June 20, 1933. C. F. JENKINS 1,914,570

MULTIPLEX RADIO COMMUNICATION

Filed Sept. 1, 1926 3 Sheets-Sheet 1

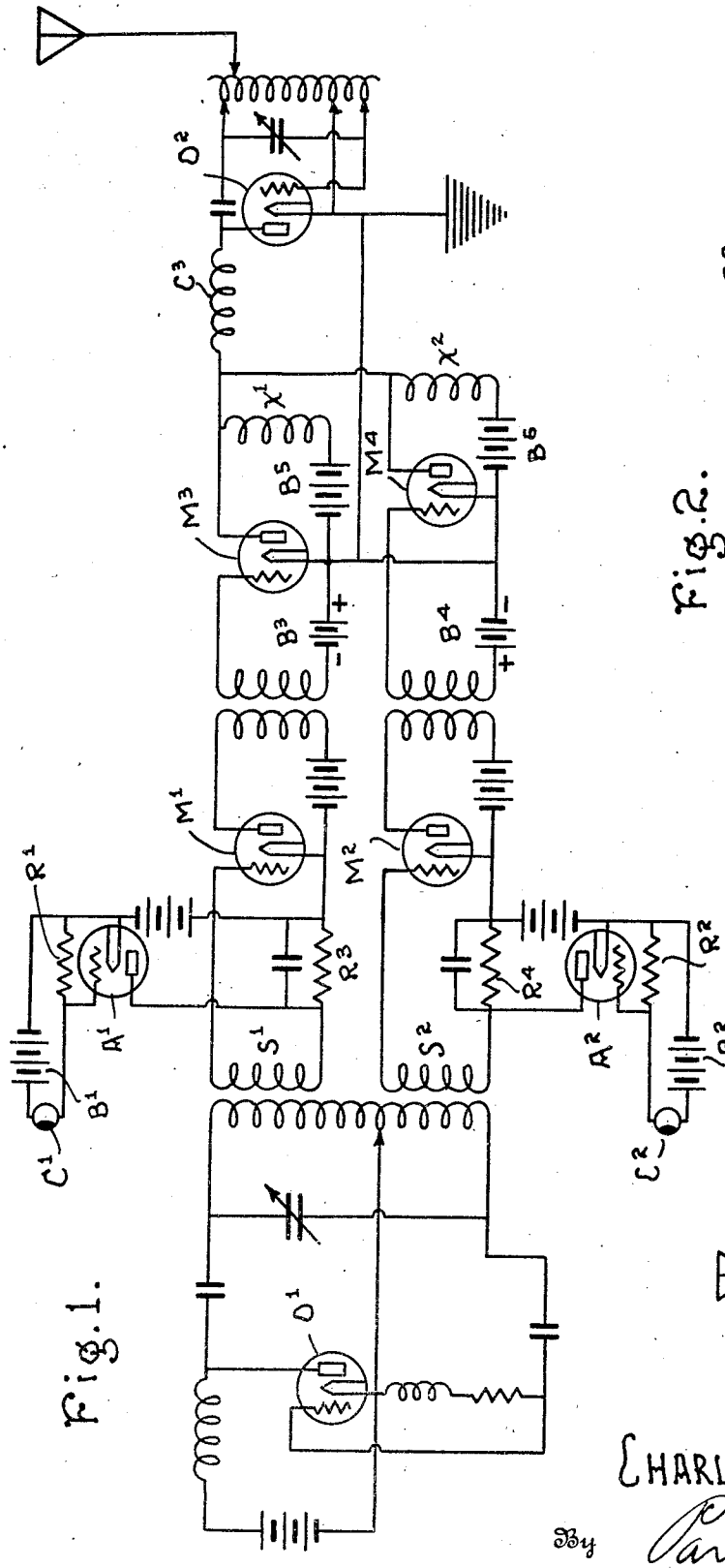


Fig. 1.

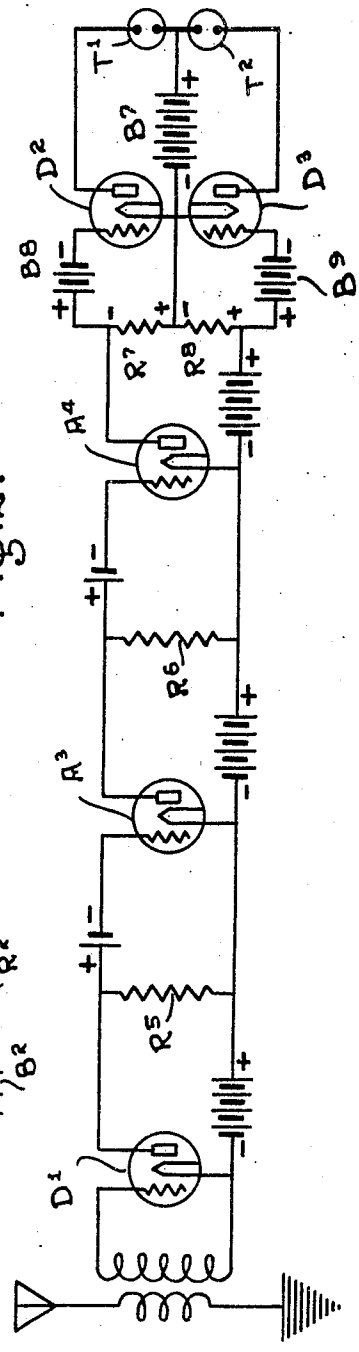


Fig. 2.

