

**March 19, 1929.**

**E. E. CLEMENT**

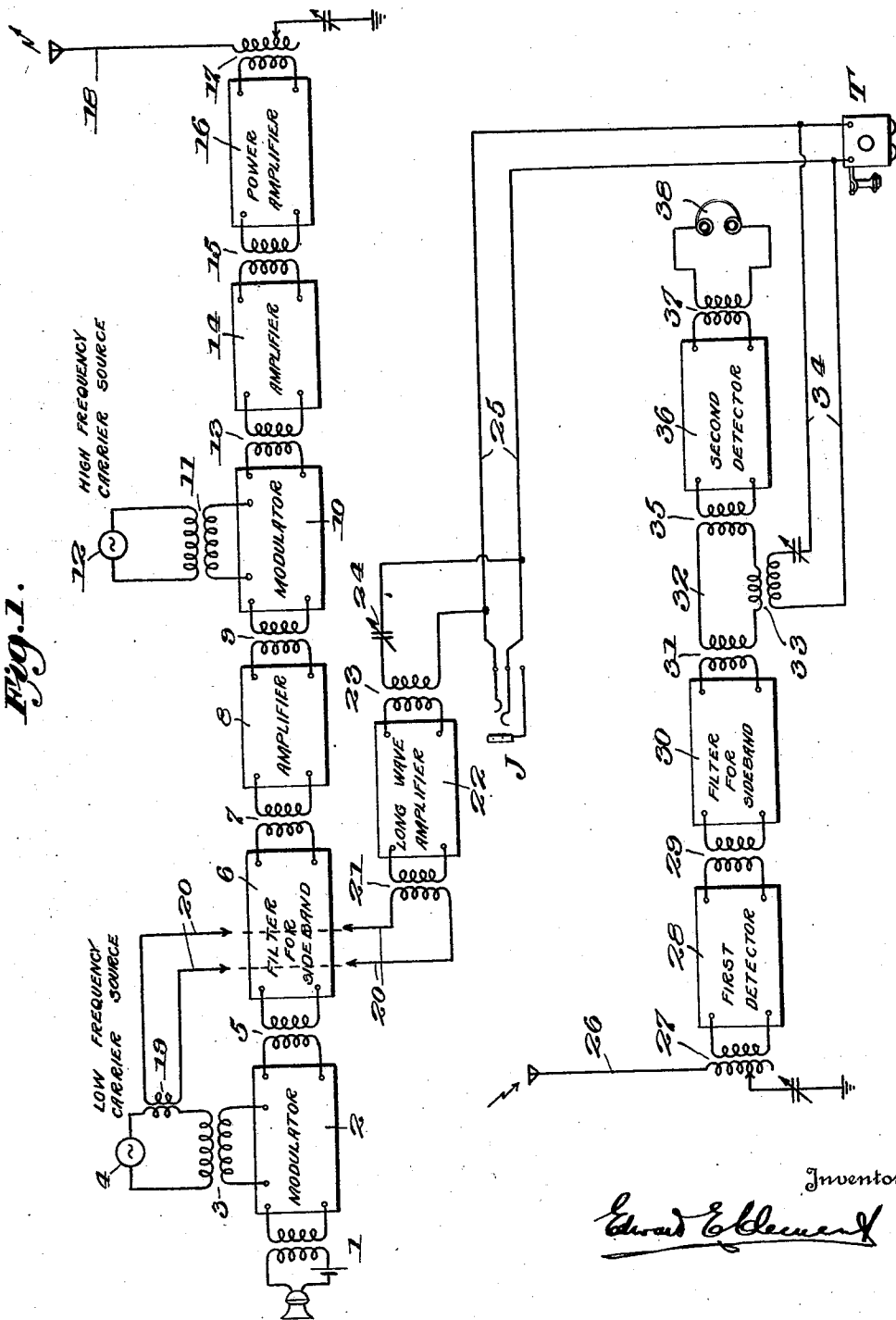
**1,706,379**

# RADIO BROADCAST DISTRIBUTING SYSTEM

Filed Nov. 25, 1925

4 Sheets-Sheet 1

