

Dec. 11, 1945.

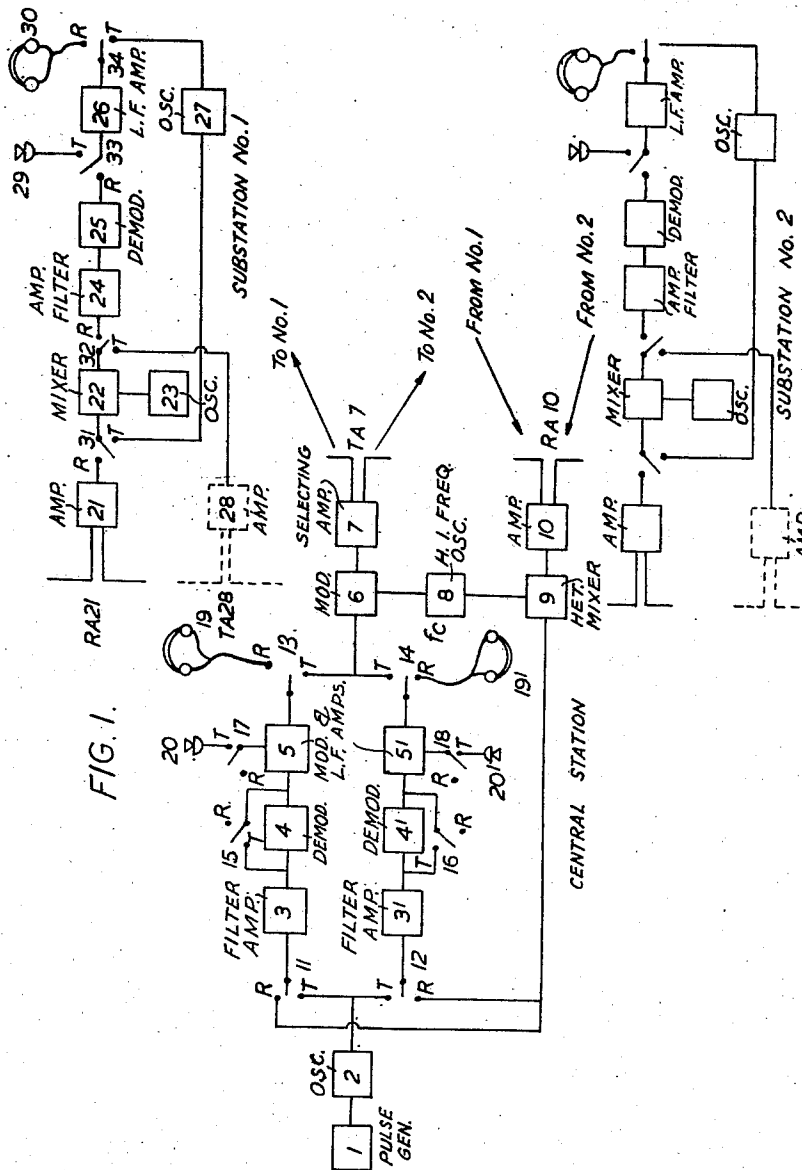
P. K. CHATTERJEA ET AL

2,390,641

MULTICHANNEL CARRIER COMMUNICATION SYSTEM

Filed Feb. 16, 1943

3 Sheets-Sheet 1



Inventor
P. K. Chatterjea
By *Edw. Houghton*
Edward Houghton
Attorney

Dec. 11, 1945.