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June 20, 1933. C. F. JENKINS 1,914,570

MULTIPLEX RADIO COMMUNICATION

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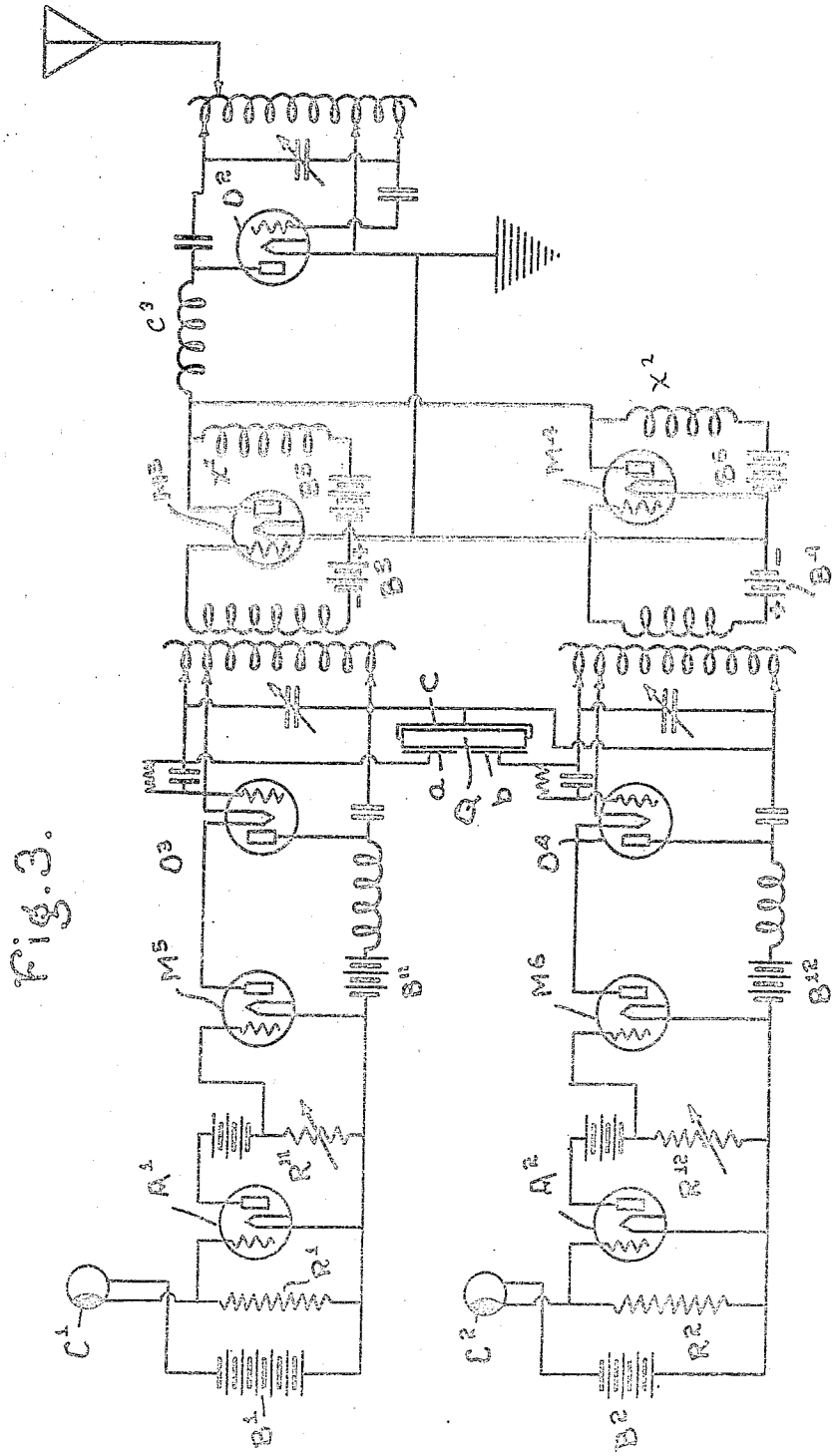


Fig. 3.

