Oct. 29, 1929. E. PETERSON 1,733,556

CARRIER WAVE TRANSMISSION

Filed July 31, 1926

Fig. 1

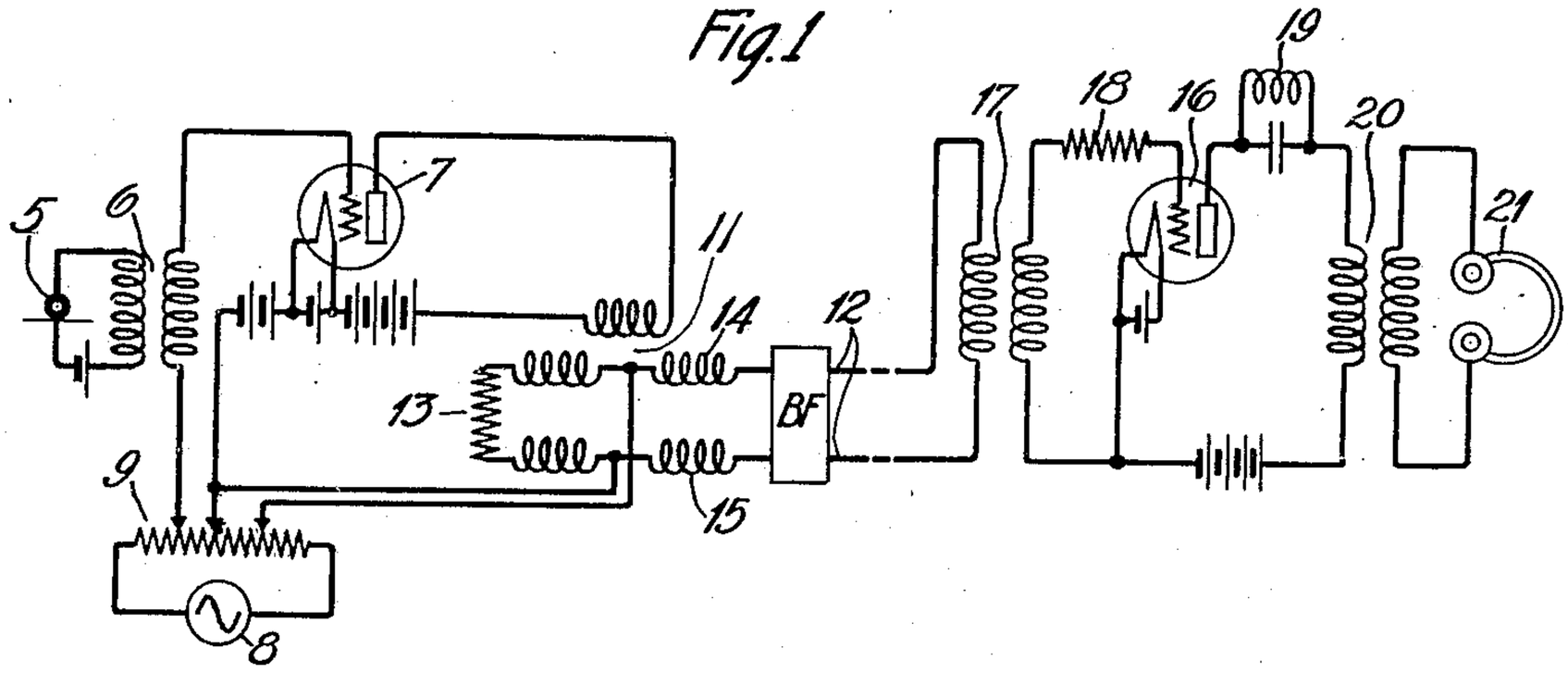