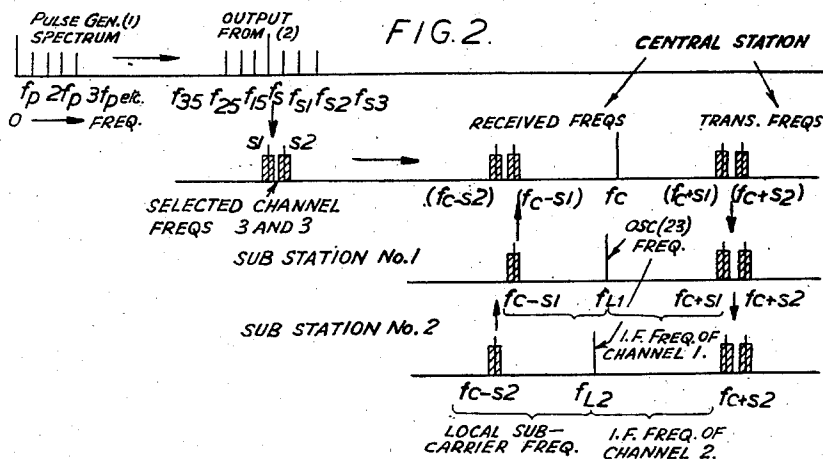
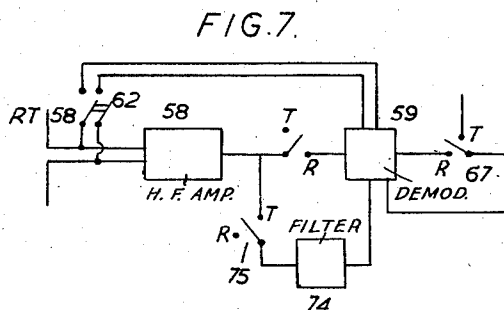
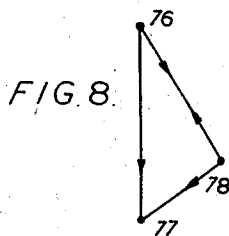
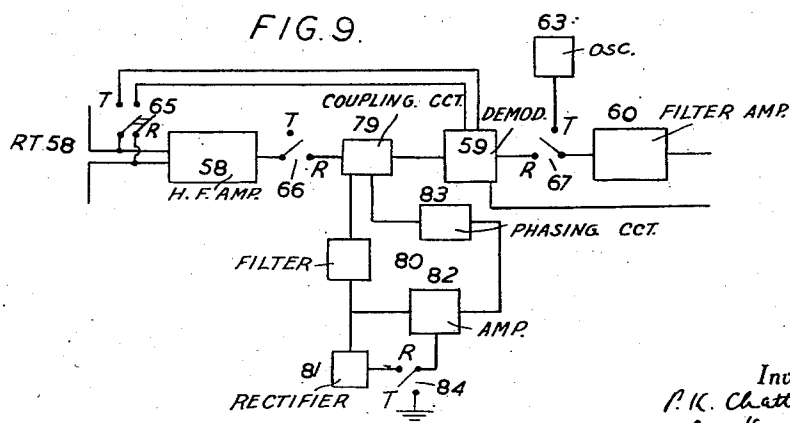
P. K. CHATTERJEA ET AL

2,390,641

MULTICHANNEL CARRIER COMMUNICATION SYSTEM

Filed Feb. 16, 1943

3 Sheets-Sheet 2



Inventor
P. K. Chatterjea
L. W. Houghton

By
Edward W. Houghton
Attorney

Dec. 11, 1945.

P. K. CHATTERJEA ET AL

2,390,641

MULTICHANNEL CARRIER COMMUNICATION SYSTEM

Filed Feb. 16, 1943

3 Sheets-Sheet 3

FIG. 3.

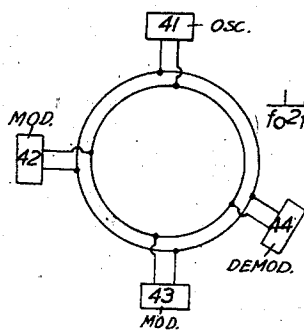


FIG. 4.

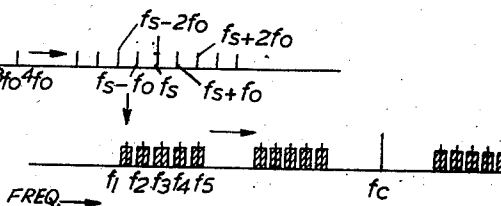


FIG. 5.