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June 20, 1933. C. F. JENKINS 1,914,570

MULTIPLEX RADIO COMMUNICATION

Filed Sept. 1, 1926 5 Sheets-Sheet 3

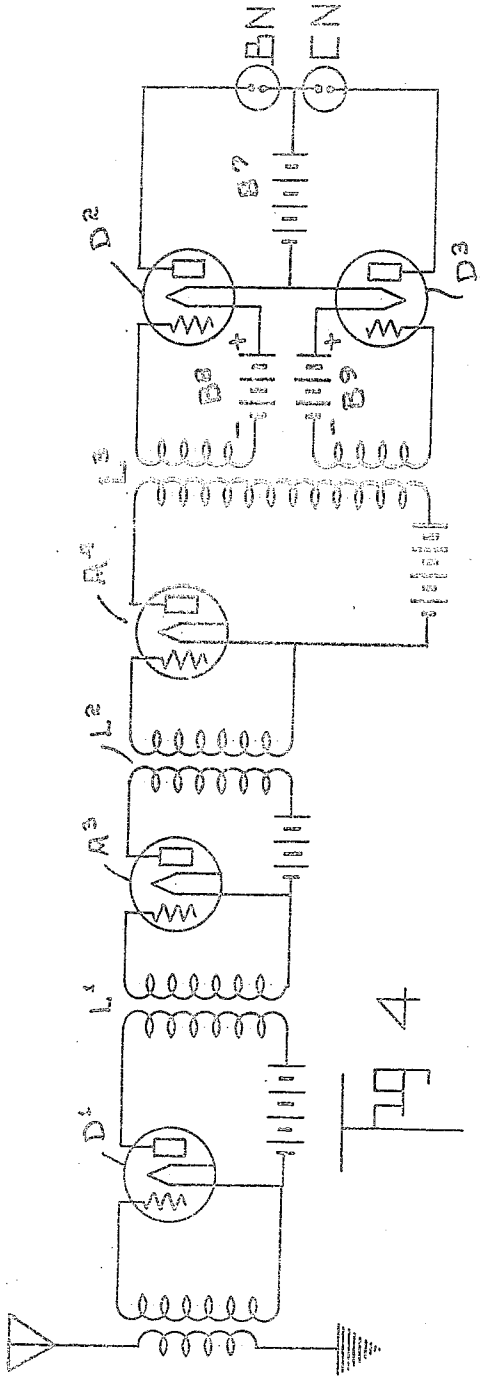


Fig 4

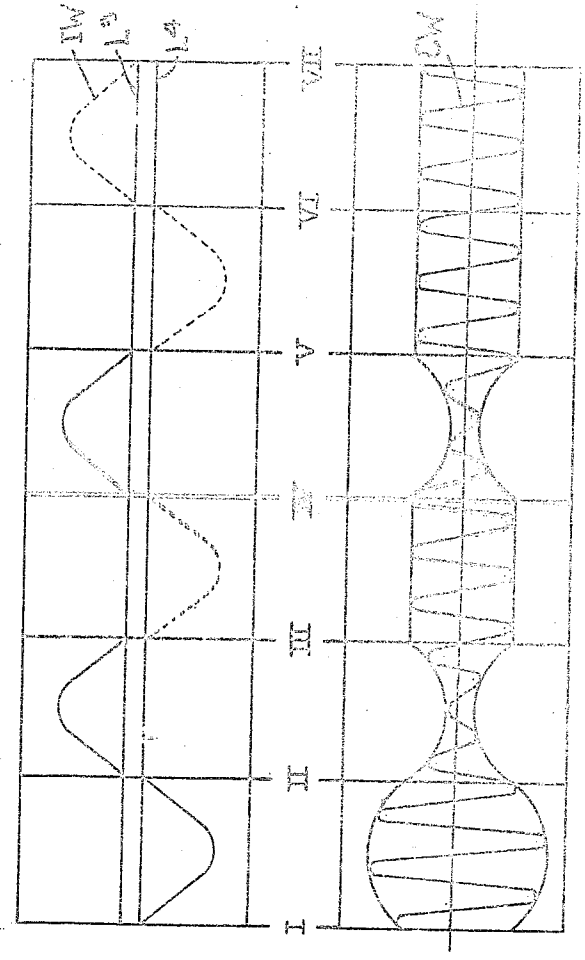


Fig 6

Fig 7

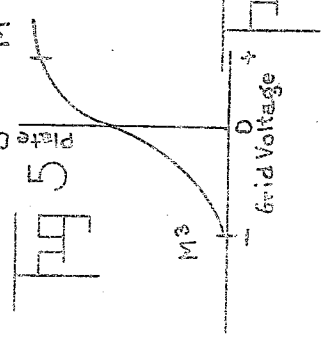


Fig 5

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Patented June 20, 1933 1,914,570

UNITED STATES PATENT OFFICE

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MULTIPLEX RADIO COMMUNICATION

Application filed September 1, 1926. Serial No. 132,979.

My present invention relates to a signalling system and more particularly to a system for transmitting and receiving a plurality of signals simultaneously.

An object of my invention is to provide a system in which a plurality of signals (or messages or other communications) may be transmitted on a single carrier wave.

With this object in view my invention contemplates an arrangement in which a carrier wave is alternately modulated by signals from two separate sources, the rate of alternation being above audibility. At the receiving station the carrier wave is received, detected and the two messages are separated and supplied to separate receivers.