**Fig. 7.**



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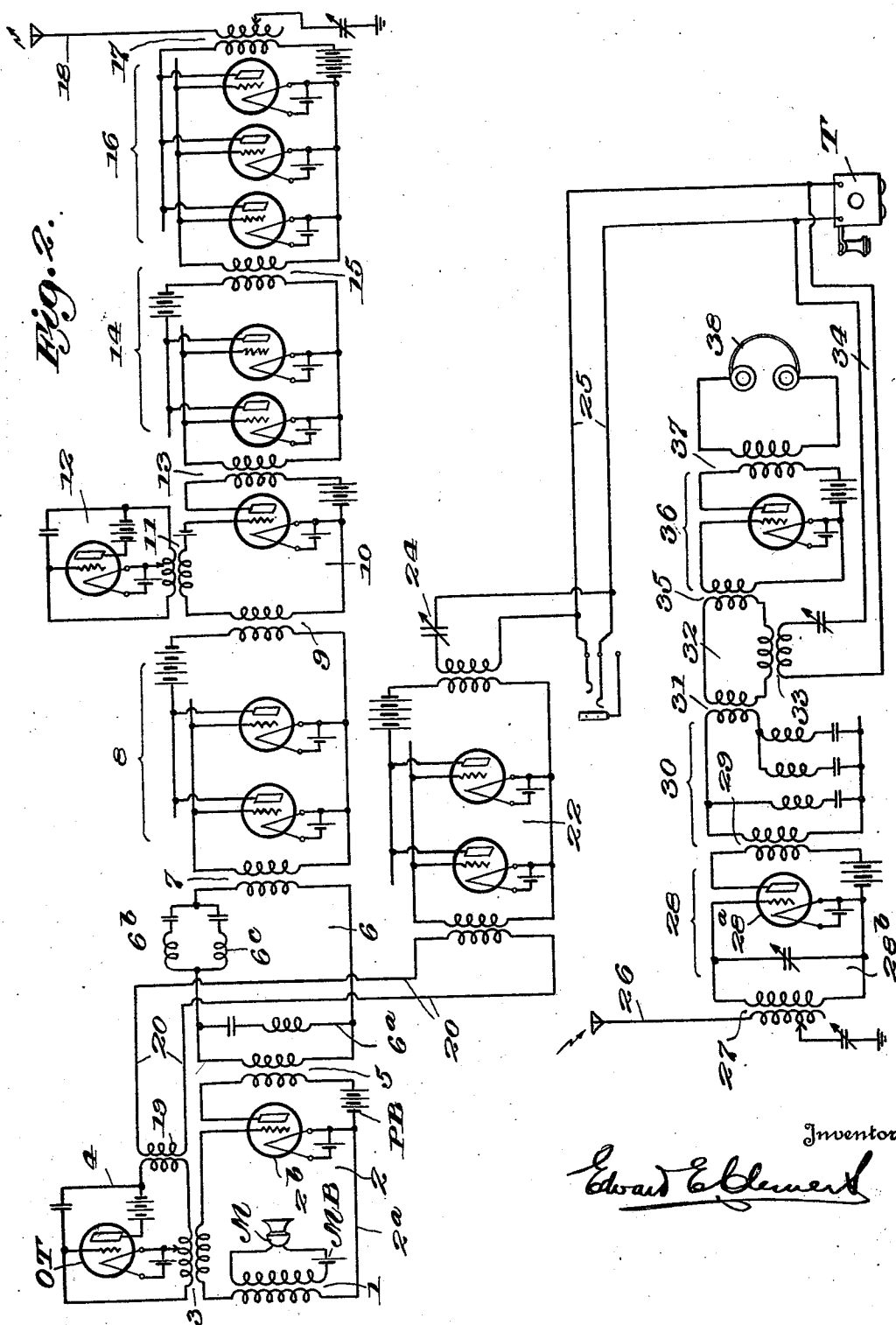
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Fig. 2.