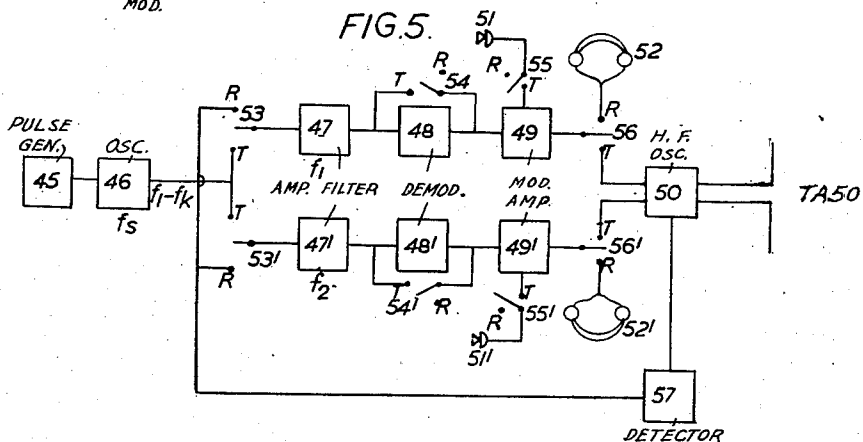
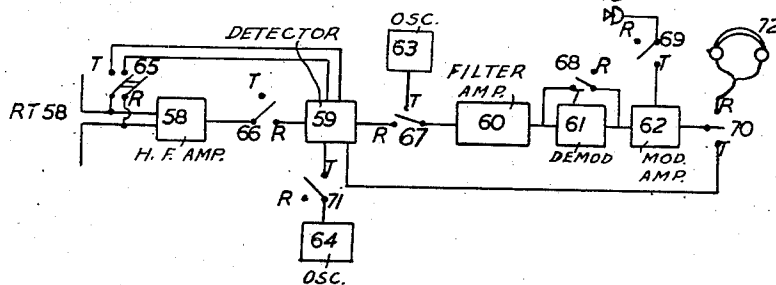


FIG. 6.



Inventor
P. K. Chatterjea
By *Edward W. Houghton*
Attorney

UNITED STATES PATENT OFFICE

2,390,641

MULTICHANNEL CARRIER COMMUNICATION SYSTEM

Prafulla Kumar Chatterjea and Leslie Wilfred Houghton, London, England, assignors to Standard Telephones and Cables Limited, London, England, a British company

Application February 16, 1943, Serial No. 476,073
In Great Britain March 13, 1942

8 Claims. (Cl. 250—9)

The present invention relates to radio communication systems and it has for its object to provide a radio communication system for communication between a central station and a plurality of stationary or mobile substations.

All the requirements of a flexible intercommunication system connecting a number of fixed positions are fully met by a modern telephone system employing cables. Where, however, all the points to be interconnected are mobile, the employment of radio as the inter-connecting link becomes essential. Where the requirements are for the provision of a number of separate channels of communication between two main centres, the substitution of radio transmission for cables presents few problems as the modulation frequency spectrum may readily be subdivided as in the case of carrier telephony and only two carrier frequencies may be required. This method becomes impracticable, however, in the case where the termination of each channel is at a different location as, although the transmission from the main or central station remains the same, the return channel from each receiving location or substation would have to be made on separate carrier frequencies with corresponding receiving equipment at the central station. Such a system is therefore only slightly less complicated than the employment of self-contained radio links for each location or substation.

In the system according to this invention about to be described radio carrier transmission is substituted for cables whilst retaining all the principal advantages of the latter systems and in addition the whole system may be made more flexible if desired.