Fig. 2

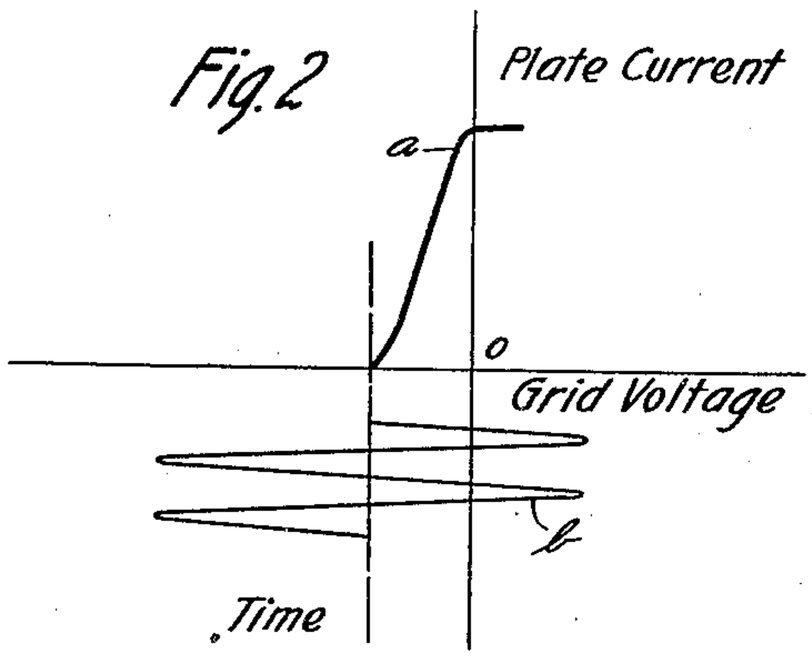


Fig. 4

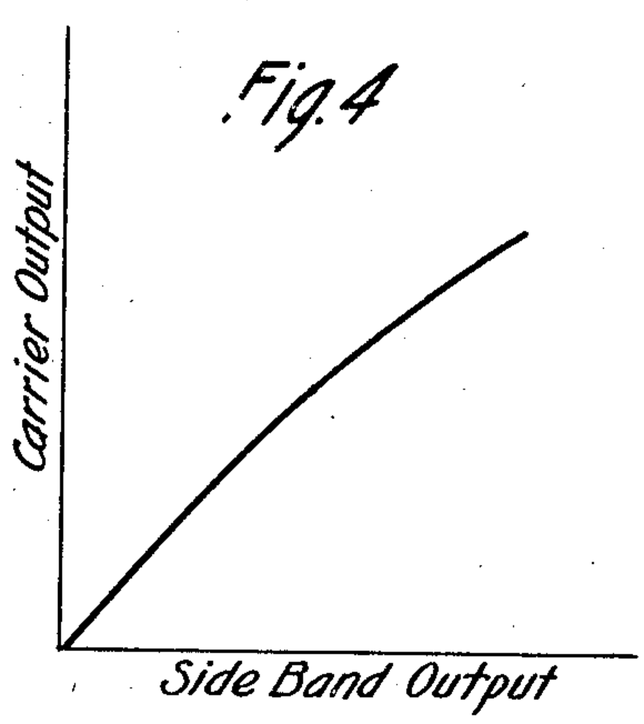
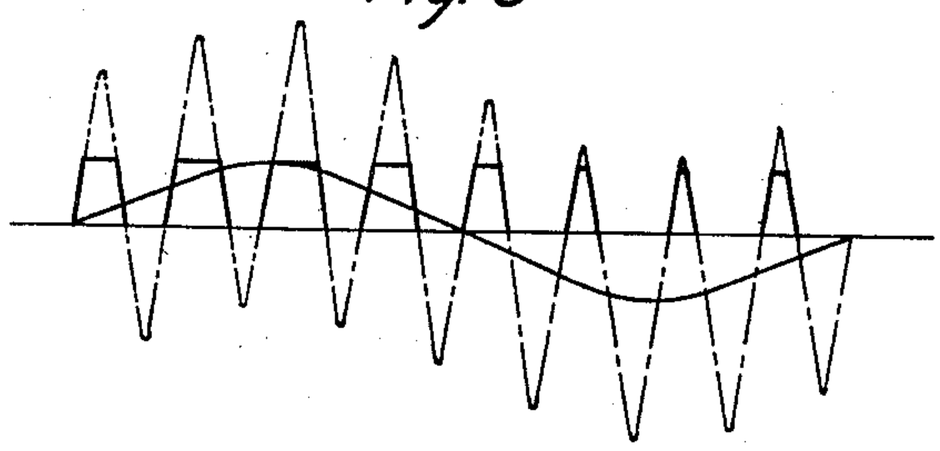