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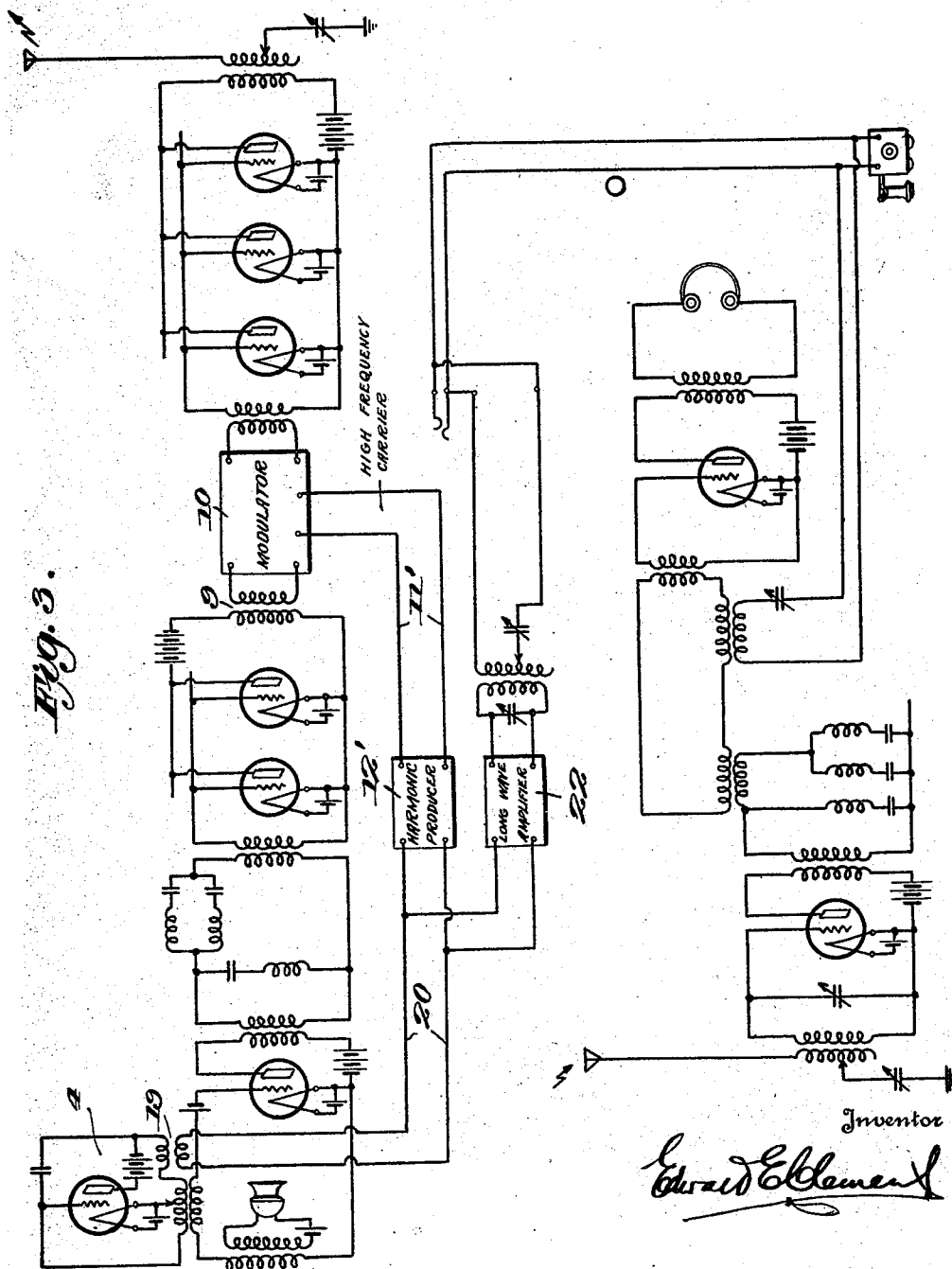
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RADIO BROADCAST DISTRIBUTING SYSTEM

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Fig. 4.