According to one aspect of the present invention in a radio communication system for communication between a central station and a plurality of stationary or mobile substations, at the central station each of a plurality of signal channels is arranged to modulate its respective sub-carrier frequency, and all the sub-carrier frequencies are combined together to modulate a principal carrier frequency, one or both of the side-bands of the modulated principal carrier frequency being radiated with or without the principal carrier frequency and at each substation the said side-band or side-bands with or without the principal carrier frequency are received and one or more of the modulated sub-carrier frequencies is/are obtained therefrom.

According to another aspect of the invention, in a radio-communication system for communication between a central station and a plurality

of mobile substations, at the central station, a plurality of signal channels each modulates its respective sub-carrier frequency and all the sub-carrier frequencies are combined together to modulate a principal carrier frequency, one or both the side-bands of the modulated principal carrier frequency with or without the principal carrier frequency being radiated and at each substation the said side-band or side-bands with or without the principal carrier frequency is/are received and one or more of said sub-frequencies obtained therefrom and also at a substation, the said principal carrier frequency is generated or derived and modulated by a sub-carrier frequency modulated by a signal wave for communication to the central station, the modulated principal carrier frequency being radiated from said substation, and received at the central station and the modulated sub-carrier from the said substation obtained from said modulated principal carrier frequency received at said central station.

In carrying the invention into practice a wave rich in harmonics is used to modulate an oscillator, and the side band frequencies so produced are then separated so as to provide individual sub-carriers, one for each required channel. Means are provided for modulating each sub-carrier and the modulated sub-carriers are then combined and, as a whole, heterodyned up to the required transmission frequencies by a local oscillator of the principal carrier frequency, say f_c or f_c may be modulated and the requisite side-bands selected. The output is therefore a number of modulated signals, rigidly related to each other which may all be transmitted by the same transmitter and aerial array.

The receiving substations for the channels consist of similar equipments comprising an amplifier and a local oscillator of, or means for deriving frequency f_c , which is caused to heterodyne the received signals so producing the initial series of modulated sub-carriers generated at the transmitter and from these sub-carriers the respective one is selected and demodulated in known manner.

For transmitting a signal in the reverse direction, namely from a substation to the central station thereby providing a two-way communication link, an oscillator of the same sub-carrier frequency as that providing the particular received channel in question is incorporated in the receiver, and then by suitable switching arrangements this frequency is modulated by the signal and heterodyned by or caused to modulate oscil-

lator f_c , and the alternative side-band or derived frequency to that selected at the central station is used for the return transmission, suitable switching arrangements being provided for the high frequency circuits, to perform this function. At the central station means are provided for receiving the return transmissions from all the substations the received oscillations are heterodyned by the same oscillation of frequency f_c so producing sub-carriers of the same frequencies as those employed for the transmission from the central station. By suitable switching arrangements the same selection circuits are employed to select the appropriate signal which is then demodulated. It is therefore apparent that each channel can be used independently, the selection equipment at the central station being arranged and operated similarly to a normal telephone exchange panel, the operator of which has no adjustments to make in connection with the transmission.

A radio system according to the invention is particularly applicable where the area of operation is limited, so that comparatively high frequency radio transmission can be employed, with low power radiation, as the individual receivers are then correspondingly simpler due to the possible dual use of high frequency sections. All the filtering of channel sub-carrier frequencies is at radio frequency level with corresponding saving in size and weight of equipment as compared with low frequency filtering.

In the event of an emergency such as might occur should the central station be put out of action, means may readily be provided for permitting intercommunication directly between individual sub-stations.

The invention will be made clearer in the following description of some embodiments of the invention illustrated in the accompanying drawings and given by way of example.

