March 13, 1928.

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H. C. SILENT

HIGH FREQUENCY MODULATING SYSTEM

Filed May 24, 1924

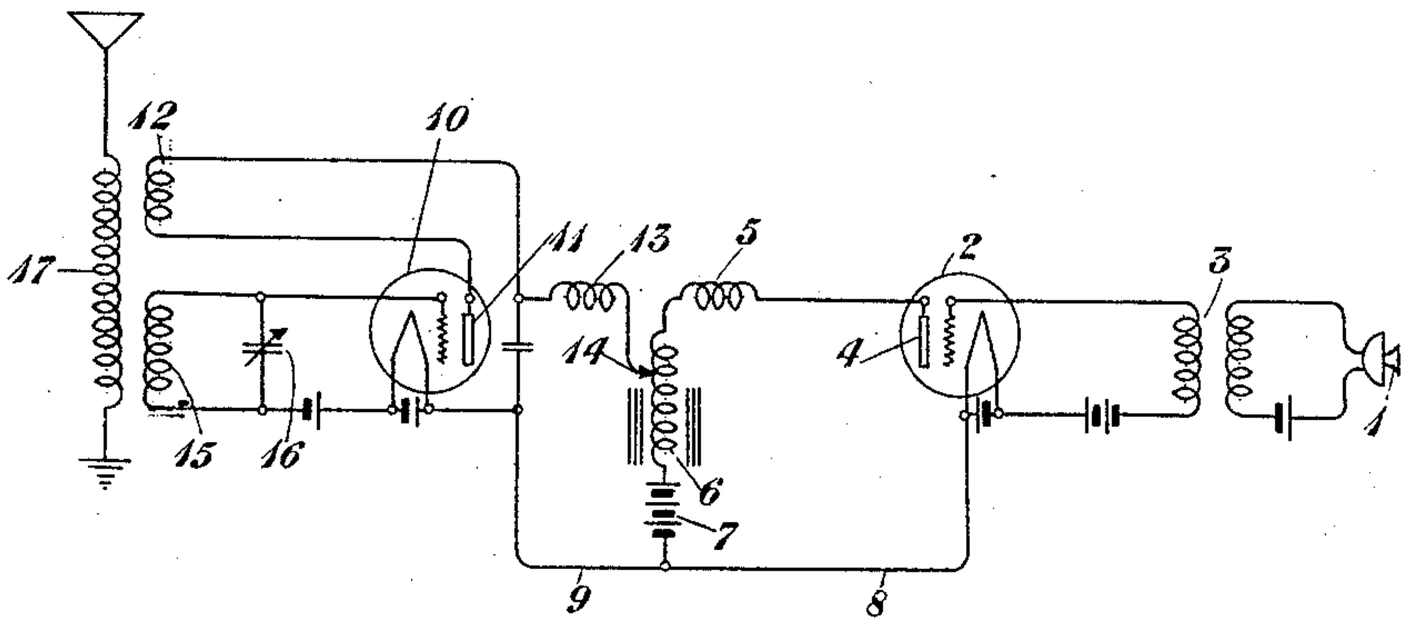

Fig. 1

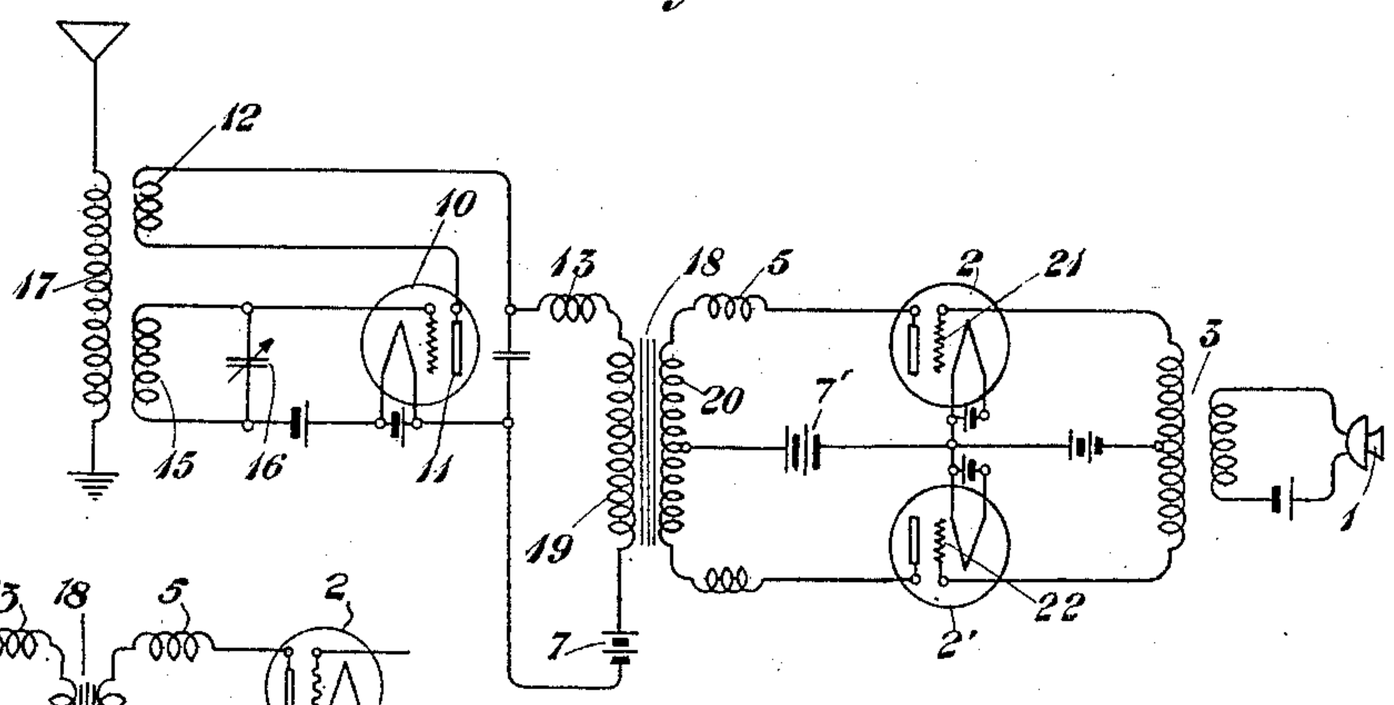

