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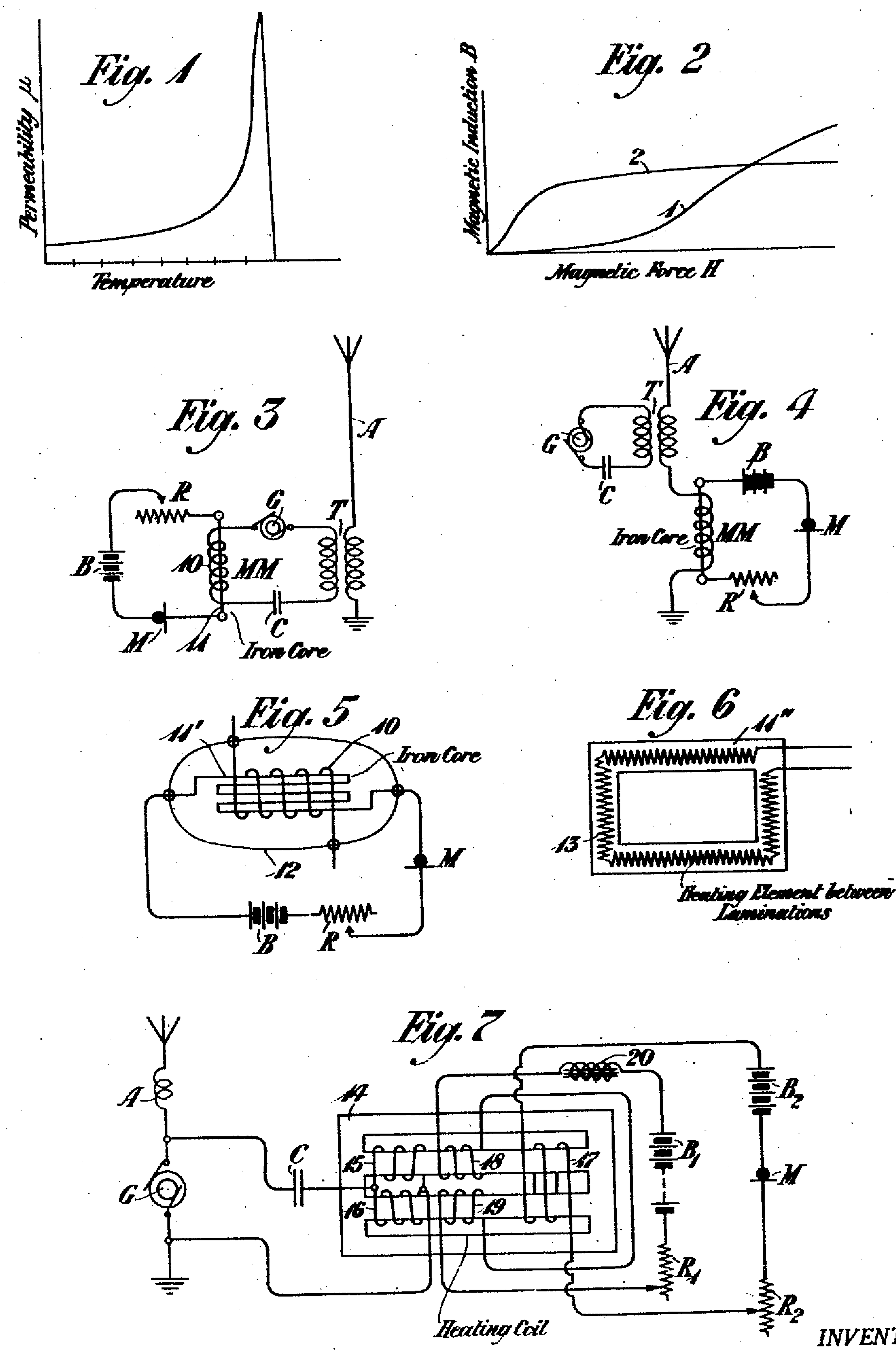

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UNITED STATES PATENT OFFICE.

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MEANS FOR AND METHOD OF MODULATION.

Application filed December 16, 1920. Serial No. 431,191.

To all whom it may concern:

Be it known that I, LLOYD ESPENSCHIED, residing at Queens, in the county of Queens and State of New York, have invented certain Improvements in Means for and Methods of Modulation, of which the following is a specification.

This invention relates to transmission by means of carrier currents for either radio or wire purposes, and more particularly to means for and methods of modulating carrier currents in accordance with signals.

