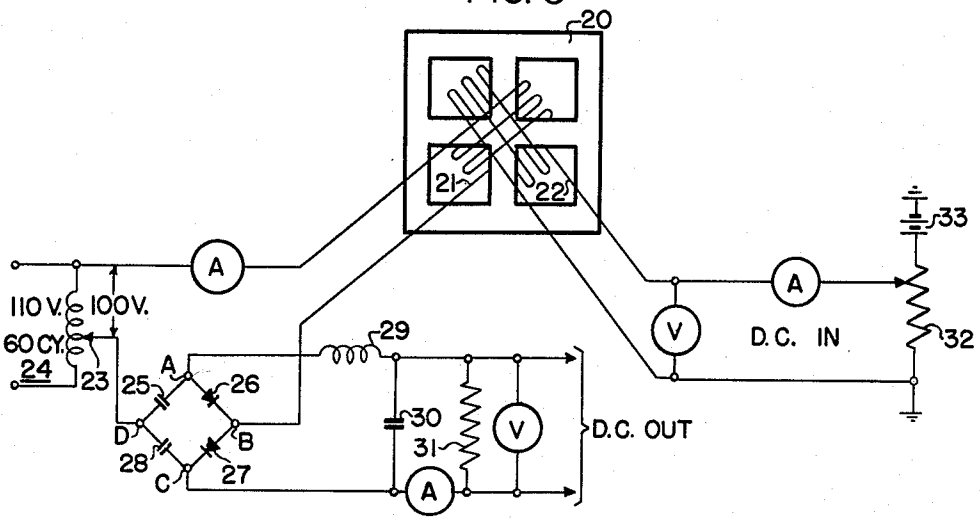


FIG. 4

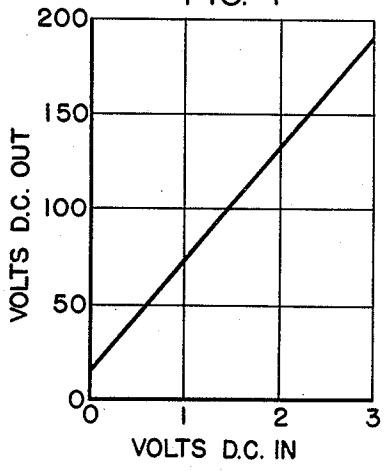
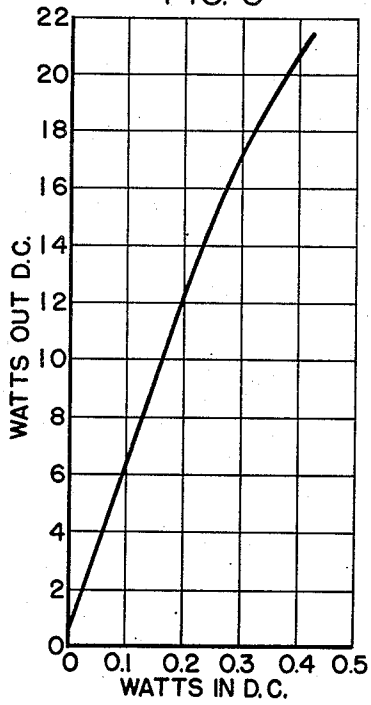


FIG. 5



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2,703,388

MAGNETIC CROSS VALVE CIRCUITS

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Application May 16, 1950, Serial No. 162,249

15 Claims. (Cl. 332—51)

This invention relates in general to magnetic cross valve circuits, but is more particularly concerned with cross valve circuits of the type used for amplifiers, oscillators and modulators.

An object of the invention is to provide an amplifier utilizing the magnetic cross valve.

A feature of the present invention is that the electrical and magnetic circuits are of a minimum length and are therefore more economical for commercial use.

Another feature of the present invention is the increased power output and efficiency with a minimum requirement of metallic substances.

Another object of the present invention is to provide an oscillatory system utilizing the magnetic cross valve.

Another object of the present invention is to provide a modulating system utilizing the magnetic cross valve.

Other objects of the invention will appear upon a further perusal of the specification taken in conjunction with the accompanying drawings which illustrate an embodiment of the invention in the form of a schematic circuit diagram.

Fig. 1 illustrates a diagrammatic representation of the magnetic cross valve oscillator.

Fig. 2 illustrates a diagrammatical representation of the magnetic cross valve amplifier and modulator.

Fig. 3 illustrates a diagrammatic representation of the magnetic cross valve amplifier.

Fig. 4 is a graphical representation between the input volts and the output volts of the amplifying system shown in Fig. 3.