Fig. 2

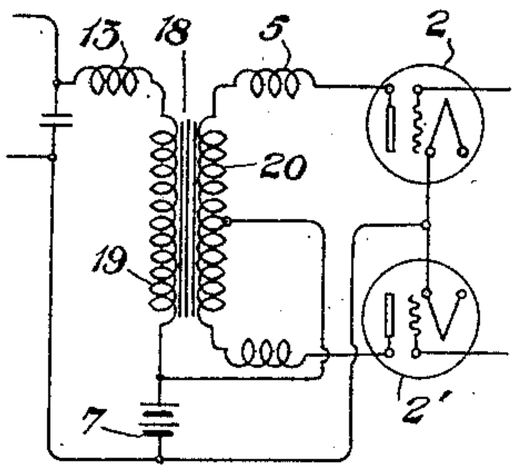

Fig. 2a

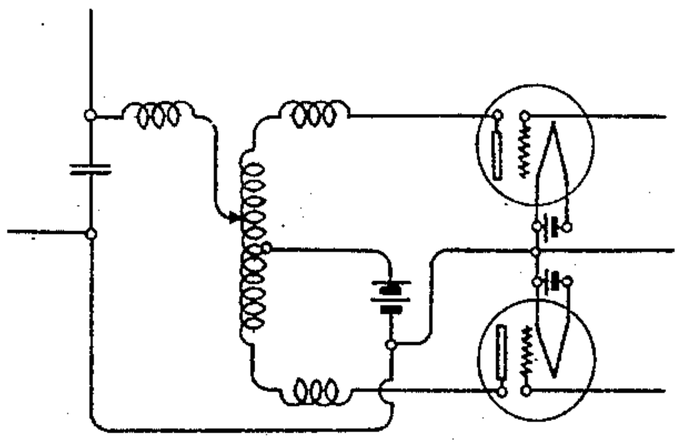

Fig. 3

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UNITED STATES PATENT OFFICE.