In the drawings:

Figure 1 shows diagrammatically the circuit arrangements of the central station and two substations;

Figure 2 is an explanatory diagram showing a channel frequency distribution in the frequency spectrum;

Figure 3 is an explanatory diagram;

Figure 4 is an explanatory diagram showing the channel frequency distribution in the frequency spectrum of a second embodiment of the invention;

Figure 5 shows diagrammatically the circuit arrangements of a central station of a second embodiment of the invention;

Figure 6 shows diagrammatically the circuit arrangements of a substation of the second embodiment;

Figure 7 shows diagrammatically a modification of the arrangements shown in Figure 6;

Figure 8 is an explanatory diagram and

Figure 9 shows diagrammatically a further modification of the arrangements shown in Figure 6.

Referring now to Figure 1 there is shown the circuit arrangements for the case in which only one side-band of the modulated principal carrier frequency is radiated from the central station, and the frequency of the other side-band or image of the modulated principal carrier frequency is transmitted from the substations.

Sufficient of the principal carrier frequency may be transmitted, so that it is not able to cause heterodyne whistle, but from which, when received at a substation, the principal carrier fre-

quency could be derived. Only two substations are shown, but it will be understood that more than two substations may be employed.

It has so far been implied for the sake of simplicity, that the principal carrier frequency employed at each substation, is the same as that used at the central station. A further modification of this which may be incorporated in the case shown in Figure 1 and which does not alter the circuit arrangements involved but only the frequency, consists in using a different frequency for each substation principal carrier frequency and then using a corresponding sub-carrier frequency so as to transmit a signal corresponding to the central station alternative side band frequency to that transmitted by the central station and received by the substation. This has the advantage that the selectivity of the high frequency stages at the central station has only to be sufficient to prevent unwanted side-band break through which would show itself as interchannel interference, the possible low frequency beat occurring between received and local principal carrier frequency being completely eliminated. The required selectivity of the central station high frequency circuits will depend on the arrangement of aials, and at the substations on the possibility of a signal from another channel appearing as an "image" signal, but this may be completely avoided if too large a number of channels are not employed.

Referring to Figure 1, the central station consists of generator 1 of pulses which are rich in harmonics of the pulse repetition frequency, and are used for modulating an oscillator 2 from the output of which by means of selective devices are produced the sub-carrier frequencies. For transmission from the central station these frequencies are selected by filter amplifiers 3, 3¹ and modulated at 5 and 5¹ by, for example, a signal from a microphone 20, 20¹ and then fed to a modulator unit 6 to which is also fed the output consisting of the principal carrier frequency f_c from a high frequency oscillator 8. The required side-band components are then selected in any known manner and amplified by 7 before being fed to aerial TA7 for radiation.

It will be seen from the diagram that for this operation all switches operating to one channel i. e. 11, 13, 15, 17 or 12, 14, 16 and 18 are in position T and for reception of a signal they will be changed to position R when the operation would be as follows: Incoming signals, which are arranged to have frequencies corresponding to "images" or opposite sidebands to those transmitted relative to the frequency of oscillator 8, are received at aerial RA10 and amplified at 10, then heterodyned at 9 by oscillator 8 so reproducing sub-carriers which may then be selected by filter amplifiers 3, 3¹ after which they are demodulated at 4 and 4¹ and fed to, for example, headphones 19, 19¹ after being amplified by 5, 5¹, which are now used as low frequency amplifiers.

The operations of all substation units are identical and differ only in the actual frequencies employed. So referring to substation No. 1 the signals radiated by the central station are received by aerial RA21 and amplified by amplifier 21 after which they are heterodyned by oscillator 23 at 22 so producing a subcarrier frequency corresponding to the required channel which is selected by amplifier filter 24, demodulated by 25 and fed to headphones 30 via low frequency amplifier 26 for which operation switches 31, 32, 33 and 34 are switched to position R.

For transmission from substation No. 1 back to the central station these switches are moved to position T and a signal obtained for example from microphone 28 is after amplification by amplifier 28 caused to modulate an oscillator 27, the frequency of which is such that when heterodyned by or caused to modulate the output of oscillator 23 at 22 produces a side-band frequency equal to that required to be received by the central station for that particular channel allotted to substation No. 1. This is then selected and amplified by amplifier 28 before transmission by aerial TA28.