Fig. 3



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UNITED STATES PATENT OFFICE

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CARRIER-WAVE TRANSMISSION

Application filed July 31, 1926. Serial No. 126,128.

This invention relates to carrier wave transmission and particularly to modifying electrical waves in accordance with signals or other effects to be transmitted.

An object of the invention is to suppress the unmodulated carrier waves when no signals are transmitted, and to transmit a carrier component along with side band components during the transmission of signals.

Related objects of the invention are to transmit a carrier wave component having an amplitude proportional to the signal wave amplitude, and to utilize the carrier wave component in detecting the transmitted signals without undue distortion.

In carrier wave transmission systems, which include both radio and wire systems, it has been customary either to transmit the unmodulated carrier component continuously or to suppress the unmodulated carrier component at the transmitting terminal. There are certain difficulties inherent in both types of transmission. Systems in which the carrier component is transmitted at all times are wasteful of power, and also require amplifiers of large load carrying capacity at repeater points in order to avoid distortion. Systems in which the carrier component is at all times suppressed require a source of carrier current at the receiving terminal to supply to the incoming side band carrier current of the frequency suppressed at the transmitting terminal. For efficient reception in systems of this type means must also be provided to synchronize the carrier sources at both terminals as to frequency.

These difficulties are largely overcome by means of this invention which provides an intermittent carrier transmitting system in which the unmodulated waves of carrier frequency are suppressed during the quiescent intervals between modulation, and in which modulation causes a component of carrier frequency to be transmitted with the side band to enable the signals to be detected at the distant terminal without the aid of a local source of oscillations.

According to a feature of the invention, the modulator at a transmitting terminal is overloaded by impressing upon it a carrier wave of large amplitude, the carrier wave being normally neutralized in the load circuit by means of a balancing circuit including suitable phase controlling devices. By impressing a signaling current on the modulator, a side band is produced by modulation with the carrier, and further, the amplitude of the carrier in the modulator circuit is reduced by an amount depending on the amplitude of the signaling current. As a result of this action, the normal balance of the carrier in the load circuit is disturbed and there is transmitted to the load, along with the side band, a carrier component which varies with the amplitude of the impressed signals. Thus, according to the invention, even though the normal carrier is balanced out at the transmitting terminal, the presence of the signaling current in the input circuit of the modulator causes an out-of-balance carrier component to be impressed upon the transmitting medium, and this carrier component is utilized in detecting the transmitted signals at the distant receiving terminal.

The invention will be described in detail in connection with the accompanying drawing, in which:

Fig. 1 is a diagrammatic illustration of a carrier transmission system embodying the invention;

Fig. 2 shows a grid voltage-plate current characteristic curve of the modulator circuit employed in the system of Fig. 1;

Fig. 3 shows curves illustrating the nature of the currents produced when a signal voltage is impressed upon the modulator; and

Fig. 4 shows a curve illustrating the relation between the side band output and the carrier output.