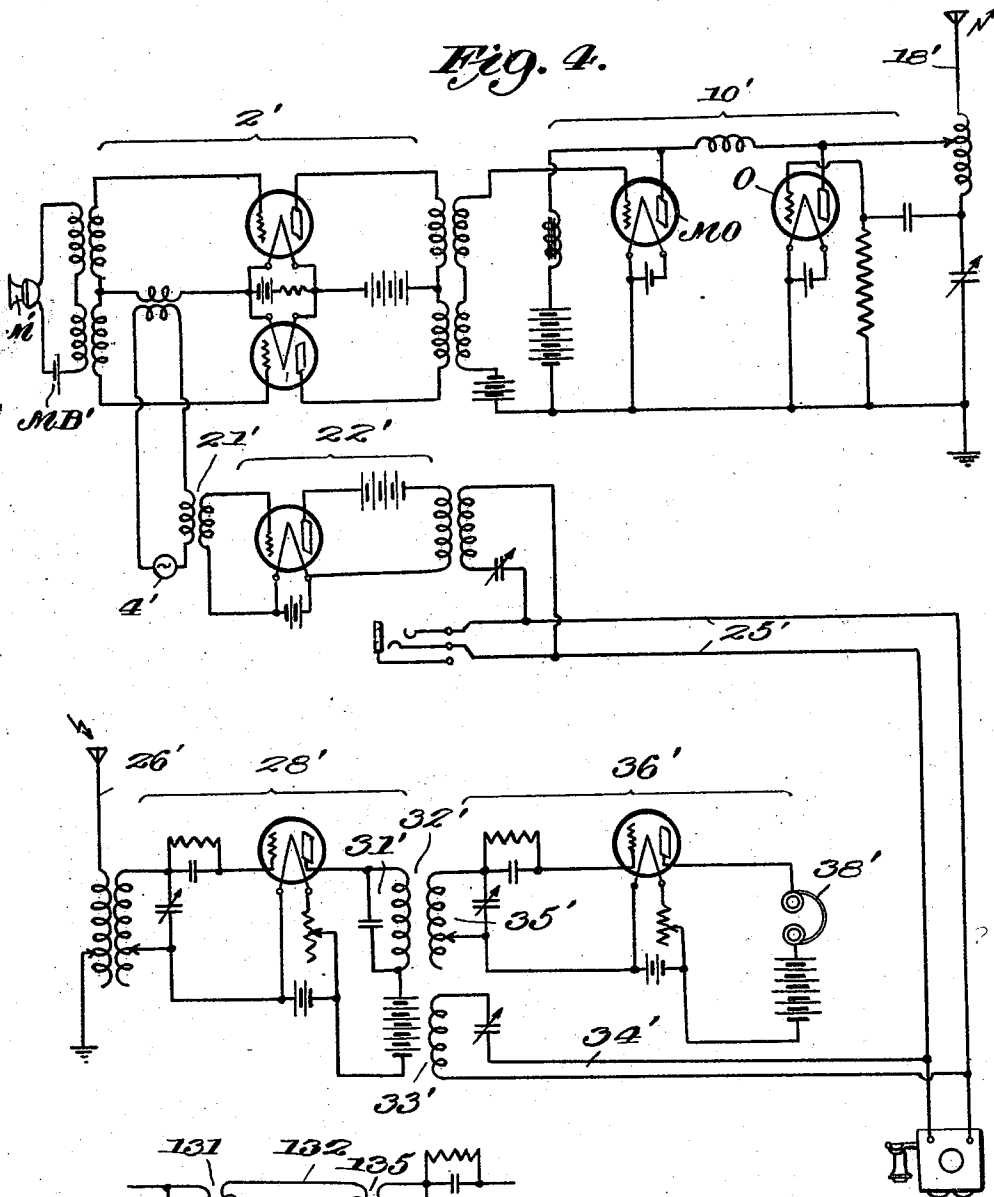
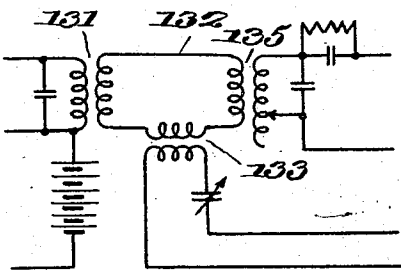


Fig. 5.



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# UNITED STATES PATENT OFFICE.

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## RADIO BROADCAST DISTRIBUTING SYSTEM.

Application filed November 25, 1925. Serial No. 71,457.

My invention relates to the art of broadcasting and particularly radio broadcasting, and has for its object to produce a system of transmission which shall be efficient, secret, and shall be non-interfering with respect to other systems simultaneously operating on wave bands adjacent to or even overlapping in frequency the wave band or bands employed herein. The full system in which this invention is particularly adapted to be used is that disclosed in my prior copending application, Serial No. 746,357, filed October 28, 1924, patented July 5, 1927, No. 1,635,153. In said application I have described a system of broadcast distribution in which the ultimate receiving stations are divided into groups, each group served by a local or regional broadcasting station which may both relay and originate programs. These regional stations (called C stations) are in turn grouped according to districts or divisions, which are served by district or divisional broadcasting stations (called B stations), which may also both relay and originate programs. All these relay stations are related to a master station (called A station). The several stages of distributing or relay stations have interconnection by radio channels and wire trunk lines, and the regional or C stations may be connected with their several groups of receivers or subscribers by wire lines, such as telephone lines, which enable supervision, testing, metering, and the like to be performed locally. With a system organized as thus described, great flexibility is possible whereby average efficiency of transmission throughout the entire system may be maintained at all times and under all conditions; and the ingathering and distribution of material may be arranged so as to enable local subscribers with simple instruments to receive from any part of the system, and make selection of all items from a plurality of programs. A feature of this ingathering and distribution is the modulation of audio signals at or near the point of origin, upon carrier waves of a frequency suitable for transmission over wire circuits, and the transmission of these modulated waves interchangeably over wire circuits or by secondary modulation upon a high frequency carrier wave with subsequent radiation thereof.

