May 9, 1944. J. J. ANTALEK 2,348,585

MODULATION SYSTEM

Original Filed May 8, 1942 2 Sheets-Sheet 1

Fig. 1.

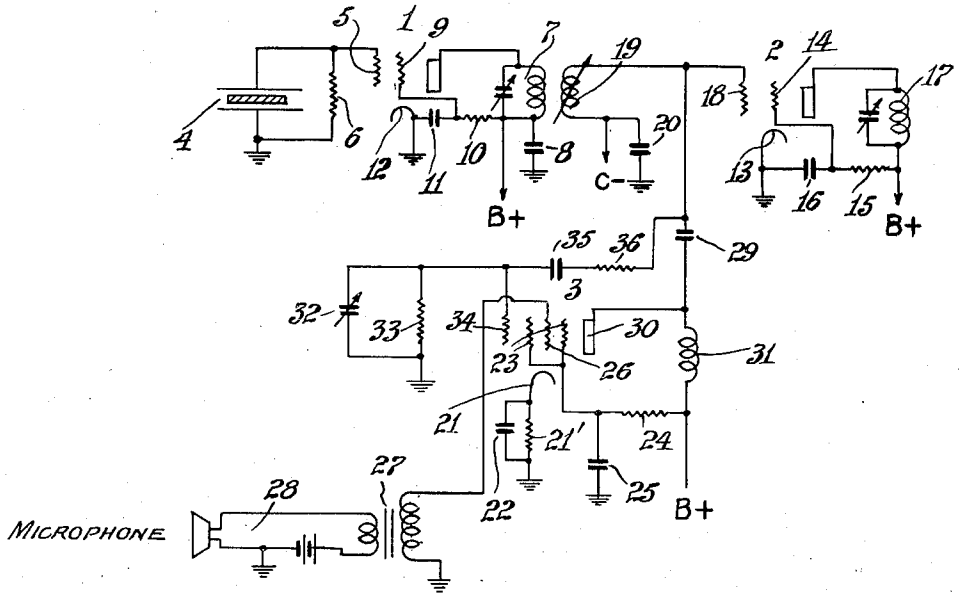
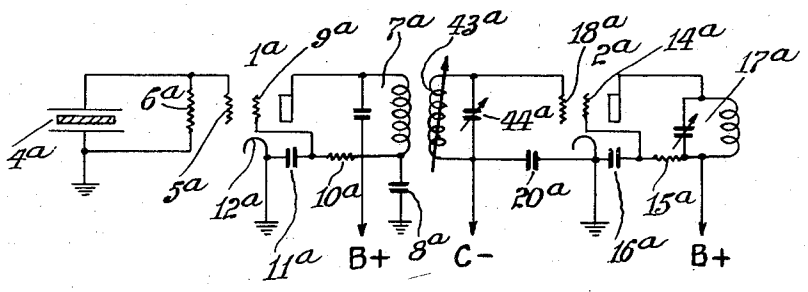


Fig. 2.



INVENTOR
John J. Antalek
BY Paul Mellish
ATTORNEY

May 9, 1944. J. J. ANTALEK 2,348,585

MODULATION SYSTEM

Original Filed May 8, 1942 2 Sheets-Sheet 2

Fig. 3.