Fig. 5 is a graphical representation between the input watts and the output watts of the amplifying system shown in Fig. 3.

The construction of the magnetic cross valve affords many favorable operating advantages in that the two windings wound thereon are mutually non-inductive and yet symmetrically magnetize the same core. Since in the magnetic cross valve there are no lumped conjugate potentials which cancel each other, the problem of electrical insulation is greatly reduced. In the magnetic cross valve, the control winding is not required to link some other coil in order to produce its control function. It is to be further noted that in the cross valve system the core can be completely saturated with none of the flux of the control winding linking the anode winding.

Referring now to Fig. 3 which shows the magnetic cross valve amplifier, the cross valve **20** may be of the type disclosed in Patent No. 2,445,857, issued on July 27, 1948, to the present inventor, in Patent No. 2,461,992, issued on February 15, 1949, to the present inventor, and in Patent No. 2,455,078, issued on November 30, 1948, to the present inventor. The physical structure of the cross valves herein used is shown in detail in the aforementioned patents. An anode winding **21** is shown diagonally wound across the cross valve **20** and in an opposite diagonal direction is wound the control winding **22**. Power supply unit **24** comprises an autotransformer with a variable tap for regulating the A. C. voltage supplied to the amplifier. The voltage may be of 110 volts. Interconnecting the power unit **24** and the anode winding **21** is a bridge rectifying unit ABCD comprising two selenium rectifiers **26** and **27** and two 6MF condensers **25** and **28**. Resistance **32** is a 1,500 ohm resistance load which is connected across the D. C. input leads of the control winding **22**. Connecting the

bridge rectifying unit ABCD is the D. C. output circuit comprising a 4H choke **29**, an 8MF condenser **30** and a 1,500 ohm resistance load **31**.

With no direct current flowing in the control winding **22**, the anode winding **21** has a maximum reactance. Therefore, the impedance drop at the poins D and B of the bridge rectifier is at a minimum. When a D. C. current is allowed to flow in the control winding **22**, the core of the cross valve **20** becomes magnetized. Since the core of the cross valve **20** is non-linear in its magnetizing characteristics, the effective permeability of the core varies and the reactance of the anode winding **21** likewise varies. When the control winding **22** is energized, the permeability of the core increases. As a result thereof, the reactance of the anode winding **21** decreases. As the impedance voltage drop across the anode winding **21** decreases, the impedance voltage drop across the junctions A and C must increase. This is achieved by a corresponding increase in current. When the alternating current across the junctions D and B increases, the D. C. current across the junctions A and C must also increase. The effect, therefore, is essentially a voltage doubler circuit. The pulsating D. C. current from terminals A and C is filtered by choke **29** and condenser **30** and is applied to the load resistor **31**.

In more detail the D. C. input is applied to the resistor **32**. A current flow through the control coil **22** caused by the applied voltage at the resistor **32** magnetizes the core of the cross valve **20** and thereby increases the permeability of the core. As a result thereof the reactance in the anode coil **21** varies inversely to the applied current flow in the control winding **22**. As the impedance drop of anode winding **21** decreases, the impedance voltage drop from junctions D to B must increase. This is achieved by a corresponding increase in current through the series circuit comprising the power supply unit **24**, the anode winding **21** and the junctions DB of the bridge rectifier. When the alternating current across the junctions DB of the bridge rectifier increases, the D. C. current which is rectified by the rectifiers **26** and **27** must also increase. The alternating current path through the anode winding **21** from the power supply unit **24** is as follows: power supply unit **24**, anode winding **21**, junction B, rectifier **27**, junction C, condenser **28**, junction D and variable tap **23**. The other A. C. path is as follows: variable tap **23**, junction D, condenser **25**, junction A, rectifier **26**, junction B, control anode winding **21** and power supply unit **24**. It is to be noted that the only possible direct current path is as follows: D. C. output, inductance choke **29**, junction A, rectifier **26**, junction B, rectifier **27**, junction C, and D. C. output. The increased direct current flows through the junctions A and C of the bridge rectifier. The rectified D. C. voltage is then filtered by the choke **29** and condenser **30**. Connected across this filter circuit is the D. C. output resistance **21**. The effect, therefore, is that the voltage drop across the junctions D and B of the bridge rectifier is inversely proportional to the reactance of the anode winding **21**, but is directly proportional to the voltage drop across the control winding **22**.

Referring now to Fig. 4 which is a graphical representation of a voltage input applied to the resistor **32** against the D. C. voltage output as received across the resistor **31**. The horizontal axis shows the D. C. input, while the vertical axis shows the D. C. voltage output.