More particularly my invention contemplates an arrangement in which a high frequency carrier wave is modulated by an intermediate frequency wave, the positive alternations of which are modulated in accordance with one signal, while the negative alternations are modulated in accordance with the other signal. Preferably the carrier wave is modulated by the two signals in opposite senses, that is to say, one signal effects a reduction in the amplitude of the carrier wave alone, while the other signal effects an increase in the amplitude of the carrier alone. At the receiving station the carrier wave is received and detected to derive therefrom the intermediate frequency waves, the positive and negative alternations of which bear the original message modulations. The intermediate frequency wave is then supplied to a double detector arrangement, each detector being provided with a separate indicator, one detector being responsive only to the positive alternations of the intermediate frequency wave, while the other is responsive only to the negative alternations of the wave, thereby separating the two messages or signals.

A further object of my invention is to provide a novel high speed electric switching arrangement whereby a plurality of messages transmitted over a single channel may be diverted into separate individual channels.

My present invention is illustrated in the accompanying drawings, in which—

Figure 1 is a circuit diagram of one form of the arrangement employed at the transmitting station;

Figure 2 is a circuit diagram of one form of receiving apparatus which may be employed;

Figure 3 is a circuit diagram of a modified transmitting apparatus;

Figure 4 is a circuit diagram of a modified form of receiving arrangement;

Figure 5 is a characteristic curve useful in explaining the operation of the invention;

Figures 6 and 7 are wave diagrams employed in explaining the operation of the transmitting apparatus.

In Figure 1, part O^1 is an ordinary three-electrode, hot-cathode, electron tube which, with its associated circuits, constitutes a generator of an intermediate frequency current. The frequency of this current is preferably above audibility, for example, it may be 60 kilocycles. However, I do not intend to be limited to any particular value of frequency. Oscillator O^1 supplies intermediate frequency currents of the same phase to two secondary windings S^1 and S^2 arranged respectively in the input circuits of amplifiers M^1 and M^2. The output circuits of amplifiers M^1 and M^2 are coupled respectively to the input circuits of rectifier-modulators M^3 and M^4, the output circuits of the modulators being connected in a manner to modulate the current generated by the high frequency oscillator O^2. Two signalling devices C^1 and C^2 are connected respectively through amplifiers A^1 and A^2 to the input circuits of additional amplifiers M^1 and M^2. The signalling devices shown in Figure 1 are preferably light-sensitive cells, although it is to be understood that for certain purposes other types of signalling devices, such as a microphone, or a telegraphic signalling device, may be used instead of the light-sensitive cells. The light sensitive cells may be either of the type in which an internally generated electromotive force is varied in accordance with

the light falling on the cell, or of the type in which the internal resistance of the cell varies in accordance with the light variations. Batteries B^1 and B^2 are inserted in series with the cells in local circuits, including resistance R^1 and R^2, respectively, for the purpose of energizing the cells. The input circuits of amplifiers A^1 and A^2 are connected respectively across resistances R^1 and R^2 in the local cell circuits, the output circuits of amplifiers A^1 and A^2 being coupled respectively to the input circuits of amplifiers M^1 and M^2 by means of coupling resistances R^3 and R^4. Resistances R^3 and R^4 are shunted by suitable condensers for the purpose of by-passing the intermediate frequency current. The grid element of rectifier-modulator M^3 is normally maintained at a negative potential by battery B^3, and the grid element of rectifier-modulator M^4 is normally maintained at a positive potential by battery B^4. These potentials are adjusted to such values that rectifier-modulator M^3 operates at a point on the lower part of the characteristic curve and rectifier-modulator M^4 operates at a point on the upper part of the characteristic curve, the respective points being indicated at M^3 and M^4 on the characteristic curve, shown in Figure 5. The output circuits of modulators M^3 and M^4 are connected in parallel with the plate circuit of the oscillator O^2, a radio-frequency choke-coil C^3 being interposed between rectifier-modulators and the oscillator O^2 for the obvious purpose of preventing radio-frequency currents from O^2 passing into the rectifier-modulator.

Parts X^1 and X^2 are radio-frequency choke-coils (of a value depending on the frequency of O^1) placed in the plate circuit to provide a constant current supply to the rectifier-modulators and the oscillator O^2; obviously these coils are necessary to modulate O^2 with the output of O^1. Batteries B^5 and B^6 supply the plate currents of rectifier-modulators M^3 and M^4, and oscillator O^2. It is obvious that a single battery may be used as a source of plate current instead of separate batteries B^5 and B^6.

It is to be understood that vacuum tube O^2, with its associated circuits, constitutes a generator of high-frequency oscillations which may be radiated from an antenna as shown in Figure 1, or as is well known these high frequency currents may be transmitted over line wires to the receiving station. The frequency of the wave generated by oscillator O^2 may be of the order of 3000 kilocycles, although I do not intend to be limited to any particular frequency.