In Fig. 1 a source of signaling current 5 is coupled by means of transformer 6 to the input circuit of the modulator 7. The modulator comprises a space discharge tube provided with the usual sources of electrical energy to properly polarize the grid electrode, to heat the cathode, and to furnish anode-cathode current, respectively. The modulator 7 is supplied with waves of carrier frequency from a source 8 through a differential potentiometer 9. The output circuit of the

modulator is connected to one winding of a balanced transformer or hybrid coil 11. The output terminals of transformer 11 are connected to the transmisison line 12, a balancing impedance or artificial line 13 being connected to the opposite terminals of the transformer 11 in the usual manner. The midpoints of windings 14 and 15 of transformer 11 are connected to one side of the differential potentiometer 9, whereby an unmodulated wave of the carrier frequency may be impressed upon these windings. This connection is so made that the component of carrier frequency impressed directly from the source 8 upon the transformer 11 is 180 degrees out of phase with the component impressed thereon by way of the modulator 7, so that the normal carrier frequency output of the modulator is neutralized in the transformer and is not impressed upon the transmission line 12. The use of a balancing circuit for neutralizing the carrier in the output of a modulator is disclosed in my copending application, Serial No. 696,766, filed March 4, 1924, which became Patent 1,699,711, January 22, 1929.

The operating condition with reference to the modulator tube characteristic and the normal carrier wave is illustrated in Fig. 2, the curve *a* representing the characteristic of the modulator tube circuit and the curve *b* the impressed carrier potential. According to the invention, the steady negative potential applied to the grid of the modulator tube is sufficiently negative to make the normal plate current very small or zero. The amplitude of the carrier current impressed upon the input circuit of the modulator from the source 8 is such that the plate current is blocked during about half the period and is saturated during the other half period. When the source of signaling current 5 is quiescent, that is, when no signals are being transmitted, the modulator plate current consists of a train of substantially flat topped impulses of carrier frequency of about a half period duration. The flat top is due to saturation of the space current when the impressed carrier wave is strongly positive, and the intervals between impulses correspond to the intervals when the impressed carrier wave is strongly negative.

The curves of Fig. 3 illustrate the nature of the currents produced when a signal voltage is impressed upon the input circuit of the modulator from the source 5. The broken lines indicate the carrier waves, the continuous line indicates the signal wave, and the heavy lines indicate the actual output current as produced by the alternate blocking and saturation of the modulator tube. The effect of impressing the signal current upon the modulator may be pictured as moving the carrier wave up and down with respect to the plate current characteristic. When the signal current is negative, the plate current will depend upon the action of the tips of positive halves of the carrier wave, and when the signal current is positive the plate current wil depend upon the action of portions nearer the base of the positive halves of the carrier waves, which will cause current to flow for a greater fraction of the carrier period. The result of this action is to lengthen and shorten the duration of the space current impulses in accordance with the signal variations. The wave which is thus transmitted has been found by experiment to include amongst other components a component of the carrier wave frequency together with side frequencies corresponding to the signal, but differs from the ordinary type of modulated carrier waves in that the carrier is not of constant amplitude, but diminishes as the intensity of the signal wave increases. As a result, the normal balance of the carrier in the transformer 11 is disturbed, and there is transmitted to the line along with the side band, a carrier component that varies with the signal amplitude.

It will be seen that as a result of the unbalance referred to above, the outgoing currents include a component of carrier frequency and side bands corresponding to the signal, the amplitudes of both waves being controlled by the amplitude of the impressed signal current. A band filter BF is associated with the line 12 at the transmitting terminal and is arranged to transmit selectively the carrier frequency and either the upper or lower side band produced by modulation, and to suppress waves of all other frequencies. This filter may be of the type disclosed in Patent No. 1,227,113, issued to G. A. Campbell, May 22, 1917.