Referring now to Fig. 5 which is a graphical representation of the D. C. wattage input against the D. C. wattage output. Across the resistor **32** is measured the watt input to control winding **22** from the input resistor **32**. The wattage output is measured from the load resistor **31**. The vertical axis illustrates the D. C. watt output and the horizontal axis illustrates the D. C. watt input.

Referring now to Fig. 1 which illustrates an oscillator utilizing the magnetic cross valve **1**. The magnetic cross valve may be of the type disclosed in Patent 2,461,992, issued on February 15, 1949, to the present inventor, also of the type disclosed in Patent No. 2,445,857, issued on July 27, 1948, to the present inventor and also in Patent 2,455,078, issued on November 30, 1948, to the present inventor. An anode winding **2** is diagonally wound across

the cross valve 1 and at a right angle to the anode winding is wound the control winding 3 across the magnetic cross valve 1. The power supply unit 13 illustrates an auto-transformer with a variable tap for regulating the A. C. voltage supplied to the amplifier interconnecting the power supply unit 13. Connecting the anode winding 2 is the bridge rectifier EFGH. The bridge rectifier comprises two selenium rectifiers 10 and 9 and two 6MF condensers 8 and 11. The control winding 3 is connected to a filter circuit comprising 4H choke 6, 8MF condenser 7 and 1,500 ohm resistor 5. The feedback circuit to the control winding 3 is connected at the junctions E and G of the bridge rectifier. The operation herein involved is somewhat similar to the operation of the aforementioned amplifier shown in Fig. 3.

In more detail, an A. C. input across the auto-transformer winding 13 is rectified by the rectifiers 10 and 9. The rectified voltage appearing across the junctions E and G of the bridge rectifier is fed to the control winding 3 through a filter comprising choke 6 and condenser 7. The D. C. voltage appearing across the condenser 4 is fed to the control winding 3. The effect therefore is to vary the permeability of the core of the cross valve 1. As the current through the control winding 3 increases, the reactance of the anode winding 2 decreases. Thereupon the voltage drop across the junctions HF increases. This A. C. voltage appearing across the junctions HF are rectified by the rectifiers 9 and 10. A rectified voltage appearing across the junctions EG of the bridge rectifier EFGH is again fed to the control winding 3 through the just-mentioned filter circuit. This operation continues until oscillations are sustained. The path for the alternating current flow from the power supply unit 13 through the anode winding 2 is as follows: auto-transformer 13, control winding 2, junction F, condenser 8, junction G, rectifier 9, junction H and the tap 12 of the power supply unit. The other alternating current path is from the variable tap 12 of the power supply unit 13, junction H, rectifier 10, junction E, condenser 11, junction F, anode winding 2 and back to the power supply unit 13. The D. C. path from the bridge rectifier to the control winding 3 is as follows control winding 3, resistance 5, choke 6, junction G, rectifier 9, junction H, rectifier 10, junction E and back to the control winding E. The output for the oscillator is taken across the condenser 7.

Referring now to Fig. 2 which illustrates the magnetic cross valve as an amplifier and modulator. This invention utilizes the magnetic cross valve as an amplifier and modulator of high frequency currents such as carrier currents and radio frequency currents. A magnetic cross valve 14 may be of the type disclosed in Patent No. 2,445,857, issued on July 27, 1948, to the present inventor, and also in Patent No. 2,461,992, issued on February 15, 1949, to the present inventor, and also of the type disclosed in Patent No. 2,455,078, issued on November 30, 1948, to the present inventor. A microphone 19 is connected in series with the battery 18 and the control winding 16. Control winding 16 is wound diagonally across the cross valve 14 and at right angle to the control winding 16 is wound the anode winding 15 across the cross valve 14. High frequency power source 17 is connected in series with the anode winding 15 and the modulated output circuit. An audio frequency current is produced by the microphone 19. The audio frequency current creates a variation in the magnetization of the core of the cross valve 14, but induces no potential in the anode winding 16. This characteristic is caused by the structure of the cross valve and the method of winding herein used and disclosed in the aforementioned patents showing the structure and operation of the magnetic cross valves. However, due to the variation in the magnetization of the magnetic cross valve core, the reactance of coil 15 is varied.

When the high frequency power source is connected in series with the anode winding 15, the output is controlled or modulated by the coil 15 according to the value of its reactance. This operation provides amplitude modulation. It is apparent that since the reactance of coil 15 is a function of the current in coil 16, that the magnetic cross valve can also be substituted for the reactance tube to provide frequency modulation.