The operation of the embodiment of Figure 1 is as follows:

Assuming for the present that oscillator O^1 is not operating, oscillator O^2 generates a high frequency current of constant amplitude represented by the curve CW in Figure 7, the unmodulated portions of the current being represented between vertical lines III and IV, and V and VII. It will be understood that under normal conditions current from batteries B^5 and B^6 is distributed among the plate circuits of rectifier-modulators M^3, M^4 and oscillator O^2 in such proportion that oscillator O^2 receives a plate current of a certain normal value, rectifier-modulator M^4 receives a plate current of high value, indicated at point M^4 in Figure 5, and modulator M^3 receives very little plate current, indicated at point M^3 in Figure 5. Assuming now that oscillator O^1 is in operation, intermediate frequency currents having the same phase and frequency will be supplied to amplifiers M^1 and M^2, which will induce into the input circuits of rectifier-modulators M^3 and M^4 intermediate frequency currents having the same phase and frequency. Referring to Figures 6 and 7, the vertical lines indicated by the numerals I to VII indicates the half-cycle divisions of the alternating current generated by oscillator O^1. Line L^3 is an origin line for rectifier-modulator M^3 and line L^4 is an origin line for rectifier-modulator M^4. These two lines are shown slightly separated for clearness of illustration and explanation. Assuming that a negative alternation of the intermediate frequency current is impressed upon both grid elements of rectifier modulators M^3 and M^4, it will be seen from Figure 5 that the plate current of rectifier-modulator M^3 will be practically unaffected since due to the negative bias on the grid, the plate current is normally very low, but since modulator M^4 is biased by a positive potential the effect of this negative modulating potential is to increase the filament-to-plate resistance of the tube, which results in a decrease in the plate current of modulator M^4 and a corresponding increase of plate current in oscillator O^2. The increased plate current supplied to oscillator O^2 results in an increase in the amplitude of the high frequency waves indicated between lines I and II in Figure 7. Assuming next that a positive alternation of the intermediate frequency waves is impressed upon the grid elements of rectifier-modulators M^3 and M^4, it will be seen from Figure 5 that the plate current in rectifier-modulator M^4 will be practically unaffected since due to the high positive bias, this tube is normally working at the saturation point, but in case of rectifier-modulator M^3 the positive alternation will act to oppose the negative bias and thereby decrease the filament-to-plate resistance, with the result that rectifier-modulator M^3 will take an increased plate current. The decrease in resistance of rectifier modulator M^3 will rob the plate circuit of

oscillator O^2 of some of its current which will result in a decrease in the amplitude of the high frequency waves indicated between lines II and III Figure 7 and between lines IV and V of the same Figure. It will readily be understood that the amplitude of the positive and negative alternations of the intermediate frequency wave supplied to rectifier-modulators M^3 and M^4 are controlled respectively by the signalling devices C^1 and C^2. The wave which is radiated is a doubly modulated wave, that is, a high frequency modulated by an intermediate frequency wave which in turn is modulated by signal modulations, the positive alternations of the intermediate frequency wave being modulated in accordance with one signal, while the negative alternations are modulated in accordance with another signal.

The receiving arrangement employed for separating the two signals or messages is shown in Figure 2, in which D^1 is a vacuum tube detector, the input circuit of which is coupled to a suitable receiving antenna and the output circuit of which is coupled to a vacuum tube amplifier A^3 by means of a coupling resistance R^5. The output circuit of amplifier A^3 is coupled to the input circuit of amplifier A^4 by coupling resistance R^6. The output circuit of amplifier A^4 is coupled to a double detector arrangement comprising two vacuum tube detectors D^2 and D^3, two signal indicating devices T^1 and T^2 and a common plate battery B^7. The indicating devices T^1 and T^2 are preferably audible signal indicators, for example, telephones, buzzers, or telegraphic sounders, visual or light indicators or any combination of these, and are connected respectively in the plate circuits of detectors D^2 and D^3. The input circuits of detectors D^2 and D^3 are coupled to the output circuit of amplifier A^4 across coupling resistances R^7 and R^8 respectively. Each input circuit contains a grid biasing battery, indicated at B^8 and B^9. The potentials of these batteries are so chosen that normally no current flows through the signal indicating devices T^1 and T^2.

It will be seen that detectors D^2 and D^3 are connected in a differential arrangement with respect to the output circuit of amplifier A^4, that is, they are so connected that the drop in potential across the coupling resistance will produce a negative biasing voltage in one grid circuit and a positive biasing voltage in the other grid circuit. Normally the combining voltage of batteries B^8 and B^9 and drop across resistances R^7 and R^8 respectively are so adjusted that the plate current of detectors D^2 and D^3 is reduced substantially to zero. The polarity of the voltage drop across each resistance is indicated by appropriate signs in the drawings.

