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HIGH FREQUENCY SIGNALING SYSTEM

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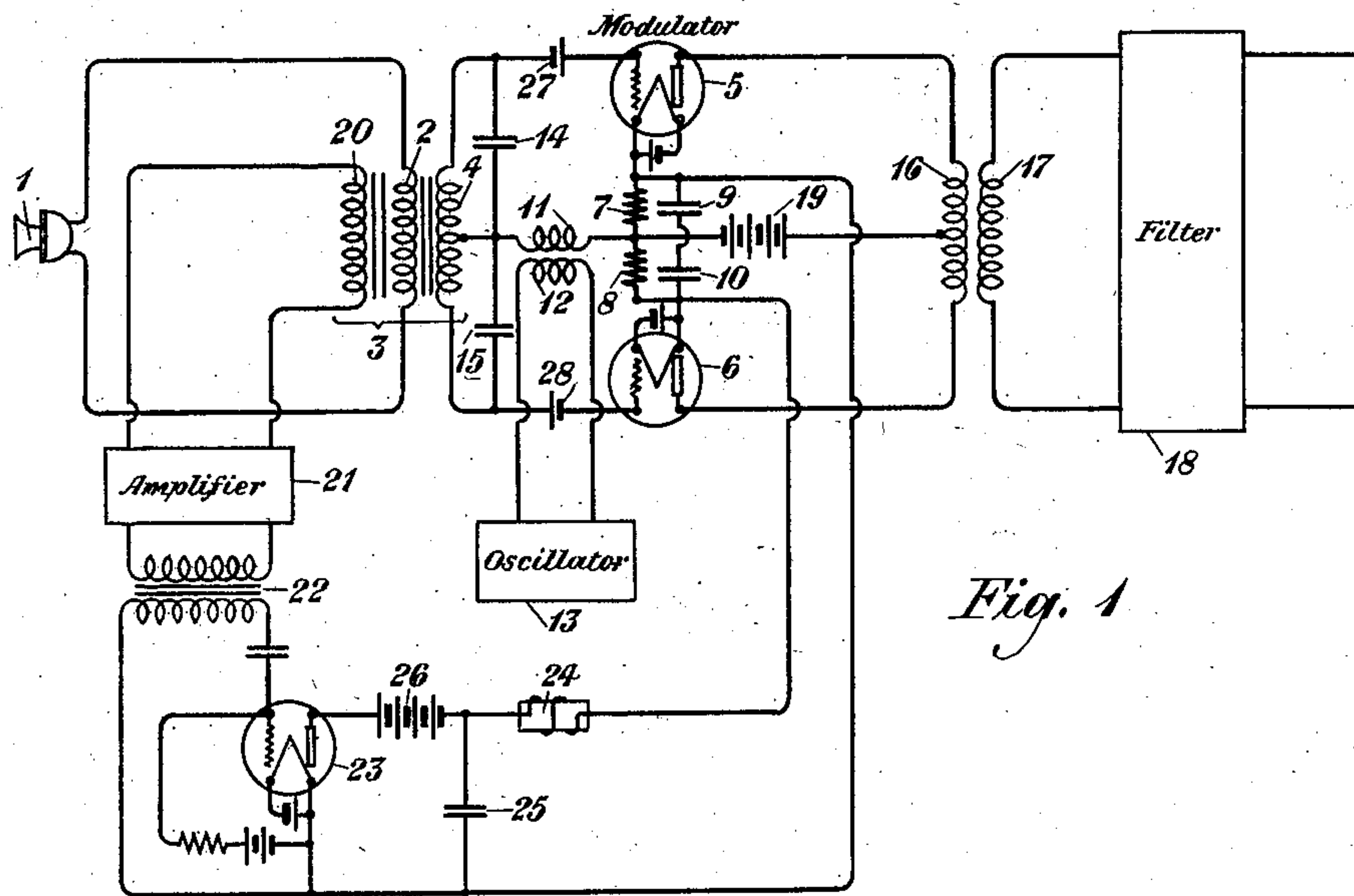