The relation between the side band output and the carrier output is illustrated by the curve of Fig. 4, and is shown to be approximately linear. It also appears that the effect of a variable carrier component is to cause each component of the signal current to modify the intensity of the other components in the process of detection, and this effect, while most pronounced when the carrier is modulated by a signal current, may be present to some extent in any system employing a variable carrier. In order to avoid distortion it is therefore desirable to employ a special mode of detection which is independent of the amplitude of the carrier component. A suitable detector for this purpose is the grid current detector disclosed in my copending application, supra, which has the advantage of giving an output wave which is proportional to the side band wave amplitude and substantially independent of the carrier amplitude so long as the amplitude of the carrier is greater than that of the side band. A detector of this type is illustrated in Fig. 1 and comprises a space discharge tube 16 cou-

pled to the transmission line 12 by means of a transformer 17. The received carrier and side band components are combined in the input circuit of the tube 16 by the action of an impedance element 18 included in the input circuit. An anti-resonant circuit 19 in the output circuit of the detector, tuned to the carrier wave frequency, serves to prevent the flow of carrier frequency currents in the space current path and thus prevents plate current demodulation. The detected signal waves in the output circuit of the detector are impressed through transformer 20 upon a receiver 21 of any suitable type.

Although the invention has been described in connection with certain specific embodiments, it is apparent that the principles herein disclosed are susceptible of numerous other applications without departing from the scope and spirit of the invention as defined by the appended claims.

What is claimed is:

1. In a carrier wave transmission system, the method of signaling which comprises generating a series of impulses varying in duration in accordance with the amplitude of a signal, said series having a normal carrier frequency component, suppressing said component by opposing thereto an unmodulated carrier wave of like amplitude, and transmitting the modified wave thus produced.

2. In a carrier wave transmission system, the method of signaling which comprises generating a series of flat topped impulses varying in length in accordance with the intensity of a signal, said series having a normal carrier frequency component, suppressing said component by opposing thereto an unmodulated carrier wave of like amplitude, and transmitting the modified wave thus produced.

3. In a carrier wave transmission system, the method of signaling which comprises generating a series of impulses varying in duration in accordance with the amplitude of a signal, said series having a normal carrier frequency component, suppressing said component by opposing thereto an unmodulated carrier wave of like amplitude, transmitting the modified wave thus produced, and rectifying said modified wave to detect the signal.

4. In a carrier wave transmission system, the method of signaling which comprises generating a series of impulses varying in duration in accordance with the intensity of a signal, said series having a normal carrier frequency component, suppressing said component by opposing thereto an unmodulated carrier wave of like amplitude, transmitting the modified wave thus produced, and rectifying said modified wave to detect the signal.

5. In a carrier wave transmission system, the method of signaling which comprises generating a carrier wave, producing therefrom voltage impulses of substantially flat topped wave form, introducing thereinto a modulation variation which consists principally in changing the length or time duration of the successive impulses, and producing in response to such modulation a carrier component varying in amplitude in accordance with said modulation variation.

6. In a carrier wave transmission system comprising a modulator, a source of carrier waves, and a source of signaling current to modulate said carrier waves, the method of signaling which consists in suppressing the transmission of the carrier waves when the amplitude of the signal current is zero, and in transmitting substantially without phase reversal a carrier wave which varies with the amplitude of the signaling current at all other times.

7. In a carrier wave transmission system comprising a modulator, a source of carrier waves, and a source of signaling current to modulate said carrier waves, the method of signaling which consists in balancing out said carrier waves when no modulation is occurring, and transmitting substantially without phase reversal during modulation a carrier wave proportional to the amplitude of the signaling current.

8. In a carrier wave transmission system comprising a modulator, a source of carrier waves, and a source of signaling current to modulate said carrier waves, the method of signaling which consists in suppressing the transmission of the carrier waves when no modulation is occurring, and transmitting during modulation a series of impulses varying in duration in accordance with said signaling current.

9. In a carrier wave transmission system comprising a modulator, a source of carrier waves, and a source of signaling current to modulate said carrier waves, the method of signaling which consists in suppressing the transmission of the carrier waves when no modulation is occurring, and transmitting during modulation a series of flat topped impulses varying in length in accordance with said signaling current.