The operation of the receiving arrangement is as follows:

The incoming wave is received and detected by detector D^1 to derive therefrom the intermediate frequency wave bearing the original signal modulations, the positive alternations bearing the modulations of one signal and the negative alternations bearing the modulations of the other signal. The intermediate frequency wave is amplified successively by amplifiers A^3 and A^4 and fed into the double detector arrangement coupled to the output circuit of amplifier A^4. Assuming that a positive alternation of the intermediate frequency wave is flowing in the output circuit of amplifier A^4, and further assuming that the positive alternation tends to increase the normal plate current and produce a corresponding increase in voltage drop across resistances R^7 and R^8 in the input circuits of detectors D^2 and D^3 respectively, the increase in voltage drop across resistance R^7 has the effect of rendering the grid more negative than normally and, therefore, there will be no change in current and no response in signal indicator T^1, but since the voltage drop across resistance R^8 tends to oppose the negative bias on the grid of the detector D^3, a plate current will flow and produce a response in signal indicator T^2. Assuming next that a negative alternation of the intermediate frequency wave is impressed upon the output circuit of amplifier A^4, the result will be a decrease in the plate current of the amplifier. The decrease in the plate current of the amplifier A^4 will again unbalance the biasing voltages in the detector circuits, but in an opposite manner, with the result that plate current will flow and produce a response in signal indicator T^1, and there will be no response in indicator T^2. Thus it will be seen that the receiving arrangement is selective with respect to the positive and negative alternations of the intermediate frequency wave, and the separate messages may be received independently upon indicators T^1 and T^2.

From the foregoing it will be seen that the action of the receiving arrangement is that of a high-speed switching device for automatically and instantaneously switching the successive positive and negative alternations, bearing the different signals, into their respective signal detecting and indicating circuits. It is obvious that this arrangement has general utility, and may be used in various situations where it is desired to separate positive and negative pulsations from a single channel and divert them into individual channels.

The modified form of transmitting apparatus shown in Figure 3 differs from the

arrangement of Figure 1, in that a separate intermediate frequency oscillator is provided for each signalling device C^1 and C^2. The arrangement for modulating the intermediate frequency waves by the signalling currents is also slightly different. Where elements serve the same function in the two figures they have been indicated by the same reference characters. Parts O^3 and O^4, with their associated circuits, constitute separate generators of intermediate frequency current. These two oscillators should be maintained in synchronism and in proper phase relationship, and to accomplish this the oscillators are controlled from a common piezo-electric resonator. This resonator comprises a piezo-electric crystal Q, preferably of quartz, having mounted on one side thereof two separated conducting plates *a* and *b*, and a third conducting plate *c* on the opposite side. Plate *a* paired with *c* is connected across the frequency determining circuit of oscillator O^3, while plate *b* also paired with *c* is connected across the frequency determining circuit of oscillator O^4. The dimensions of crystal Q are so chosen that it has a natural frequency equal to the intermediate frequency. It will readily be understood that if the frequency determining circuits of oscillators O^3 and O^4 are adjusted approximately to the frequency of crystal Q, the action of the crystal, when set in operation, will be to maintain the oscillators in synchronism and proper phase relationship. Parts M^5 and M^6 are modulators for modulating respectively the current generated by oscillators O^3 and O^4 in accordance with the signals impressed upon signaling devices C^1 and C^2. As will be seen from the drawings the plate circuits of modulator M^5 and oscillator O^3 are connected in serial relation with a single battery B^{11} for supplying the plate current. Similarly the plate circuits of modulator M^6 and oscillator O^4 are connected in serial relation, with battery B^{12}, as a supply for plate current. The output circuits of amplifiers A^1 and A^2 are coupled respectively to the input circuits of modulators M^5 and M^6 by means of coupling resistances R^{11} and R^{12}.

The operation of the embodiment of Figure 3 is as follows:

Varying signals impressed upon the signalling device C^1 and C^2 produce correspondingly varying currents in the output circuits of amplifiers A^1 and A^2. The potentials on the grids of modulators M^5 and M^6 will vary in accordance with the varying plate currents of amplifiers A^1 and A^2, thereby resulting in corresponding variations of the filament-to-plate resistances of modulators M^5 and M^6. The variations in internal resistances of modulators M^5 and M^6 will produce corresponding changes in the plate current of oscillators O^3 and O^4, thereby modulating the current generated by the oscillators in accordance with the signal impressed upon their respective signalling device. It will be seen that intermediate frequency currents having the same phase and frequency will be supplied to the input circuits of rectifier-modulators M^3 and M^4, the current supplied to rectifier-modulator M^4 being modulated in accordance with signals impressed upon signalling device C^2. From this point on, the operation is the same as in the arrangement shown in Figure 1 and will be readily understood.

A modified form of receiving apparatus is shown in Figure 4, which differs from that shown in Figure 2 merely by the substitution of coupling transformers L^1, L^2, and L^3 for coupling resistances R^5, R^6, and R^7, R^8. The operation of this form of receiving arrangement will be readily understood in view of the foregoing description of the operation of the arrangement of Figure 2.