It has heretofore been proposed to modulate alternating carrier current in accordance with signals by means of a magnetic modulator, a well-known type of which is described in the U. S. patent to Alexanderson No. 1,206,643, November 28, 1916. In accordance with the present invention, however, it is proposed to take advantage of a peculiar property of the temperature-permeability characteristic of an iron core. As is well known, at a certain critical point in the temperature-permeability characteristic of an iron core known as the recalescent point, the permeability of the core undergoes a rapid change. By working the core of a magnetic modulator at or near the recalescent point, a greater modulating effect may be obtained in accordance with the present invention because of the rapid change in permeability at this point.

The invention may now be more fully understood from a detailed description thereof when read in connection with the accompanying drawing, Figures 1 and 2 of which are curves illustrating the properties of an iron core coil, Figs. 3 and 4 of which are circuit diagrams showing apparatus for operating in accordance with one method embodying the invention, Figs. 5 and 6 of which are schematic arrangements showing structures for heating the iron core of the magnetic modulator and Fig. 7 of which is a circuit diagram showing apparatus for operating in accordance with another method embodying the invention.

Referring to Fig. 1, the curve indicates roughly the temperature-permeability characteristic of an iron core up to the critical temperature known as the recalescent point. It will be seen from an examination of this curve that the permeability is a very rapid function of the temperature, for temperatures in the neighborhood of 700° to 800° centigrade. For temperatures in this region the B—H curve also undergoes a marked change, as is indicated in Fig. 2, in which the curve 1 represents the B—H curve under normal conditions, while 2 indicates the B—H curve at or about the condition of recalescence. It will be observed from the curve 2 that, for small magnetizing forces, the magnetic induction B, and hence the permeability, rises much more rapidly for temperatures near the critical frequency than in the case of the curve 1, which indicates the characteristic for normal temperatures.

In taking advantage of the phenomena of recalescence for magnetic modulation, it is possible to utilize either the characteristic indicated by the curve of Fig. 1 or the characteristics indicated by the curve 2 of Fig. 2. A circuit arrangement for employing the characteristic of Fig. 1 is illustrated in Fig. 3. In this figure A is a transmitting antenna coupled through a transformer T to a tuned circuit, including a source of carrier oscillations G, a tuning condenser C and a magnetic modulator MM, comprising an iron core 11 and a winding 10. The winding 10 is serially included in circuit with the generator G while the core is included in a circuit, including a battery or other source of heating current B, a resistance R for regulating the amount of heating current passing through the iron core 11 and a microphone M for impressing voice currents upon the modulator. In operation, the resistance R is adjusted so that the current passing through the iron core 11 will heat it to the recalescent point. As will be seen from the curve of Fig. 1, when the core is heated to this point a slight change in temperature produces a very considerable change in the permeability of the coil of the modulator. Consequently, when the microphone M is operated, the variations in the current flow through the circuit including the battery B produce variations in the temperature of the core 11, and the consequent changes in the permeability in the coil of the modulator MM result in large changes in the amplitude of the oscillations supplied by the generator G through the transformer T to the antenna A.

In order that the iron core of the coil MM may be heated by an electric current and at the same time be capable of producing a considerable magnetic flux in the coil, it may be constructed in the form of a filament or filaments 11′, looped back and forth through the coil 10, as illustrated in Fig. 5. These filaments are included serially in the circuit of the battery B, resistance R and microphone M, so that the current flowing through the filaments raises the temperature thereof. In order to prevent rapid oxidation, the filaments forming the core of the inductance coil may be mounted in a container 12 of glass or other suitable material, the said container being evacuated in a well-known manner and provided with terminals for the purpose of connecting the filamentary core to the microphone circuit and for connecting the windings of the inductance coil to the generator circuit.

Another manner in which the core may be constructed is illustrated in Fig. 6. In this case, the core 11″ is made up of a number of flat plates or laminations, as is well understood in the art and between each pair of laminations or between certain of the laminations a heating element 13 of the resistance type may be placed. The terminals of the heating element or elements may then be connected to the circuit, including the battery B, microphone M and resistance R, so that the laminations of the core will be heated by contact with the heating element 13. In this case, variations in the current flowing through the heating element will produce changes in the temperature of the core and, consequently, changes in the permeability of the coil, so that the carrier frequency supplied by the alternator will be modulated in accordance with the signal variations.

Another circuit arrangement for employing a modulator of the type illustrated in Figs. 5 and 6 is shown in Fig. 4. In this case, the modulator MM is not included in the series circuit including the primary of the transformer T, the generator G and the condenser C, but is inserted serially in the ground connection of the antenna A. The signaling circuit, including the microphone M is associated with the modulator MM, however, in the same manner as in Fig. 3. The operation will be obvious from the operation already described in connection with Fig. 3 and, consequently, need not be referred to here.