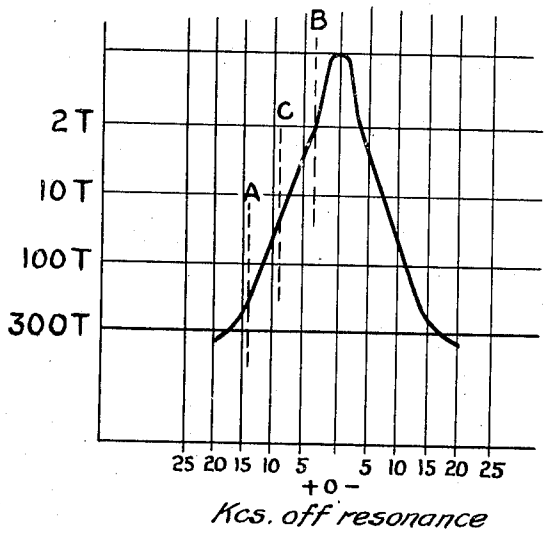
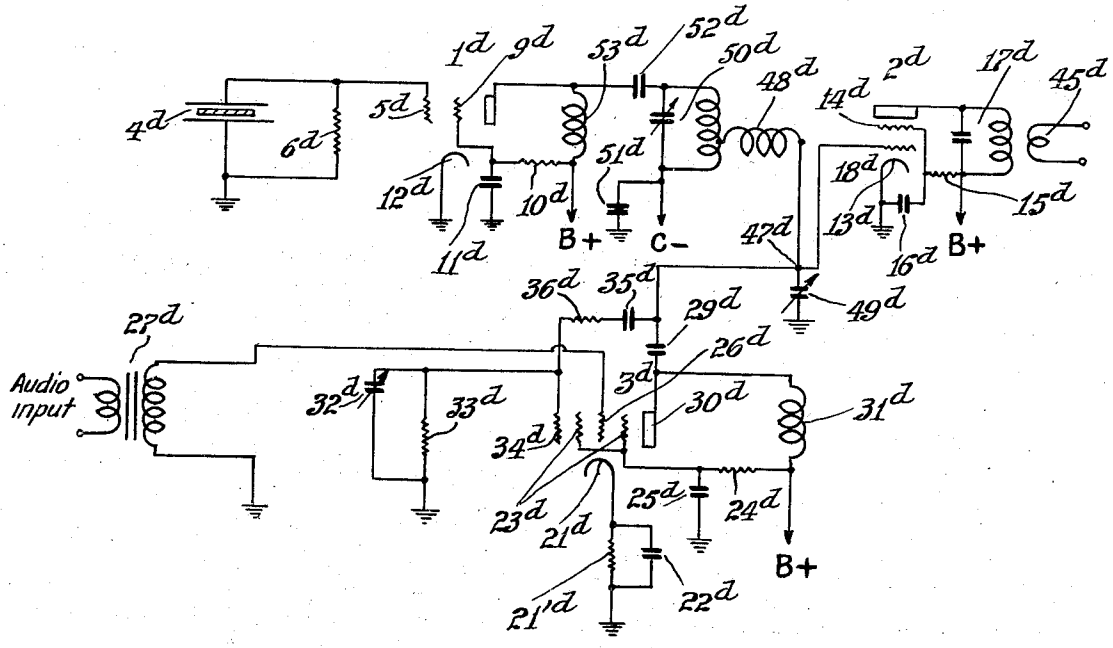


Fig. 4.



INVENTOR
John J. Antalek

BY Paul Kolisch

ATTORNEY

Patented May 9, 1944

2,348,585

UNITED STATES PATENT OFFICE

2,348,585

MODULATION SYSTEM

John J. Antalek, Chicago, Ill., assignor to The Rauland Corporation, Chicago, Ill., a corporation of Illinois

Original application May 8, 1942, Serial No. 442,185. Divided and this application November 21, 1942, Serial No. 466,404

5 Claims. (Cl. 179—171.5)

This invention relates to modulation systems, especially as employed in connection with radio telegraph and telegrone transmitters. More particularly it relates to a system of amplitude modulation.

This is a division of the application of John J. Antalek, Serial No. 442,185, filed May 8, 1942.

One purpose of my invention is to provide a modulation system of comparatively great simplicity and one capable of modulating a carrier frequency by the use of an extremely small amount of power, the amount of power required being comparable to that required for the modulation of a transmitter of the frequency modulation type.

Another purpose of the instant invention is to provide a method of modulation adapted for use in the low frequency spectrum, due to the relatively narrow band of side frequencies produced thereby.

A further object of my invention is to provide a modulation system giving high fidelity transmission with a minimum amount of apparatus at relatively low cost and adapted to produce a transmitted signal which can be received upon apparatus of the type used for the reception of ordinary amplitude modulated signals.

My invention modulates an independently produced carrier current by varying the impedance of a circuit or circuits connected either to the grid or the anode of a tube which acts as the modulated amplifier tube.

In order to explain my invention, reference is made to the accompanying drawings, where:

Fig. 1 shows one embodiment of my invention using a microphone of the variable resistance type, connected so as to secure modulation of the variable impedance type;

Fig. 2 shows an alternative and simple method of using a variable impedance microphone to secure impedance modulation;

Fig. 3 is a graphical representation of the resonance curve of a typical tuned circuit with which my modulation system may be employed;

Fig. 4 shows yet another impedance modulation method according to my invention, utilizing a series resonant circuit and an alternative method of coupling the tube producing the carrier frequency to the modulated amplifier tube.

Referring now to Fig. 1, electron tubes 1 and 2 are tetrodes and tube 3 is shown as a hexode of conventional type. Tube 1 has a piezo-electric crystal 4 connected to the grid thereof and having a suitable grid leak resistor 6 shunting the crystal. The tuned anode or output circuit 7 of this tube is by-passed to ground by condenser 8 and tuned either to the fundamental frequency of crystal 4 or to some harmonic thereof, according to the design of circuit employed. The screen electrode 9 is connected through dropping resistance 10 to a source of suitable positive potential and by-passed to ground through condenser 11, while the tube cathode 12 is directly grounded.