From the foregoing description it is apparent that the output of modulators M^3 and M^4 constitutes a composite wave of the same frequency as the intermediate frequency waves from which it is derived, and that the positive alternations of this composite wave are modulated in accordance with one signal and the negative alternations are modulated in accordance with another signal. It is therefore, obvious that instead of modulating oscillator O^2 directly from modulators M^3 and M^4, the composite wave produced by these two modulators may be passed through a resistance coupled, intermediate frequency, power amplifier, in the usual manner, which would then modulate oscillator O^2.

If line wires are used as a transmitting medium, the composite wave produced by modulators M^3 and M^4 need not be transmitted by the carrier wave generated by oscillator O^2, but may be impressed directly upon the line and transmitted to a distant receiving station. In this arrangement a detector at the receiving station will not be necessary, and the input circuit of amplifier A^3 would be connected directly to the line circuit.

It is also apparent that, if desired, amplifier M^1 and M^2 in Figure 1 may be omitted. In such an arrangement the output circuit of oscillator O^1 would be coupled directly to the input circuits of modulators M^3 and M^4, and the output circuits of amplifiers A^1 and A^2 would be coupled respectively to the input circuits of modulators M^3 and M^4 in the same manner as they are shown connected to modulators M^1 and M^2.

Also, it will thus be observed that I have provided a system including both method

of and apparatus for transmitting and receiving multiple signals representing any desired intelligible communication over the same carrier wave, so that it is possible to send a plurality of sets of signals, of which one or more may be messages of voice or code, music or speech, visual effects or audible effects.

Having thus described my invention and illustrated its use what I claim as new and desire to secure by Letters Patent is:

1. The method of signaling which comprises generating a sustained high frequency wave, diverting said wave into two separate channels, recombining the waves in said channels to produce a single composite wave having portions above zero amplitude modulated only in accordance with one signal, and portions below zero amplitude modulated only in accordance with another signal.

2. In a signaling system, the combination of means for generating a sustained high frequency wave, means for modulating only the positive portion of the wave by one signal, and for modulating only the negative portion of the wave by another signal, means to receive said modulated waves, means to separate the alternate modulated portions of the wave, and means to detect said modulated wave portions to derive therefrom the separate signals.

3. A method of multiplex signaling which comprises, generating a carrier in the form of sustained oscillations having a frequency above audibility, modulating the positive alternations of said wave in accordance with one signal, modulating the negative alternations in accordance with a second signal, transmitting the modulated wave to a receiving station, diverting the positive and negative alternations into separate channels, and detecting separate signal indications from said alternations.

4. In a signaling system the combination of, a signaling channel, means to impress upon said channel an inaudible carrier in the form of sustained oscillations, means to modulate the positive alternations of said carrier in accordance with one signal and means to modulate the negative alternations in accordance with another signal, means for transmitting both said modulated alternations to a receiving station, means at the receiving station for diverting the modulated positive and negative alternations from said channel into separate channels, and means in each of said separate channels to detect the signal transmitted.

5. A method of signaling which comprises generating a carrier in the form of sustained oscillations, modulating the positive alternations of said carrier in accordance with a signal, modulating the negative alternations of said carrier in accordance with a second signal, generating a second carrier, and modulating said second carrier by the first modulated carrier, transmitting the second modulated carrier to a distant receiving station, receiving and detecting said resultant wave to derive therefrom the original first carrier, and producing independent signal indications by the positive and negative alternations of said derived carrier.

6. In a signaling system the combination of, a signaling channel carrying a superaudible current having positive and negative portions independently modulated by separate signals, and means associated with said channel for diverting the positive and negative portions of the current into separate channels, said means comprising a pair of three electrode electron discharge devices.

7. In a signaling system the combination of, a signaling channel carrying a superaudible wave bearing modulations in accordance with separate signals, and means for separating and diverting the modulated portions corresponding to the separate signals into separate channels, said means including a pair of detectors oppositely biased by the modulated wave.

8. In a signaling system the combination of, a source of waves having portions above and below zero amplitude respectively modulated in accordance with different signals, means for diverting the respective portions of each signal into separate channels and means in each channel responsive to the respective wave portions for producing separate signals, the last mentioned means including a pair of differentially connected electron discharge devices.

9. In a signaling system the combination of, a source of alternating current of superaudible frequency, the positive alternations only of which are modulated in accordance with one signal and the negative alternations only of which are modulated in accordance with a second signal, and means associated with said source for diverting the positive and negative alternations into separate channels and means in each channel responsive to the alternations for producing separate signals, the last mentioned means including a pair of electron discharge devices oppositely biased by the modulated alternations.

10. The method of signaling which comprises generating a carrier current in the form of sustained oscillations of normally constant amplitude, modulating alternately succeeding sections of said wave in accordance with separate signals to be transmitted from said station, and causing one of said signals to increase the amplitude of said wave and the other of said signals to decrease the amplitude of said wave.

11. The method of signaling which comprises generating at a transmitting station

a carrier current in the form of sustained oscillations, modulating alternate portions of said current in accordance with separate messages, one message effecting only an increase in the amplitude of said carrier, and the other message effecting only a decrease in the amplitude of said carrier.