In the present case, I attain my objects,

and at the same time render the invention applicable to the general system above described, as follows: Audio frequency signals are modulated upon a suitable carrier wave of superaudio frequency; the resultant composition current minus current variations of the said intermediate frequency are then modulated upon a primary radio frequency carrier current and are radiated the same as a primary carrier wave. This primary carrier wave is received at a distant station, demodulated to detect off the intermediate frequency composition current, and the original intermediate frequency carrier current is transmitted separately and by means of a separate medium to the receiving station for recomposition with said detected composition current to reproduce a carrier current of the original intermediate frequency modulated with the audio signal wave; and this carrier current is then demodulated by detecting off the audio signal waves therefrom.

My invention is illustrated in the accompanying drawings, in which

Fig. 1 is a diagram of a system embodying the invention, using conventionalized symbols with no detail.

Fig. 2 is a diagram showing the detail of circuits that may be employed in the manner indicated in Fig. 1.

Fig. 3 is a diagram similar to Fig. 2, with some parts conventionalized as in Fig. 1, showing secondary modulation upon a carrier wave produced as a harmonic of the carrier wave originally used in primary modulation; the original carrier wave being also shown as transmitted to the receiving station, with means for deriving the same harmonic therefrom for use in recomposing the original modulated carrier form.

Fig. 4 shows a diagram of still another modified arrangement, in which a balanced primary modulator is employed with the Colpitts-Heising circuit for secondary modulation; the receiver in this figure being also modified by the elimination of the separate composition circuit shown in Figs. 1, 2 and 3 between the first and second detectors.

Fig. 5 is a fragmentary diagram showing the said separate composition circuit applied to the receiver circuit of Fig. 4.

Referring to Fig. 1, 1 represents an audio frequency modulator such as a microphone circuit, working into a super-audio fre-

quency modulator 2, connected through coupling 3 to an oscillator circuit 4, which in the present case is assumed to be tuned to a so-called "intermediate frequency", that is, a frequency suitable for transmission over wires, also suitable for secondary modulation and usually chosen between the upper limits of audition and 100 kc. per second. 6 is a filter adapted to suppress or filter out unmodulated current of the frequency produced by the oscillator 4. This is connected with the audio modulator 2 by means of a coupler 5 and with an amplifier 8 by means of a coupler 7. The amplifier 8 is connected through coupler 9 to a modulator 10 receiving high frequency carrier current to coupler 11 from a source 12. This is the secondary modulator, which, receiving the amplified side band of waves from the original modulator, in turn impresses or modulates these amplified and primary modulated waves upon a secondary or high frequency carrier derived from the source 12. The double modulated high frequency carrier thus produced is propagated through the coupling 13 into the amplifier 14 and if desired, through another coupling 15 to the power amplifier 16 to the antenna coupling 17 and so into the antenna 18 for radiation. In addition to furnishing low or intermediate frequency carrier current for the modulator 2, the source 4 is connected through coupler 19 to a circuit 20, extending to a coupler 21, by means of which current at the same frequency is supplied to an amplifier 22 and thence through coupling and tuning elements 23-24 to the wire circuit 25, which is shown as the individual wire circuit of a telephone subscriber, having the usual central office switchboard connections and terminal apparatus typified by jack J, and at the subscriber's station having connected to it a telephone instrument typified at T. It is to be clearly understood that I am not limited either to a telephone line or to a subscriber's line.

At the subscriber's station is a radio telephone receiving set comprising a receiving antenna 26 connected through a coupler 27 to a first detector 28, the elements 26 and 27 being suitably tuned to receive the primary or high frequency carrier wave radiated from the antenna 18. The first detector 28 is arranged to demodulate the primary carrier wave receiver on the antenna 26 and detect out the side band which is of the order of an intermediate or superaudio frequency and transfer this through the coupler 29, side band filter 30, and the coupler 31 to the composition circuit 32. The composition circuit 32 also receives original unmodulated low frequency carrier current through coupler 33 from an extension 34 of the line 25. A coupler 35 connects the composition circuit 32 to the input

terminals of a second detector 36 whose output circuit is connected through an audio transformer 37 to a telephone receiver 38, the second detector 36 being arranged to demodulate the composition currents derived from the circuit 22 and detect out the audio modulations.

The operation of the system as shown in Fig. 1 is as follows: Audio waves produced at 1 are combined in the modulator 2 with low or intermediate frequency carrier current from the source 4 to produce in the output circuit of the modulator a band comprising the carrier current of both side bands which is transmitted through the coupler 5 to the filter 6 which passes the side bands only through coupler 7 to the amplifier 8 where they are amplified and transferred to the modulator 10 through coupler 9. In the modulator 10 these side bands which are of intermediate or superaudio frequency, are modulated onto a high or radio frequency carrier current hereinafter termed the primary carrier current which primary carrier current modulated with the superaudio frequency band is transferred through coupler 13 to the amplifier 14 and thence through coupler 15, second amplifier 16 and coupler 17 to antenna 18 where the primary carrier wave modulated with the intermediate frequency band is radiated in the form of a double modulated wave in which the primary wave is produced by the source 12, the intermediate wave is the band of superaudio or intermediate frequencies without the intermediate frequency carrier current and the signal wave is the audio wave produced at 1.