In actual practice appropriate switching arrangements may be included in amplifier 21 for performing the function of 28.

If oscillator 23 is made to generate the same frequency as the central station principal carrier frequency then the oscillator 27 will be the same frequency as the corresponding central station sub-carrier and as the frequency at which 24 is selective so that, if desired, the output of oscillator 27 may be amplified by 24 prior to modulation by output of 29 and 28.

A schematic representation of the frequencies involved is shown in Fig. 2 with reference to sections of Fig. 1.

In Figure 2, f_p represents the pulse repetition frequency of the pulse generator 1 (Figure 1) and $2f_p$, $3f_p$ etc. are the harmonic frequencies of f_p . These pulses are applied to modulate oscillator 2 (Figure 1) and produce the sub-carrier frequencies f_s , f_{s1} , f_{s2} , f_{s3} , f_{s4} etc. which are modulated by respective signals to produce the modulated side-bands $s1$, $s2$. These modulated subcarriers $s1$, $s2$ then modulate the principal carrier frequency f_c and each produces two side-bands of modulation products f_c+s1 and f_c-s1 ; f_c+s2 and f_c-s2 . Only one each of these pairs of side-bands of each signal, for example, f_c+s1 and f_c+s2 , is transmitted from the central station, and are received at the substations No. 1 and No. 2 as indicated in Figure 2. One of the side-bands f_c+s1 is then selected at substation No. 1 and f_c+s2 is selected at substation No. 2. For transmission of signals from the substations to the central station, the "image" side-bands of (f_c+s1) and (f_c+s2) or other frequencies below f_c are employed. In order to utilise the same apparatus for transmitting and receiving, the "image" frequencies are preferably employed. For example, substation No. 1 receives and selects (f_c+s1) and transmits (f_c-s1) whilst substation No. 2 receives and selects (f_c+s2) and transmits (f_c-s2) . Then assuming that the local oscillator 23 at substation No. 1 has a frequency f_{L1} the intermediate frequency on reception will be f_c+s1-f_{L1} and the sub-carrier frequency at substation No. 1 will be $f_{L1}-f_c+s1$. At substation No. 2, if the local oscillator 23 has a frequency f_{L2} , the intermediate frequency on reception will be f_c+s2-f_{L2} . In order to keep the possibility of a second channel interference at a minimum, it is advisable to arrange that the signal transmitted back to the central station from any substation does not coincide with the image frequency of any other substation while receiving, for which, in the arrangement shown it is necessary to arrange that $f_{Ln}-(f_c-s_n)$ does not become equal to $(f_c+s_n1)-f_{Ln1}$ where n and $n1$ represents any channel.

The actual frequencies employed would be dictated by design and requirements, but in an actual experimental rig up, the pulse repetition frequency was 15 kc./s. so giving a channel separation of this amount of 15 kc./s. These pulses were then used to modulate a 445 kc./s. oscillator

so producing a series of frequencies as its side-bands separated by 15 kc./s. two of which, i. e. the 445 and 460 kc./s. components were selected as sub-carriers and after modulation caused to modulate a 29.555 mc./s. oscillator so producing a side-band of 30.0 and 30.015 mc./s. for transmission. At a substation receiver built for a sub-carrier frequency of 472 kc./s. the local oscillator had to be $30-472=29.528$ mc./s. The transmission back from the substation to the central station had to be $29.555-445=29.110$ mc./s. so that the local sub-carrier oscillator 27 at the substation was $29.528-29.110$ mc./s. = 418 kc./s.

In the arrangement now to be described and shown in Figures 5 and 6 the sub-carriers modulate a high frequency principal carrier frequency oscillator as before, but both side-bands are transmitted together with the principal carrier frequency. At each substation this modulated principal carrier frequency when received is rectified so as to give the whole series of sub-carriers, the required one of which is then selected. At each substation means are provided for filtering out the principal carrier frequency for use as the frequency to be modulated by a locally produced sub-carrier for communication back to the central station where it is received and mixes with the modulated principal carrier being transmitted from the central station in the aerial circuit. Provision is made for preventing carrier frequency phasing trouble on both reception and transmission at substations.