12. In a signaling system the combination of a first source of sustained oscillations, means for dividing the current from said source into two separate channels, a signaling device associated with each channel for modulating both halves of the oscillating waves in the said channels, a rectifier-modulator associated with each channel, said rectifier-modulators being biased in opposite senses so that one passes current only above a certain selected value and the other passes current only below said certain selected value, a common output circuit for said rectifier-modulators, a second source of sustained oscillations, and means for modulating the oscillations from said second source in accordance with the currents in said common output circuit.

13. In a signaling system the combination of means for generating a sustained high frequency wave, means for diverting said wave into a pair of separate channels, and means including separate signaling devices for translating said diverted waves into a single composite wave, said composite wave having a portion above zero amplitude modulated only in accordance with one of said signal devices, and the remaining portion of said composite wave below zero amplitude modulated only in accordance with said second signal device.

14. A radio transmission system comprising a generator of alternating current of carrier frequency above audibility, and means for modulating either the positive or the negative component of the alternating current independently of the other half.

15. A communication system comprising means for producing and transmitting an alternating current of carrier frequency above audibility with either the positive component or the negative component or each of said components modulated independently of the other, and a receiving apparatus comprising two detectors, one detecting the positive component of the received carrier wave and the other detecting the negative component thereof.

16. A radio transmission system comprising a generator of alternating current of carrier frequency above audibility, and means for modulating the positive and negative components of the alternating current independently of each other.

17. A radio transmission system comprising a generator of alternating current of carrier frequency above audibility, and means for modulating independently and successively the positive and negative components of the alternating current.

18. A radio transmission system comprising a generator of alternating current of carrier frequency above audibility, an antenna to be energized thereby, a rectifier interposed between said generator and said antenna for passing current pulsations in one direction only between said antenna and generator, and means for modulating the current pulsations passed by said rectifier.

19. A radio transmission system comprising a generator of alternating current at carrier frequency above audibility, an antenna to be energized thereby, a pair of oppositely conductive rectifiers constituting parallel paths for current pulsations in their respective directions of conductivity between said generator and said antenna, and means for modulating the current pulsations in each rectifier independently of the other.

20. Method of modulating alternating current of carrier frequency above audibility which comprises resolving the alternating current into positive and negative components, and superimposing a modulation upon one of said components independently of the other.

21. Method of modulating alternating current of carrier frequency above audibility which comprises resolving the alternating current into positive and negative components, and superimposing a modulation upon each of said components independently of the other.

22. Method of communication which comprises resolving an alternating current of carrier frequency above audibility into positive and negative components, superimposing a modulation upon one of said components independently of the other and transmitting the component thus modulated.

23. Method of communication which comprises resolving an alternating current of carrier frequency above audibility into positive and negative components, superimposing a modulation upon each of said components independently of the other, and transmitting the two components thus independently modulated as a complete carrier wave.

24. A communication system comprising means for producing and transmitting an alternating current of carrier frequency above audibility with either the positive component or the negative component or each of said components modulated independently of the other, and a receiver having selective means for detecting either the positive or the negative component, at will.

25. The method of signaling which comprises generating a sustained high frequency wave, modulating only the positive alternations of said wave with a signal to be prop-

agated and modulating only the negative alternations of said wave with a different signal to be propagated.

26. The method of signaling which comprises generating a sustained high frequency wave, separably modulating the positive and negative portions of said wave with different signals, transmitting the modulated portions as a composite carrier wave to a receiving station, conducting one-half portion of the composite wave through a rectifier and detecting and indicating the modulations in said portion of the wave passing through said rectifier.

27. A high frequency transmitter comprising a source of continuous wave high frequency oscillations, means for propagating said oscillations, a rectifier in circuit with said source, a signal device for modulating said oscillations independently of said rectifier, said rectifier being conductive to one half portion only of the high frequency wave from said source, and means including a second signal device operable to modulate in accordance with signals to be transmitted only that half portion of the high frequency wave to which said rectifier is conductive.

28. A high frequency transmitter comprising a source of continuous super-audible waves, a pair of signaling generators, a pair of asymmetrically conductive vacuum tubes in circuit with said source, said vacuum tubes being arranged so as to be conductive to the two half portions respectively of the high frequency waves from said source, and means including said generators for independently varying the conductivity of the respective circuit paths in which said vacuum tubes are individually included, said means being operable to effect modulation of the two half portions of the high frequency wave, each independently of the other.

29. A high frequency wave signaling system comprising a source of super-audible waves, means for modulating the two portions of said wave above and below zero amplitude independently, means for transmitting the modulated waves, and a receiving station comprising an asymetrically conductive path operable to pass one half of said modulated wave and exclude the other half, and receiving apparatus at said receiving station operatively associated with said asymmetrically conductive path.

In testimony whereof I have hereunder signed my name.

CHARLES FRANCIS JENKINS.