Electron tube 2 acts as the modulated amplifier tube, having its cathode 13 grounded and its screen electrode 14 supplied with a suitable positive potential through dropping resistance 15, and by-passed to ground through condenser 16. The output circuit connected to the anode of this tube may take the form of the tuned circuit 17. The grid 18 is connected through input coil 19 and by-pass condenser 20 to the ground, while a source of suitable negative bias potential is connected to the junction point of this coil and condenser. The input circuit of tube 2 is electromagnetically coupled to the output circuit of tube 1, by means of coil 19, this coupling being quite critical.

Electron tube 3 and its associated elements constitute an electron controlled variable capacity which is effectively connected in parallel with coupling coil 19 of the input circuit of tube 2, these two elements thus constituting a circuit having a variable resonant period. In order to secure good stability and maximum efficiency, it is preferred that coil 19 have its inductance determined by so-called permeability tuning, but this is not essential. The input circuit of tube 2 is so tuned as to have, in its quiescent or non-modulated condition, a frequency which will be removed from the frequency of tuned circuit 7 by an amount corresponding approximately to that indicated at C in Fig. 3. It will be noted that point C is the middle point of the linear portion of the selectivity or resonance curve, embraced between points A and B. This point C is usually about one percent away from the frequency of tuned circuit 7 and may be chosen upon either the plus or the minus side of the resonant point of circuit 7.

Tube 3 has its cathode 21 suitably biased through resistance 21' and by-pass condenser 22 to ground, while its two screen electrodes 23 obtain their positive potential through dropping resistor 24, and are by-passed to ground through condenser 25. The control grid 26 of tube 3 is supplied with audio-frequency modulating energy through transformer 27, the primary of which is excited by microphone circuit 28.

The elements acting to give the variable capaci-

ty effect of the circuits associated with tube 3 comprise condenser 29 connected between the non-grounded end of coil 19 and anode 30, the latter of which is fed from a suitable source of positive potential through choke coil 31, and variable condenser 32 and resistance 33 connected in parallel with one another and between grid 34 of the tube and the ground. Phase coupling of grid 34 to the connection between coil 19 and condenser 29 is made via series connected condenser 35 and resistance 36.

When modulation signals are impressed upon grid 26 of tube 3, the resonant frequency of the circuit comprised by coil 19 and the effective capacity of tube 3 and its associated elements, is varied approximately one-half percent plus or minus the resonant frequency which this same circuit has when non-modulated. In other words, the resonant period shifts from point C as far as points A or B, thus traversing the linear portion of the resonance curve shown in Fig. 3. This results in a linear variation of the radio frequency energy applied to input grid 18 of tube 2, which tube is preferably so constructed and biased as to function as a class B amplifier, whereby the power output in anode circuit 17 will be proportional to the square of the grid excitation voltage.

While I have described and shown in Fig. 3 a selectivity curve upon which the point C is removed about one percent from resonance frequency, it is to be understood that the shape of curve and the location of point C will vary with different circuits, the elements of which have different constants or magnitudes.

In the system of modulation just described, the modulation is brought about by varying the effective impedance of the input circuit of the modulated amplifier tube, so that the amount of energy transferred thereto from the oscillator tube will vary in accordance with the modulating signals.

Referring now to Fig. 2, there is here shown one comparatively simple form which my invention may assume. In this form the modulating device is physically, as well as electrically, incorporated into the circuits coupling the oscillator to the modulated amplifier. A suitable variable inductance microphone, 43*a*, may be used to secure impedance modulation by connecting the microphone directly in place of the inductance constituted in Fig. 1 by coil 19 and by using the condenser, 44*a*, in lieu of the condenser, 29, and associated tube capacity shown in Fig. 1. The system will then function similarly to that of Fig. 1, but the inductance, 43*a*, will be varied instead of the capacity, thereby varying the absorption of power from coil 7*a* as resonant conditions are approached, or vice versa.

With the system of Fig. 2, a condenser type of microphone may be employed in lieu of the variable impedance type, sound impingement upon the microphone causing the same shift of resonant period as in the case of the use of a variable impedance type microphone.