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HIGH-FREQUENCY MODULATING SYSTEM.

Application filed May 24, 1924. Serial No. 715,701.

This invention relates broadly to systems for modulating high frequency current and particularly to means for coupling the modulating device with the source of high frequency current to be modulated.

In the patent to Heising 1,442,147, which issued on January 16, 1923, there is disclosed a system of modulation in which the modulation is effected by variably diverting portions of the normal space current of a vacuum tube oscillator, that is to say, the modulating current varies the effective electromotive force of the source of a space current of the oscillator so that the output current of the said oscillator will be modulated by and in accordance with the signals which produce the modulating current. In the arrangement disclosed by Heising for carrying out his method of modulation the plate electrodes of the modulating tube and of the oscillating tube are connected with a common source of plate potential, the said connection including a choke coil or auto-transformer which establishes a unity ratio coupling between the modulating and the oscillating tubes. The manner in which this circuit functions to effect the desired result is fully described in the said patent and is also well known to those skilled in the radio art and consequently it need not be described herein. Experience has shown that in order to get the maximum power from such circuit the impedance of the plate circuit of the modulator should equal that of the plate circuit of the oscillator.

It is the object of this invention to provide a method and means by which this equality of impedances may be readily obtained.

This invention will be clearly understood from the following description when read in connection with the attached drawing of which Figure 1 shows an embodiment of the invention in which a single modulating tube is employed; Fig. 2 is an embodiment of the invention in which the modulating circuit is of the push-pull type and the coupling is a multiple winding transformer; Fig. 2[a] shows a variation of a detail of Fig. 2, and Fig. 3 is a modification of the arrangement shown in Fig. 2 in which a variable auto-transformer is substituted for the multiple winding transformer of Fig. 2.

In Fig. 1 the transmitter 1 is coupled to the grid circuit of the modulator 2 by means of the transformer 3. The plate 4 of this modulator is connected through the impedance 5 with the winding 6 of the auto-transformer with which is connected the positive pole of the plate battery 7. The negative pole of this battery is connected by conductors 8 and 9 with the filaments of the modulator 2 and the oscillator 10, respectively. The plate 11 of the oscillator 10 is effectively connected with the auto-transformer 6, the connection including the winding 12, the impedance 13 and the movable contact 14 of the auto-transformer. The grid of the oscillator 10 is connected with the tuned circuit made up of the winding 15, and the condenser 16. Windings 12 and 15 are inductively related with the winding 17 of the transmitting antenna. It is desirable to make clear that the invention is not concerned with a particular kind of input circuit for the modulator 2 nor with a particular kind of output circuit of the oscillator. That is to say, a transmitting device different from the transmitter 1 and an output circuit different from 17, might be used without varying the character of the invention.

When no current variations are impressed upon the grid of the modulator 2, a steady unidirectional current will flow from the plate battery 7 through the winding 6 of the auto-transformer and thence through two branches in parallel, one branch including the impedance 5, the space between the plate 4 and the filament of the modulator 2 and conductor 8; the other branch including the impedance 13, winding 12, the space between the plate 11 and the filament of the oscillator 10 and conductor 9. When variations are impressed upon the grid of the modulator 2 the plate current of the modulator will vary in accordance with the grid variations. This will cause a variation in the total current through the winding 6 of the auto-transformer which varies the potential difference across said winding. Consequently, the plate potential of the oscillator 10 will be varied accordingly and the output current of the oscillator will be modulated in accordance with the current variations applied by the transmitter 1 to the grid of the modulator 2.