Fig. 1

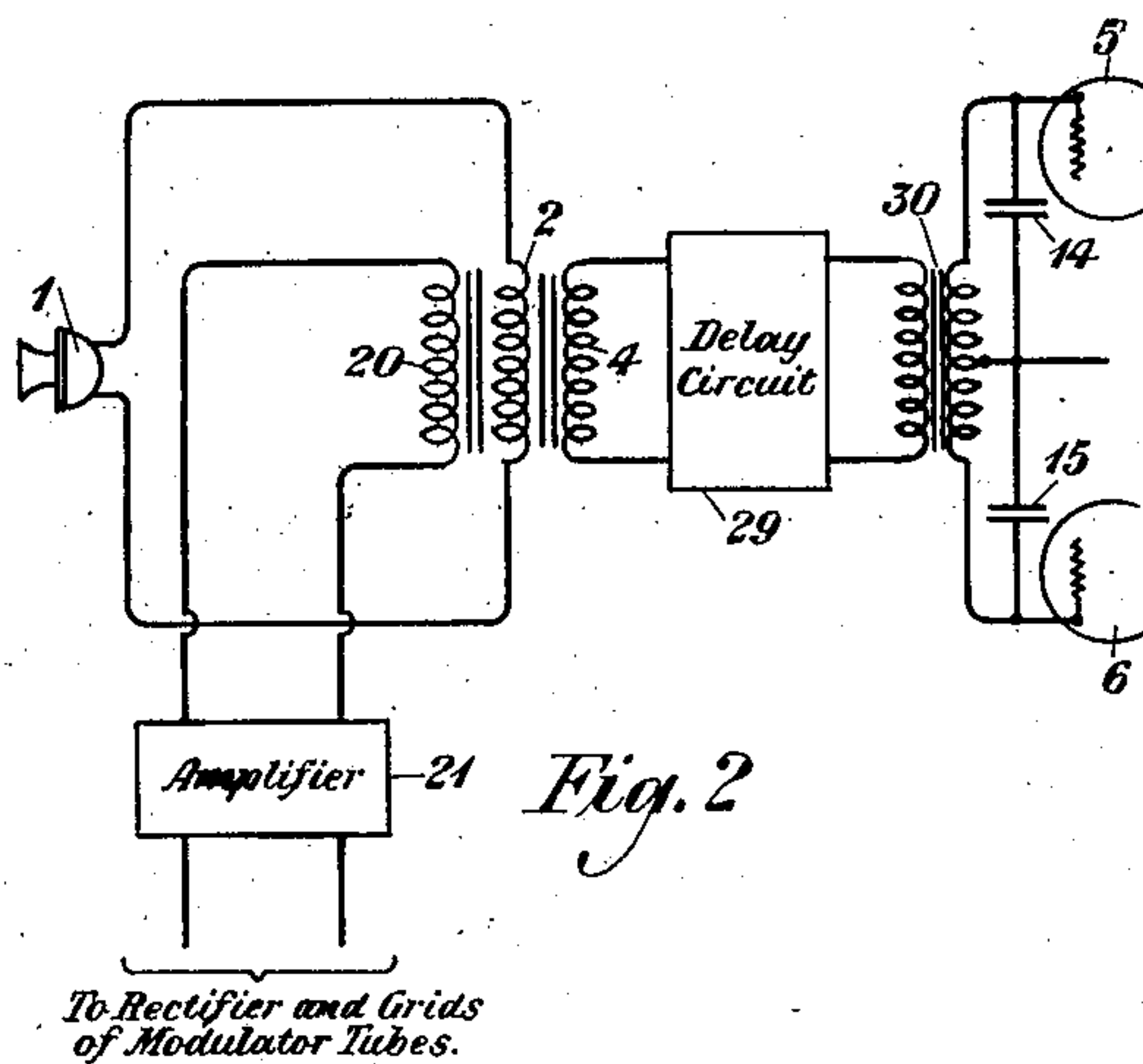


Fig. 2

To Rectifier and Grids
of Modulator Tubes.