The principle of operation of this embodiment may be explained briefly by considering the case of an oscillator whose output is connected to a ring main. Now, it will be apparent that the output of this oscillator may be amplitude modulated by means of the requisite modulation unit connected to any section of the ring main provided that the modulation unit is capable of correctly varying the voltage existing in the main, an operation which would be equivalent to introducing additional side-band frequency components. If the modulation frequency or frequencies of each modulating unit are different then there will be no mutual interference, and any particular modulating frequency may be obtained at any position on the ring main by connecting thereto an appropriate demodulator and selecting the required frequency from its output. Such an arrangement might be illustrated as shown in Figure 3 where 41 is an oscillator, 42 and 43 modulating units and 44 a demodulation unit.

Similar conditions may also be accomplished by substituting electromagnetic radiation for the conductors forming the ring main.

The radiation to be modulated may be regarded as the principal carrier frequency f_c and is generated at the central station where, at the same time it may be also modulated by a number of individual groups of frequencies. The process whereby additional modulation may be added to this carrier is accomplished at a substation by receiving the signal transmitted by the central station, and by means of a filter separating the carrier frequency f_c or generating a similar frequency and then modulating it in the usual way by a sub-carrier before re-transmitting it. This new modulation will therefore cause additional frequency components to appear in the general radiation, and the carrier component f_c will be an addition to the existing f_c their relative phases determining whether the resultant amplitude is greater or less than one component of f_c ; however, this can be arranged to have little effect on

the remainder of the system. Demodulation of f_c at the central station may be accomplished by normal receiver technique, and an individual sub-carrier modulation may then be further selected as required.

Each sub-carrier corresponds to a separate communication channel, these sub-carriers being generated, (at the central station) preferably by the modulation of an oscillator with a voltage waveform rich in harmonics, such as a short duration pulse, if a large number of channels are required. The separation of these harmonic side-band frequencies will then be at a frequency interval equivalent to the pulse repetition frequency or frequency of other modulating waveform.

At each sub-station the requisite channel sub-carrier has to be generated by a local oscillator.

The complete frequency spectrum involved is shown diagrammatically in Fig. 4 where f_0 represents the fundamental frequency of the initial waveform rich in harmonics together with its harmonics $2f_0$, $3f_0$ etc. which are employed at the central station for generating the required number of sub-carriers, one for each communication channel. By modulating a frequency f_s , side-bands are generated on either side of f_s as shown and the requisite number are then separated by filters to form the individual sub-carrier f_1 , f_2 , f_3 etc. which may then be individually modulated as desired. This group of frequencies is then caused to modulate the principal carrier frequency f_c which forms the signal radiated from the main transmitter. Where a message is being received at the main station on any particular channel, the sub-carrier, together with its modulation is inserted by the sub-station concerned.

The actual value of the sub-carrier frequencies employed depends mainly on the bandwidth of the frequencies in the messages to be communicated, and also on the final transmission frequency. One probable arrangement for use with speech signals might have f_0 equal to 15 kc./s., f_s between 100 kc./s. and 500 kc./s. depending mainly on filter designs, and the value of f_c might be approximately 30 mc./s. if the distance range of communication required is limited.

One possible circuit arrangement of central station is shown schematically in Figure 5, where for simplicity only two channels are shown. The reference 45 represents a generator of pulses of short duration which, as is well known in the art, are electrical waves rich in harmonics of the pulse repetition frequency and these pulses are applied to modulate oscillator 46 of frequency f_s so generating the sub-carrier frequencies f_1 , f_2 etc. one of which is selected by each amplifier filter 47, 47' etc.