In Fig. 4 oscillator tube 1*d* has its tuned output circuit 50*d* by-passed to ground at 51*d*, fed through coupling condenser 52*d* and conductively coupled to input grid 18*d* of modulator tube 2*d*, through coil 48*d*. Anode supply is through choke coil 53*d*. Coil 48*d* and condenser 49*d* form a series resonant circuit conductively coupled to tuned output circuit 50*d* of tube 1*d*. Tube 3*d* and its associated elements are connected and act in the same fashion as indicated in Fig. 1. The effective capacity of tube 3*d* is modulated by the signals impressed upon control grid 26*d* and this capacity is connected to the point of common connection 47*d*, between coil 48d and condenser 49*d*. In operation, modulation of tube 3*d* results in corresponding variation of the impedance of circuit 48*d*, 49d, which is tuned to a point corresponding to C of Fig. 3, as previously described. This causes the radio frequency energy supplied to grid 18*d* to be modulated in accordance with the modulating energy supplied to transformer 27*d*.

It is preferred that my modulation systems be connected to the radio-frequency tuned circuits carrying low power in a transmitter, for the reason that it is then much easier to modulate the lower energy level there present. However, my systems are applicable for tuned circuits carrying any amount of energy. For example the modulator tube 3 may be coupled to the anode circuit of tube 2, instead of being coupled to the input circuit.

The selectivity of the circuits involved, the circuit constants, and the proper adjustment of all the resonant circuits are some of the factors which determine the percentage of modulation to be attained by the employment of my invention.

While the resonant circuit including 19 (Fig. 1) and the corresponding resonant circuits of the other figures are preferably tuned to a frequency which is of the order of one or one-half percent removed from the carrier frequency, the difference may be higher. For instance, with a carrier frequency of 1000 k. c. the resonant circuit could be tuned to 1080 k. c. or 920 k. c., i. e., 8% removed. This depends on the coefficient of the coupling and the efficiency of the resonant circuits, e. g., 7 and 19 in Fig. 1, and on the result desired.

In Fig. 1, the resonant circuit, e. g., 19, could be tuned to the exact carrier frequency and tube 3 used as a loading device to vary the impedance of the circuit thereby obtaining radio frequency modulation of the grid 18.

An important advantage of my system of modulation is that it makes possible a greater percentage of modulation without distortion than would be possible with conventional types of amplitude modulation systems. This can be done by biasing tube 3 to a suitable value on its grid voltage plate current characteristic curve so that during the modulation cycle the negative modulation peaks will be limited to a value never to exceed a point where the carrier would be cut-off. The positive peaks may reach a value which is three or four times the value of the carrier without modulation. Thus a controlled carrier system is produced.

What I claim is:

1. A modulation system including a source of carrier frequency energy, a modulated amplifier excited by said energy and variable impedance coupling means feeding said energy from said source to said modulated amplifier, said coupling means including a series resonant circuit having a mid-connection between the capacitative and inductive elements thereof, tuned to a frequency of the order of one percent different from said carrier frequency and impedance varying means coupled to the mid-connection of said series resonant circuit, said impedance varying

means including audio-frequency modulated capacity varying means having an effective reactance varying in accordance with said audio-frequency.

2. A modulation system including a first resonant circuit supplied with carrier energy at a frequency corresponding with the natural period of said circuit, a second series resonant circuit having a mid-connection between the capacitative and inductive elements thereof, conductively coupled to said first circuit and tuned to a frequency about one percent different from the frequency of said carrier energy, means for varying the effective resonant frequency of said second circuit at audio-frequency, whereby the energy derived by said second circuit through its coupling with said first circuit is modulated at said audio-frequency, and means for withdrawing at least part of the modulated energy from the mid-connection of said second series resonant circuit.

3. Modulation system including a source of carrier frequency, a first tuned circuit fed by said carrier frequency, a series resonant circuit having a mid-connection between the capacitative and inductive elements thereof, coupled to said first tuned circuit and slightly detuned therefrom, a load coupled to the mid-connection of said series resonant circuit so as to receive energy therefrom, a variable capacity also connected to said mid-connection and effectively in shunt with the capacity of said series resonant circuit so as to vary the tuning thereof, and means connected so as to vary said variable capacity at audio-frequency, whereby the energy appearing at said mid-connection and fed to said load is audio-frequency modulated.

4. System according to claim 3, in which the coupling between said first tuned circuit and said series resonant circuit is conductive.

5. System according to claim 3, in which said means for varying said variable capacity at audio-frequency includes a multi-element electronic tube displaying anode circuit characteristics equivalent to a variable condenser and a source of audio-frequency modulating energy connected to one grid thereof.

JOHN J. ANTALEK.