The double modulated wave transmitted from antenna 18 is received on the receiving antenna 26 at the receiving station where it is transferred through coupler 27 to the detector 28 which demodulates the primary carrier wave to detect out the intermediate frequency band which is transferred through coupler 29 to filter 30. In the filter 30 the side bands are filtered to further free them of the primary and intermediate carrier. The side bands thus stripped of the carriers are passed through coupler 31 into the composition circuit 32 where the original low frequency carrier current is supplied to form a low frequency carrier current modulated with the audio signal waves which audio modulated low frequency or intermediate carrier is passed to the second detector 36 through coupler 35 where it is demodulated and the audio signal waves detected out and passed to the telephone receiver 38 through the audio transformers 37.

Fig. 2 is a detail showing of a specific type of circuits and apparatus which may be used for the elements diagrammatically or symbolically indicated in Fig. 1, the circuit elements of Fig. 2 being used in place

of the symbols of Fig. 1 bearing similar reference characters.

Referring to Fig. 2 more in detail, the element 1 for producing the telephonic currents consists of the usual microphone M and battery MB connected through a transformer as shown to the input circuit 2<sup>a</sup> of the modulator element 2. The modulator element 2 consists of a modulating tube 2<sup>b</sup> having its filament and grid terminals connected through the input circuit 2<sup>a</sup>, and its plate or output circuit arranged to include the usual plate battery PB and the primary winding of a coupler transformer 5. Oscillator element 4 consists of the oscillator tube OT having its input and output circuits connected with suitable inductances and capacities to form a generator of continuous waves of the desired frequency, in this case, an intermediate or superaudio frequency capable of being modulated on a radio frequency carrier and capable of being modulated by audio frequency waves. The side band filter 6 comprises a circuit 6<sup>a</sup> tuned to the intermediate frequency connected in shunt of the secondary of transformer 5, and in series with the primary of transformer 7 across the terminals of a multiple group of tuned circuits 6<sup>b</sup> and 6<sup>c</sup> each tuned to pass one of the side bands only and not the carrier frequency. Thus the carrier frequency is suppressed by being confined to the circuit 6<sup>a</sup> while the upper and lower side bands only are permitted to pass through the primary of the transformer 7. The various amplifier elements 8, 14, 16 and 22 are the usual audion tube amplifiers of the multiple tube type for volume amplification and consist as shown, of a plurality of amplifier tubes having their input circuits connected in multiple through the secondary of a coupler transformer and their output circuit connected through the primary of a coupling transformer all as will be clearly seen from the circuit diagrams and which will be sufficiently understood by those skilled in the art without further detail reference to the parts. The oscillation generator 12 is the usual audion tube oscillator element similar in all respects to the oscillator 4 except that it is arranged to produce oscillations of radio frequency here used as the primary carrier wave. The modulator 10 is substantially the same as the modulator 2 except that it is connected in the system so as to modulate the two audio signal side bands of the superaudio frequency onto the primary carrier wave produced by the oscillator 12 and propagate the same as double modulated radio frequency currents through amplifiers 14 and 16 and coupling transformers 13, 15 and 17 to the radiating antenna 18, the side bands being supplied to the modulator 10 through amplifier 8 and coupling transformers 9

while the primary carrier current is supplied from a source 12 to the coupling transformer 11. The first detector element 28 of the subscriber's receiving set consists of an audion tube detector 28<sup>a</sup> having an input circuit 28<sup>b</sup> tuned to the primary wave and including in its plate circuit the primary of the transformer 29, the detector element 28 as a whole being adjusted in a manner well known in the art to demodulate the primary wave and detect off the intermediate frequency side bands causing them to traverse the output or plate circuit including the primary of the transformer 29 through which transformer they are passed to the filter element 30. This filter element is the same as the filter element 6 with the same electrical constants so that it operates to pass only the two side bands and hold back whatever of the intermediate carrier frequency might exist in the coupling circuit 29. The composition circuit 32 is simply a closed circuit including a pair of input coupling windings and an output winding, the input windings consisting of the secondary windings of transformers 31 and 33 while the output winding is the primary winding of coupler transformer 35. The second detector element 36 of the subscriber's set is the usual audion tube detector element having its input and output circuits including the primary of the coupling transformers 34 and the secondary of the audio transformers 36, respectively, suitably tuned and adjusted to demodulate the oscillator current received from the composition circuit 32, and detect out the audio frequency or telephonic signal currents to be transferred through the transformer 36 to the receiver 37.