As already stated, instead of modulating by changing the temperature, the modulation may be controlled in accordance with the signal by varying the magnetic force under conditions such that the core of the coil is heated to the recalescence point. As shown by the curve 2 of Fig. 2 for small applied magnetic forces, the magnetic induction B changes rapidly and if the magnetic force varies in accordance with the signal, large variations in the permeability of the coil will result. Fig. 7 illustrates a circuit arrangement for utilizing this characteristic. In this circuit diagram 14 designates the core of a magnetic modulator of the general type disclosed in the patent to Alexanderson, above referred to. Coils 15 and 16 are connected in parallel in a circuit including the condenser C, said circuit being connected to the generator G in shunt with the antenna A. The coils 15 and 16 are wound upon the core 14 in such a manner as to normally aid each other around the two inner limbs. Another coil 17 is included in circuit with a battery B_2, a microphone M and a resistance R_2 and is wound to affect alike the two inner limbs of the core 14 in such a manner as to produce changes in the permeability thereof, with changes in the applied magnetic force, these changes being produced by changes in the direct current flowing through the coil, in response to the actuation of the microphone M. It is, of course, obvious that a vacuum tube amplifier may be included in this circuit for the purpose of increasing the signaling energy. Additional coils 18 and 19 are also wound upon the core, these coils being included in circuit with the battery B_1 and resistance R_1. Reaction between the high frequency windings 15, 16 and the heating circuit of windings 18, 19 is prevented by the reactance of choke coil 20. The resistance R_1 is adjusted so that the current flowing through these coils will heat the core up to the recalescence point. With the core thus heated, relatively small changes in the current flowing through the coil 17 will produce large changes in the permeability of the core and in accordance therewith, large changes in the inductance included in series with the condenser C will result, so that more or less current from the generator G is shunted from the antenna A, depending upon the instantaneous magnitude of the signaling current. The signaling current obviously may be telegraphic instead of telephonic in which case the microphone M is replaced by a telegraph key or relay.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated, without departing from the spirit of the invention, as defined in the following claims.

What is claimed is:

1. In a modulating system comprising a carrier source and an inductance, the method of modulating a carrier frequency in accordance with signals which consists in subjecting the energy of the carrier source to the action of said inductance, maintaining the temperature of said inductance in the neighborhood of the recalescence point, and varying the permeability of said inductance in accordance with a signal.

2. In a modulating system comprising a carrier source and an inductance, the method of modulating a carrier frequency in accordance with signals which consists in passing the energy from the carrier source through said inductance, maintaining the temperature of said inductance near the recalescence point, and varying the permeability of said inductance in accordance with a signal.

3. In a modulating system comprising a carrier source and an inductance, the method of modulating a carrier frequency in accordance with signals which consists in subjecting the energy of the carrier source to the action of said inductance, maintaining the temperature of the core of said inductance in the neighborhood of the recalescence point, and varying the permeability of said inductance in accordance with a signal.

4. In a modulating system comprising a carrier source and an inductance, the method of modulating a carrier frequency in accordance with the signals which consists in subjecting the energy of the carrier source to the action of said inductance, maintaining the temperature of the core of said inductance in the neighborhood of the recalescence point, and varying the magnetic force applied to the inductance in accordance with signals, thereby producing corresponding changes in the permeability of the inductance.

5. In a modulating system comprising a carrier source, an inductance and an electric heating circuit, the method of modulating a carrier frequency in accordance with signals which consists in subjecting the energy of the carrier source to the action of said inductance, translating the energy of said electric circuit to heat, heating the core of said inductance by means of said heat to maintain its temperature in the neighborhood of the recalescence point, and varying the permeability of said inductance in accordance with a signal.

6. In a modulating apparatus a source of carrier current, an inductance for controlling the energy of said source, means to maintain the temperature of said inductance in the neighborhood of the recalescence point, and means to vary the permeability of said inductance in accordance with a signal.

7. In a modulating apparatus a source of carrier current, an inductance for controlling the energy of said source, means to maintain the temperature of the core of said inductance in the neighborhood of the recalescence point, and means to vary the permeability of said inductance in accordance with a signal.

8. In a modulating apparatus a source of carrier current, an inductance for controlling the energy of said source, a circuit for supplying current to heat said inductance to a temperature in the neighborhood of the recalescence point, and means for varying the permeability of said inductance in accordance with a signal.

9. In a modulating apparatus a source of carrier current, an inductance for controlling the energy of said source, a circuit for supplying current to heat the core of said inductance to a temperature in the neighborhood of the recalescence point, and means for varying the permeability of said inductance in accordance with signals.

10. In a modulating apparatus a source of carrier current, an inductance for controlling the energy of said source, means for heating said inductance to a temperature in the neighborhood of the recalescence point, and means to vary the magnetic force applied to said inductance in accordance with signals, whereby corresponding variations in the permeability of said inductance are produced.

In testimony whereof, I have signed my name to this specification this 13th day of December 1920.

LLOYD ESPENSCHIED.