Although I have described my invention with a certain degree of particularity, it should be understood that the present disclosure has been made only by way of example and that numerous changes in the details of construction and the completion and arrangement of parts may be resorted to without departing from the spirit and scope of the invention as hereinafter disclosed.

I claim:

1. In a magnetic system, a saturable magnetic core structure comprising two intersecting members, a first source of varying current to provide for an input signal, a control winding wound through one pair of diagonally opposite corners of the intersection and energized by said first source of current for varying the permeability of said magnetic core structure, an output circuit, a second source of current, an anode winding wound through the other pair of diagonally opposite corners, energized by said second source of current and responsive to the varying of the permeability of said magnetic core structure for providing an amplification of the current of said first source in said output circuit.

2. In a magnetic system, a saturable magnetic core structure comprising two intersecting members, a source of varying direct current to provide for an input signal, a control winding wound through one pair of diagonally opposite corners of the intersection and energized by said direct source of current for varying the permeability of said magnetic core structure, an output circuit, a source of alternating current, an anode winding wound through the other pair of diagonally opposite corners, energized by said alternating source of current and responsive to the varying of the permeability of said magnetic core structure for providing an amplification of said input signal.

3. In a magnetic system, a saturable magnetic core structure comprising two intersecting members, a source of varying direct current to provide for an input signal, a control winding disposed diagonally through opposite corners of the intersection and energized by said source of direct current for varying the permeability of said magnetic core structure, an output circuit, a source of alternating current, an anode winding disposed substantially at right angles to said control winding through the other opposite corners of the intersection, energized by said source of alternating current and responsive to the varying of the permeability of said magnetic core structure for providing an amplification of the direct current of said source in the output circuit, and a rectifier interconnecting said source of alternating current, said anode winding and said output circuit to provide for a direct current output in said output circuit.

4. In a magnetic system, a saturable magnetic core structure comprising two intersecting members, a source of varying direct current to provide for an input signal, a control winding wound through one pair of the diagonally opposite corners of the intersection and energized by said source of current for varying the permeability of said magnetic core structure, a bridge rectifier having two pairs of junctions thereon, a source of alternating current, an anode winding wound through the other opposite corners of the intersection, energized by said second source of current and responsive to the varying of the permeability of the magnetic core structure for varying its reactance, a circuit serially connecting said source of alternating current and said anode winding to one pair of junctions on said bridge rectifier, and an output circuit connected to the other pair of junctions on said bridge rectifier for providing an amplification of said input signal in response to the variance of reactance of said anode winding.

5. In a magnetic system, a saturable magnetic core structure having two members intersecting substantially at a right angle, means for providing a low frequency signal superimposed upon a direct current signal, a control winding wound diagonally through opposite corners of the intersection for varying the permeability of said magnetic core structure in response to energization by said signal, an output circuit, a high frequency generator for providing a carrier current, an anode winding wound diagonally through the other opposite corners of the intersection and connected to said generator, energized by said carrier current and responsive to the varying permeability of said magnetic core structure for providing a signal modulated in accordance with said low frequency signal in said output circuit.

6. In a magnetic system, a saturable magnetic core structure having only a control winding and an anode winding mounted thereon, a source of varying substantially unidirectional current to provide for an input sig-

nal, the control winding wound around a portion of said magnetic core structure and energized by said source of current for varying the permeability of said magnetic core structure, an output circuit, the anode winding connected to the output circuit and wound around said magnetic core structure substantially at a right angle to said control winding so that there is substantially no mutual inductance between said control winding and said anode winding, and a source of alternating current for said anode winding, said anode winding energized by said alternating current and responsive to the varying of the permeability of said magnetic core structure for providing an amplification of said input signal in said output circuit.

7. In a magnetic system, a saturable magnetic core structure, a first source of varying current to provide for an input signal, a control winding wound around said magnetic core structure and energized by said first source of current for varying the permeability of said magnetic core, an output circuit, an anode winding wound around said magnetic core structure substantially at a right angle to said control winding so that there is substantially no mutual inductance between said control winding and said anode winding, a second source of current, said anode winding energized by said second source of current and responsive to the varying of the permeability of said magnetic core structure for providing an amplification of the current of said first source in said output circuit.

8. In a magnetic system, a saturable magnetic core structure comprising two intersecting members and having only a control winding and an anode winding mounted thereon, a resonant circuit including the control winding wound around one pair of diagonally opposite corners of the intersection of said members for varying the permeability of said magnetic core structure, a source of alternating current, means for rectifying said source of current to provide direct current input for said resonant circuit to provide a bias and to cause said resonant circuit to oscillate, an output circuit, the anode winding wound around the other pair of diagonally opposite corners of the intersection of the members of said magnetic core structure substantially at a right angle to said control winding so that there is substantially no mutual inductance between said control winding and said anode winding, said anode winding connected to said source, energized by said alternating current and responsive to the varying of the permeability of said magnetic core structure for providing an amplification of said oscillating current in said output circuit.