Where it is desirable to use a common source for both the primary and intermediate carrier currents, the arrangement of Fig. 3 is used which is substantially the same as that of Fig. 2 except that the second oscillator or high frequency carrier source is omitted and the high frequency or primary carrier current derived through a harmonic producer 12' from the intermediate carrier current taken from the line 20, the harmonic producer being arranged to produce in the line 11' a harmonic of relatively high or radio frequency, at suitable amplitude for use in place of the usual original source of primary frequency carrier current. This primary carrier current is passed into the modulator 10 where it is modulated with the side bands passed to the modulator through transformer 9. From the foregoing, it will be seen that in the arrangement of Fig. 3, the frequency of the wave radiated from the antenna 18 will be a harmonic of the frequency of the oscillation generator 4 and will be modulated with a band of superaudio frequency without the base frequency,

which band is the result of the modulation of the base frequency by the audio frequency signal waves. The reception at the subscriber's station is the same as that described for Fig. 2.

In the arrangement of Fig. 4, the audio frequency signal currents generated by the microphone M' and battery MB' are combined with oscillations of intermediate or superaudio frequency from source 4' through a balanced or double tube modulator 2' to form a band of superaudio frequency without the base intermediate frequency component as a carrier, which band is modulated onto a primary radio frequency carrier through a Heising oscillator and modulator unit 10' and the resulting double modulated primary wave radiated from the antenna 18'. The double tube modulator 2' is of the type disclosed in the patent to Carson, No. 1,343,307, patented June 15, 1920, while the oscillator and modulator unit is the usual Heising type in which O is the oscillator tube and MO the modulator tube, the oscillator circuit being adjusted to produce oscillations of the desired radio frequency. Although not shown, it will be understood that suitable amplifiers may be used both before and after the oscillator-modulator unit, as well as a filter circuit or circuits between the output of the modulator 2' and the input of the modulator tube MO or an amplifier preceding it. The arrangement for supplying the intermediate frequency carrier current to the subscriber is substantially the same as that of Figs. 1 to 3, and comprises the coupler 21' connected to transfer current from the circuit of the source 4' through an amplifier 22' to the line 25' extending to a subscriber's station. This subscriber's line, as in the preceding arrangements, may be a special line for the present use only or may be any line also used for other service such as a commercial power supply line or a telephone line as here shown by way of example. The radio receiving set at the subscriber's station comprises a receiving antenna 26' coupled to the input circuit of a first detector 28' arranged to receive and demodulate the double modulated primary wave radiated from the antenna 18' to detect out the intermediate frequency band and transfer the same, after re-composition with the original intermediate wave, to the input circuit of a second detector 36' arranged to demodulate the composed or synthesized wave to detect out the audio signal wave and deliver the same to the receiver 38'. Re-composition is here effected through a composition transformer 32' corresponding in function to the composition circuit 32 of Figs. 1 and 2 and comprising the three windings 31' 33' and 35' having a common magnetic field and connected respectively in the output circuit of the first detector 28', across the line

25' through extension 34', and in the input circuit of the second detector 36'. Thus, the band detected from the primary carrier received on the antenna 26' is combined with the original intermediate carrier wave received over the line 25' and extensions 34'.

As an alternative, the re-composition may be effected through a composition link circuit as shown in Fig. 5 which is the same as that used in Figs. 1, 2 and 3 and comprises a link circuit 132 to be coupled through transformers 131, 133 and 135, respectively, to the output of the first detector 28', to the line through extension 34' and to the input of the second detector 36'.

It should be understood that the various circuits and parts thereof shown herein, are for definition only and not for purposes of limitation. Thus, in practice, especially where secrecy is desired, proper filters will be employed at 6 or after 10 in Fig. 1 to pass only one side band. Many other refinements and modifications will occur to those skilled in the art after reading this specification. omodyne duplex receiving sets of the so-called Carson type may be employed, and the modulating transmitter 1-2 of Fig. 1 may be replaced by an equivalent relay transmitter for better use in the system of my prior copending application, Serial No. 746,357, hereinbefore referred to. In the specific form described, only unmodulated superaudio current is transmitted over wire circuits. The modulated signal waves are radiated from the transmitting station to the self-contained individual receiving apparatus at the receiving station. In thus specifying unmodulated current however, I do not bar the use of selective or filtering apparatus to take out some of the frequencies in the modulated band, and transmit the same over the wire while transmitting the balance by radiation, for purposes of secrecy.