It has been found that the maximum power can be derived from the oscillator by making the impedance of the plate circuit of the modulator 2 equal to the impedance

of the plate circuit of the oscillator 10. By varying the coupling between these two plate circuits, which may be done by adjusting the contact point 14 of the auto-transformer, this equality of plate circuit impedance may be obtained.

The arrangement shown in Fig. 2 illustrates the use of a modulator of the push-pull type adapted to a circuit for carrying out the Heising method of modulation. As is well known to those skilled in the radio and vacuum tube art the push-pull type of circuit produces less distortion than the non-symmetrical type of vacuum tube circuit, and permits of greater power output for the same number of tubes. The output side of this push-pull modulator which includes the plate circuits of the tubes 2 and 2′ is coupled by means of the multiple winding transformer 18 with the plate circuit of the oscillator 10. The source of plate voltage 7 is connected with one terminal of the winding 19 and the source 7′ connected with the mid-point of the winding 20 of the same transformer. Current will therefore flow from the positive pole of the battery 7 through winding 19 to the plate of the oscillator 10 and from the battery 7′ through the two halves of the winding 20 to the plates of the modulator tubes 2 and 2′. When current variations are produced by the transmitter 1, the grids 21 and 22 will be at different potentials and consequently the current flowing from the source 7′ through the two halves of winding 20 will be different. The resultant current will produce a difference of potential across winding 19 which will vary the plate potetial of the oscillator 10. By varying the ratio of the windings 19 and 20 the impedance of the plate circuit of the oscillator 10 may be made equal to the impedance of the push-pull modulator which condition insures maximum power output.

The arrangement shown in Fig. 2ª employs a single source of plate voltage to supply windings 19 and 20. This permits the use of tubes of different types in the oscillator and in the modulator. The description of the operation as given above would be equally applicable in this case.

The arrangement shown in Fig. 3 illustrates the use of an auto-transformer in place of the multiple winding transformer 18 shown in Fig. 2.

By means of this improvement upon the well known Heising circuit the efficiency of operation of this circuit may be materially improved.

While this invention has been disclosed as embodied in particular forms, it is to be understood that it is not so limited but is capable of embodiment in other and different forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In a modulating system in which the modulating current varies the effective E. M. F. of the source of space current of a vacuum tube oscillator, the combination with an oscillator of a modulator and means to couple the said oscillator and modulator, the said means being so adjusted that the impedance of the circuit looking toward the said modulator is made equal to that looking toward the said oscillator.

2. In a modulating system in which the modulating current varies the effective E. M. F. of the source of space current of a vacuum tube oscillator, the combination with a vacuum tube modulator of a vacuum tube oscillator, a transformer coupling the plate circuit of the modulator with the plate circuit of the oscillator, sources of plate current effectively connected through the windings of said transformer with the plates of the modulator and oscillator tubes, the said coupling transformer being adjusted so that the impedances of the plate circuit of the modulator and of the plate circuit of the oscillator are equalized.

3. In a modulating system in which the modulating current varies the effective E. M. F. of the source of space current of a vacuum tube oscillator, the combination with an oscillator of a push-pull modulator, and a coupling between the said oscillator and the said modulator so adjusted that the impedance of the output of the modulator equals the impedance of the input of the said oscillator.

4. In a modulating system in which the modulating current varies the effective E. M. F. of the source of space current of a vacuum tube oscillator, the combination with an oscillator of a push-pull modulator and a coupling transformer having one winding connected across the plates of the modulator, and a second winding connected with the plate of the oscillator, and sources of direct current potential connected with the mid-point of the said first winding and with one of the end terminals of the said second winding, the impedances of the plate circuits of the modulator and the oscillator, as viewed from the coupling transformer, being equal.

In testimony whereof, I have signed my name to this specification this 19th day of May 1924.

HAROLD C. SILENT.