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UNITED STATES PATENT OFFICE.

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HIGH-FREQUENCY SIGNALING SYSTEM.

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This invention relates to radio transmitting systems, and particularly to a modulating device characterized by means for controlling the transmission of the carrier frequency.

In high frequency transmission systems which include both radio and wire systems, it has been customary either to radiate the carrier frequency continuously or to suppress the transmission of the carrier frequency. Systems in which the carrier frequency is transmitted at all times, regardless of whether modulation is or is not taking place, are not only wasteful of power but also possess other disadvantages. Systems in which the carrier frequency is at all times suppressed, that is to say, is prevented from being radiated, cannot be employed under conditions where it is necessary to supply the carrier frequency to a distant receiving station which has no local source of oscillations for beating the incoming band frequencies for the purpose of detecting the signal.

This invention resides in a system of high frequency transmission in which the carrier frequency is suppressed, that is to say, its radiation is prevented except during the time in which a signaling current is impressed upon a modulator for modulating the said carrier.

A system such as this in which the carrier is suppressed between modulation periods not only effects a saving of power but also possesses other advantages over the systems of the prior art, one of which resides in its ability to reduce the effect of static and power disturbances at the receiving station during the intervals between modulation periods, and another advantage resides in the ability of the system to effect radio transmission and reception on the same wave length. The first mentioned advantage, namely, the suppression of disturbances, results from the absence of the carrier during the quiescent intervals between modulation, and it is twofold in its character; first, there is a psychological effect upon the listener at the receiving station resulting from a reduction in the noise level when modulation is not occurring at the transmitting station; and second, it appears probable that there is a distinct improvement in the effect upon perception of intelligible sounds.

This invention will be clearly understood from the following description when read

in connection with the attached drawing, of which Figure 1 shows schematically a form of embodiment of the invention; and Fig. 2 is a modification of Fig. 1.

In Fig. 1, the transmitter 1 represents symbolically any form of transmitting station which is connected with the primary winding 2 of the transformer 3, which transformer is preferably of the step-up type. A secondary winding 4 is connected with the input circuit of the modulator M comprising the vacuum tubes 5 and 6 and associated apparatus by means of which modulation is effected. This modulating circuit is, with certain exceptions, of the well-known type disclosed in the patent to Carson No. 1,449,382, dated March 27, 1923, but it differs therefrom in that the carrier frequency is suppressed only when no modulation is occurring, and is transmitted together with the side bands resulting from the modulation of the carrier through the output circuit. The grids of the tubes 5 and 6 are connected with the extremities of the winding 4, which has its midpoint connected with the filaments of the tubes 5 and 6, the connection including resistances 7 and 8. These resistances have condensers 9 and 10 connected in parallel therewith. The common conductor of the tubes contains the winding 11 of a transformer that has its other winding 12 connected with the source of carrier oscillations 13. The condensers 14 and 15 shunt the winding 4, and permit the high frequency currents to pass directly to the grids of the tubes. The plates of the tubes 5 and 6 are connected with the extremities of the winding 16 of a transformer having its secondary winding 17 connected with an output circuit containing a filter 18 adapted to transmit therethrough the carrier frequency and one of its side bands. The midpoint of the winding 16 is connected with the junction point of the resistances 7 and 8, the connection including the source of plate potential 19. The transformer 3 has also another secondary winding 20 which is connected with the input side of an amplifier 21, whose output side is coupled by the transformer 22 (or otherwise connected) with the rectifier tube 23. The output circuit of the rectifier contains the inductance 24 and the condenser 25, constituting a simple type of low-pass filter whose function is to smooth out and to eliminate irregularities from the rectified voltage wave produced by the tube 23. The output circuit

of the rectifier is bridged across the resistances 7 and 8 so as to establish across these resistances a direct current potential, the magnitude of which is proportional to variations in the speech currents impressed by winding 2 upon winding 20 of transformer 3. The manner in which this circuit operates in order to attain the objects of the invention is as follows:

During the period in which speech or other signaling currents are not produced by activation of the transmitter 1, the oscillations created by the source 13 will be impressed upon the input circuits of the tubes 5 and 6 and will affect the grids in like manner so that no variation of the plate currents is produced, and consequently, no transmission of the carrier will be effected over the output circuit which may be either a radio or a wire circuit. As soon as speech or other form of signal is impressed upon the transmitter 1 and a corresponding current flows through the winding 2 of the transformer 3, corresponding voltages will be impressed across the windings 4 and 20. That which is produced in winding 4 affects the grids of the tubes 5 and 6 in the well-known manner to modulate the carrier frequency from the source 13. The side bands thus produced are impressed by the winding 16 upon the winding 17, and in turn upon the filter 18. The voltage simultaneously created in the winding 20 will be amplified by 21 and rectified by the tube 23. It will be seen that the plate current from the source 26 flows normally through the resistances 7 and 8 one of which is in the grid circuit of the tube 5 and the other in the grid circuit of the tube 6. The potential differences across said resistances when added to those of the sources 27 and 28, are normally sufficiently great to keep the grids negative to the same degree during the period in which modulation is not taking place, and thus a condition of balance is created which suppresses the carrier. When

a speech current flows through the winding 2 the resultant voltage will be amplified by 21 sufficiently so that the detected voltage produced by 23 will tend to keep the grid of the rectifier 23 sufficiently negative during modulation. This produces an unbalance in the tubes, and consequently, carrier oscillations will no longer be balanced out but will be transmitted by the winding 16 to the winding 17 and will be radiated together with the side band or bands.

Within a reasonable approximation the plate current of a three-element vacuum tube may be expressed by the relation

$$I = \alpha (E_B / \mu + E_C + \epsilon)^2 \quad (1)$$

where α depends upon the structure of the tube;

μ is the voltage amplification constant;

ϵ depends upon grid-filament contact potential and the power developed in the filament;

E_B is plate potential; and

E_C is grid potential.

The first and last factors within the parenthesis of equation (1) may, for the purpose of this explanation, be assumed constant and equal to C . If then two waves, one of audible and one of carrier frequency, are impressed upon the input, the general relation of equation (1) becomes

$$I = \alpha [C + E_C + e_1 \sin (pt - \phi_1) + e_2 \sin (qt - \phi_2)]^2 \quad (2)$$

where $C = E_B / \mu + \epsilon$;

e_1 = amplitude of audio wave;

e_2 = amplitude of carrier wave;

$p/2\pi$ = audible frequency;

$q/2\pi$ = carrier frequency; and

ϕ_1 and ϕ_2 are the arbitrary phase angles of the audible and carrier waves.

The expansion of equation (2) and elimination of all terms except those in the vicinity of the carrier frequency gives an output current proportional to

$$(C + E_C) e_2 \sin (qt - \phi_2) + \frac{e_1 e_2}{2} \cos (qt - pt + \phi_1 - \phi_2) - \frac{e_1 e_2}{2} \cos (qt + pt - \phi_1 - \phi_2) \quad (3)$$

Here the first term represents the carrier wave, and its amplitude is a function of the grid potential E_C . The second and third terms represent the lower and upper side band components, respectively.