The use of a harmonic generator or what I have called herein a harmonic producer, through which the frequency of the radiated wave is definitely related to the frequency of the initially modulated wave, leads to a line of development which is not fully described herein, as it does not relate to the same specific invention. However, it should be stated that the production of harmonics in the broader sense herein indicated, makes it possible to modulate, or rather to produce waves of radio frequency and bearing signal modulations, by causing the original low frequency signal waves to produce harmonics, stepping up to the desired order of frequency, which starting from the audio frequencies might be to the sixth or eighth octave for radio frequencies. Generically, this idea is the same as in the present case, although in this case the modulations in the secondary circuit 14 are not harmonics of the audio modulations produced in the

circuit 1, but they contain harmonics of frequencies which are found in the composition of the audio waves with the carrier frequency of the generator 4. Broadly speaking, the secondary modulations may therefore be said to be in harmonic relation to the low frequency modulations, and obviously the stepping up in such harmonic relation might well begin with the audio frequencies themselves. In such case, selection of particular parts of the spectrum would have to be made in order that a given number of constituent frequencies representing harmonics of the original audio waves may be brought together in the receiving circuits for recombination and detection. Theoretically, the audio portion of the spectrum may contain an infinite number of frequencies; but a very limited number may be selected, without sacrificing pitch or quality for stepping up, radiation, and recombination.

What I claim is:

1. The method of radio broadcast transmission which consists in modulating audio signal waves onto a carrier current of super-audio intermediate frequency, modulating the resultant composition current minus current variations of the said intermediate frequency onto a primary radio frequency carrier current and radiating the same as a primary carrier wave, receiving at a distant station the primary carrier wave, demodulating the same to detect out the intermediate frequency composition current, transmitting the original intermediate frequency carrier current separately and by means of a separate medium to the receiving station for recombination with said detected composition current to produce a carrier current of the intermediate frequency modulated with the audio signal wave, and demodulating or detecting the audio signal waves therefrom.

2. The method of broadcasting intelligence which comprises modulating audio signal waves onto a carrier current of super-audio intermediate frequency, transmitting on a primary carrier wave of radio frequency a band of frequencies resulting from said modulation without the unmodulated portion of the intermediate frequency waves, transmitting separately and by means of a separate medium to a distant receiving station the carrier current of intermediate frequency, receiving the primary radio frequency waves at the receiving station, detecting out the band, combining the band with the intermediate carrier, and detecting the audio frequency signals from the combined currents.

3. The method of broadcasting intelligence which comprises transmitting a radio carrier wave modulated with a band of

superaudio frequency waves minus waves of a given frequency within said band, supplying waves of said given frequency separately and by means of a separate medium to a distant station, and at the receiving station, receiving said radio waves, detecting off the band, combining the waves received separately with the band and detecting the audio signal waves from the resulting currents.

4. The method of broadcasting intelligence which comprises transmitting audio signal waves by double modulation of radio waves in which the intermediate wave is a band of waves minus waves of a given frequency essential to clear reception, transmitting waves of said given frequency separately and by means of a separate medium to a given point, and at the given point combining the separately transmitted waves with the radio transmitted waves.

5. In a system of broadcast distribution, a source of current of given intermediate frequency, a source of radio frequency current, means for combining audio frequency signaling current with intermediate frequency current to produce a band of intermediate frequencies substantially without current variations of the said given intermediate frequency, means for modulating said band onto said radio frequency current, means for transmitting said modulated radio frequency currents as radio waves, a receiving station, a radio receiving set at said station for receiving said radio waves, a wire line arranged to receive waves of said given intermediate frequency directly and separately from said source and adapted to convey the same over the line to the receiving station, and means at the receiving station for combining the waves received over the wire line with the received radio waves.

6. The system claimed in claim 5 in which the radio frequency current is a harmonic of said given intermediate frequency, with an harmonic producer for the same energized from the source of intermediate frequency current, and in which the connection to the wire line is made between said source and said harmonic producer whereby the intermediate frequency waves are transmitted directly and separately from all modulated waves.

7. The system claimed in claim 5 in which the source of radio frequency current is a harmonic producer supplied with fundamental frequency current from said source of intermediate frequency current, and the line connection is through an intermediate frequency or long wave amplifier connected in parallel with said harmonic producer.

In testimony whereof I hereunto affix my signature.

EDWARD E. CLEMENT.