10. In a carrier wave transmission system comprising a modulator, a source of carrier waves, and a source of signaling current to modulate said carrier waves, the method of signaling which consists in suppressing the transmission of the carrier waves when the amplitude of the signaling current is zero, and at all other times transmitting a signal modulated wave and a carrier wave of an amplitude proportional to the amplitude of the signaling current.

11. In a carrier wave transmission system comprising a modulator, a source of carrier waves, and a source of signaling current to

modulate said carrier waves, the method of signaling which consists in suppressing the transmission of the carrier waves when no modulation is occurring, and during modulation transmitting a train of impulses varying in duration in accordance with said signaling current and a carrier wave of fixed amplitude.

12. In a carrier wave transmission system comprising a modulator, a source of carrier waves, and a source of signaling current to modulate said carrier waves, the method of signaling which consists in suppressing the transmission of the carrier waves when no modulation is occurring, transmitting during modulation a train of flat topped impulses varying in length in accordance with said signaling current, transmitting a carrier wave of fixed amplitude, and combining said carrier wave and said impulses to detect the transmitted signal.

13. In a carrier wave transmission system, means for generating a series of impulses varying in duration in accordance with the amplitude of a signal, said series having a normal carrier frequency component, means for suppressing said component by opposing thereto an unmodulated carrier wave of like amplitude, means for transmitting the modified wave thus produced, and means for rectifying said modified wave to detect the signal.

14. A carrier wave transmission system comprising a modulator having input and output circuits, means for impressing on said input circuit a carrier wave of such amplitude as to overload said modulator to produce a series of flat topped impulses, means for neutralizing the carrier wave in said output circuit, and means for impressing a signal on said input circuit to vary the duration of said flat topped impulses in accordance with said signal.

15. A carrier wave transmission system comprising a space discharge tube modulator having input and output circuits, means for impressing on said input circuit a wave of carrier frequency of such amplitude as to overload said modulator to produce a series of flat topped impulses, means for impressing on said output circuit a wave of carrier frequency in opposite phase relation to waves of the same frequency transmitted by said modulator, and means for impressing a signal on said input circuit to vary the duration of said flat topped impulses in accordance with said signal.

16. A carrier wave transmission system comprising a space discharge tube modulator having an anode, cathode and control electrode, means for supplying to said control electrode a fixed negative potential of a magnitude sufficient to reduce the normal space current approximately to zero, means for impressing on said control electrode a carrier wave of such amplitude as to overload said modulator to produce a series of flat topped impulses, means for neutralizing the carrier wave output of said modulator, and means for impressing a signal current on said control electrode to vary the duration of said flat topped impulses in accordance with the signaling current.

17. A carrier wave transmission system comprising a modulator having input and output circuits, means for impressing on said input circuit a carrier wave of such amplitude as to overload said modulator to produce a series of flat topped impulses, means for neutralizing the carrier wave in said output circuit, means for impressing a signal on said input circuit to vary the duration of said flat topped impulses in accordance with the amplitude of said signal and to produce a carrier component varying in amplitude in accordance with the amplitude of said signal, and means for combining said carrier component and said varying impulses to detect said signal.

18. A carrier wave transmission system comprising a space discharge tube modulator having an anode, cathode and control electrode, means for supplying to said control electrode a fixed negative potential of a magnitude sufficient to reduce the normal space current approximately to zero, means for impressing on said control electrode a carrier wave of such amplitude as to overload said modulator to produce a series of flat topped impulses, a balanced transformer having windings coupled to the output of said modulator, a balancing circuit for impressing on said transformer waves of carrier frequency in out-of-phase relation to the unmodulated waves of the same frequency in the output of said modulator whereby the said unmodulated carrier frequency waves are substantially neutralized, and means for impressing a modulating current on said control electrode to produce an out-of-balance carrier component varying in amplitude in accordance with said modulating current.

In witness whereof, I hereunto subscribe my name this 30th day of July A. D., 1926.

EUGENE PETERSON.