The circuit arrangement in Fig. 1 is such that two complex currents as represented by (3) are combined in opposite sense in the output. If the amplitude factors e_1 and e_2 are considered negative for one tube and positive for the other, the output of carrier current becomes proportional to

$$(E_C - E_C') e_2 \sin (qt - \phi_2) \quad (4)$$

while the side band output containing product terms is unmodified. Here E_C is the grid

potential of one tube and E_C' that of the other. When E_C is equal to E_C' , the modulator in Fig. 1 is balanced and no carrier goes into the output. When speech is impressed upon the input, the rectified output of tube 23 flows through resistances 7 and 8, producing an unbalance and if normally $E_C = E_C'$, the carrier current now becomes proportional to

$$i_r (r_1 + r_2) e_2 \sin (qt - \phi_2) \quad (5)$$

where i_r is the rectified output of tube 23 and r_1 and r_2 are the resistances 7 and 8, respectively. Thus during modulation there is produced in the output of the modulator a carrier current proportional to (5).

The arrangement shown in Fig. 2 illus-

trates a way in which modulation may be retarded until the speech current has been rectified and effects an unbalancing of the modulating circuit, whereby modulation and effective transmission of the carrier will take place substantially simultaneously. This result is obtained by the insertion of a delay circuit 29, which, while of the nature of a low-pass filter in the sense that it readily transmits therethrough the speech or other modulating currents, it also serves to shift the phase of the modulating current so as to introduce a delay, which delay enables the rectified speech current to become effective at substantially the moment when modulation occurs.

While this invention has been disclosed as embodied in a particular form, it 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 high frequency signaling system, the combination with a balanced modulator of a source of carrier oscillations, the said modulator being of the carrier suppression type, a signal input circuit connected with the said modulator, and means controlled by the signal to unbalance the said modulator and to effect the transmission of the carrier oscillations whenever modulation takes place.

2. In a high frequency signaling system, the combination with a balanced vacuum tube modulator of the carrier suppression type of a source of carrier oscillations, a source of modulating current, and a control circuit connected with said source of modulating current and also with said modulator comprising an amplifier and a rectifier arranged to apply unlike voltages to the grids of the modulator tubes proportional to the rectified modulating current, whereby the said modulator will be unbalanced and transmission of the carrier will occur.

3. In a high frequency signaling system, the combination with a balanced modulator of the carrier suppression type, of a source of carrier oscillations connected therewith, a source of modulating current connected with the said modulator, and means connected with the said source of modulating current and said modulator to unbalance the latter and effect the transmission of carrier oscillations whenever modulation takes place.

4. In a high frequency signaling system, the combination with a balanced vacuum tube

modulator of the carrier suppression type, of a source of carrier oscillations connected with a conductor common to the grids of the tubes of the said balanced modulator so as to normally affect the grids to the same extent, a signaling circuit connected with the input of the said modulator, a vacuum tube rectifier having its plate circuit connected with the grid circuits of the modulator tubes so as to apply direct current potentials to the grids of said tubes, sources of potential also connected with the grids of said tubes to neutralize the bias upon the grids normally produced by the said direct current potential resulting from the plate current of the rectifier, and means to unbalance the said modulator during modulation by the said signaling current to effect the transmission of the carrier oscillations.

5. In a high frequency signaling system comprising a balanced modulator, a source of carrier frequency, a source of signaling frequency to modulate the said carrier frequency, and a transmitting circuit, the method of signaling which consists in preventing the transmission of the carrier frequency by maintaining the modulator in a balanced condition when modulation is not occurring, and in effecting transmission of the carrier frequency by unbalancing the modulator by the signaling current which also simultaneously modulates the carrier frequency.

6. In a high frequency signaling system comprising a balanced modulator, a source of carrier frequency, a source of signaling frequency to modulate the said carrier frequency, and a transmitting circuit, the method of signaling which consists in maintaining the modulator in balanced condition when modulation is not occurring, thus preventing the transmission of the carrier frequency, then modulating the carrier frequency by the signaling frequency to produce side bands of the said carrier, and simultaneously rectifying a part of the signaling frequency and unbalancing the modulator by the said rectified signaling frequency to cause the transmission of the carrier frequency oscillation whenever side bands thereof are being produced.

In testimony whereof, I have signed my name to this specification this 22nd day of December, 1925.

RALPH K. POTTER.