9. In a magnetic system, a saturable magnetic core structure comprising two intersecting members, means for providing a low frequency signal superimposed upon a direct current signal, a control winding wound around one pair of diagonally opposite corners of the intersection of said members for varying the permeability of said magnetic core structure in response to energization by said signal, an output circuit, a high frequency generator to provide a source of carrier current for said anode winding, an anode winding connected to said output circuit and wound around the other pair of diagonally opposite corners of the intersection of said members substantially at a right angle to said control winding so that there is substantially no mutual inductance between said control winding and said anode winding, said anode winding connected to said generator, energized by said carrier current and responsive to the variations of permeability of said magnetic core structure for providing a modulated signal in said output circuit.

10. In a magnetic system, a saturable magnetic core structure comprising two intersecting members, a control winding wound through one pair of diagonally opposite corners of the intersection, means for supplying a varying unidirectional current to said control winding for varying the permeability of said magnetic core structure, a source of alternating current; and an anode winding wound through the other pair of diagonally opposite corners of the intersection and connected to said source of alternating current; the varying of the permeability thereby causing a current to flow through said anode winding at the same frequency as the current through said control winding.

11. In a magnetic system, a saturable magnetic cross-valve comprising two members disposed to intersect at a right angle and having only an input coil and an output coil mounted thereon, the input coil wound through

one pair of the diagonally opposite corners of the intersection, means for supplying a varying unidirectional current to said input coil to vary the permeability of said cross-valve directly in accordance with the magnetic lines of flux generated by the varying current flowing through said input coil, the output coil wound through the other pair of diagonally opposite corners of the intersection, the reactance of said output coil controlled directly by said variations in permeability to vary inversely with the variations in permeability at the same frequency as the current flowing through said input coil, an output circuit comprising a source of alternating current, a load and said output coil connected in series, the varying reactance of said output coil producing a component in the current flowing through said load of the same frequency as the current flowing through said input coil, which component varies in amplitude in a direct proportion to the current flowing through said input coil.

12. In a magnetic system, a saturable magnetic core structure comprising two members intersecting each other at right angles, a control winding wound around one pair of diagonally opposite corners of the intersection, an output circuit including a load and an output coil together with circuit means for supplying an alternating current to said output coil, said output coil wound around the other pair of diagonally opposite corners, and means independent of the core structure and connected to the control winding for causing a substantially unidirectional current flow in said control winding of an amplitude varying at a rate different than the frequency of said alternating current to vary the permeability of said core structure, said variations in permeability of the magnetic core structure causing a current flow in the output winding varying at the same rate as the unidirectional current flow in the control winding.

13. A magnetic device comprising a saturable magnetic core structure having two members intersecting each other substantially at a right angle, said core structure having only two windings mounted thereon, one winding wound around one pair of diagonally opposite corners of the intersection, the other winding wound around the other pair of diagonally opposite corners of the intersection, a source of alternating current for said one winding, a circuit including said other winding and resonant at a frequency substantially less than the frequency of said alternating current, means for rectifying said alternating current, means for feeding part of said rectified current to said second winding for providing a bias therein and for shocking said resonant circuit into oscillation, whereby a varying substantially unidirectional current will flow through said second winding, said first winding and said core structure responsive to said variations in the unidirectional current for providing in said alternating current an amplified compound varying at said resonant frequency.

14. A magnetic device comprising a saturable magnetic core comprising two intersecting members and having a pair of coils mounted thereon, said coils disposed substantially at right angles to each other so that there is substantially no mutual inductance between them, each coil wound around one pair of diagonally opposite corners of the intersection of said members, a source of alternating current, a first circuit connecting said source of current to one of the windings, a load connected in said first circuit, a second circuit including the other winding and resonant at a frequency substantially less than the frequency of the alternating current, means in the first circuit for rectifying said alternating current, and means for feeding part of said rectified current to said other winding to provide a bias therein, to shock said second circuit into oscillation at its resonant frequency and to provide feedback energy to maintain said oscillations, said oscillations varying the permeability of the core, said one winding responsive to the variations in permeability for producing in the alternating current an amplified component varying at said resonant frequency.

15. The combination claimed in claim 14, wherein the load is connected in series with said one winding and across the rectifying means, whereby the remainder of said rectified current, modulated at said resonant frequency, is fed therethrough.

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