The function of each channel is identical so that one channel only will be described. When it is required to transmit a message by this channel, switches 53, 54, 55 and 56 would be in position T so that filter-amplifier 47 is connected to unit 46 enabling the required sub-carrier f_1 for example to be selected and amplified. The last stage of 47 is arranged so that its output can be modulated in a modulation amplifier 49 the modulating input to which may be for example from a microphone 51 or any other required signal generating source. This modulated sub-carrier output from 49 is then caused to modulate the higher principal carrier frequency oscillator 50 whose output is coupled to aerial array TA50 for radiation.

In the case where it is required to receive at

the central station a signal on this channel switches 53, 54, 55 and 56 are all changed to position R which enables unit 47 to select its appropriate modulated sub-carrier from a well known demodulator or detector unit 57 which is permanently coupled to oscillator 50 in such a way as to derive therefrom only a very small power, at the same time it must be capable of handling a very large carrier having a very small percentage modulation. The output from 47 is now fed into unit 48 which is another demodulator unit, but in this case adjusted for the sub-carrier frequency so that its output is the required signal, which after amplification by unit 49 (the latter being converted to this use by appropriate switching arrangements, not shown) is fed to its appropriate interpreting apparatus, shown in this case as earphones 52.

The arrangement of a sub-station equipment is shown schematically in Figure 6 where, when set for receiving a signal, switches 65, 66, 67, 68, 69, 70 and 71 are in position R. The signal transmitted by the central station is received on aerial RT58 and amplified by the high frequency amplifier 59 in such a way as to give the series of sub-carriers from which the appropriate one is selected by filter amplifier 60 which together with units 61 and 62 are similar to their corresponding section 47, 48, 49 at the central station (Fig. 5). The output from 60 is demodulated by 61 and after amplification by 62 is fed to a translation device, for example, to earphones 72.

For transmission of a signal from the substation to the central station, switches 65, 66, 67, 68, 69, 70 and 71 are changed to position T and the operation is as follows. An oscillator 63 generates oscillations of the same frequency as the sub-carrier corresponding to the channel allotted to the sub-station. This oscillation is then amplified by 60 and modulated, for example, by the output of a microphone 73 (or other signal source) after amplification in unit 62 or alternatively, oscillator 63 may be modulated directly. This resultant modulated sub-carrier from 62 or 63 as the case may be, is then caused to modulate the output of another oscillator 64, either directly, or as shown, in unit 59 which may readily be converted from a demodulator stage to a modulator stage in known manner. It is of course essential that the frequency of oscillator 64 be exactly the same as the principal carrier frequency f_c . The output from 59 is connected to the aerial RT58 and so radiated to be received by the central station aerial resulting in a slight modification to the carrier amplitude there but with the addition of the sub-station's side-bands so that the signal contained thereby may be obtained by demodulation, i. e. by unit 57 Figure 5.

An alternative arrangement of obtaining the principal carrier f_c for transmission from the substation is shown in Figure 7 where oscillator 64 and switch 71 of Figure 6 are replaced by a filter 74 and switch 75. No difference is made to the description for reception, but when transmitting, and all switches including 75 are in position T, it will be seen that the output of amplifier 58 is fed to a filter 74, arranged to be selective enough to pass only the principal carrier frequency f_c (i. e. to pass no modulating frequencies) which is then fed to unit 59 for modulation and hence to the aerial, and input of amplifier 58. It will, therefore, be seen that the two amplifiers 58 and 59 together with the selective filter 74 are capable of forming an oscillator, generating

a signal of frequency determined by filter 74 and which may be made equal to f_c . If necessary phasing correction may readily be introduced.

In an intercommunication system similar to that hereinbefore described, employing a principal carrier of very high frequency for transmission in both directions it would be quite possible for the carrier component received by one sub-station to be entirely cancelled out due to the carrier from another substation being equal and 180° out of phase with that arriving from the central station, an undesirable effect due to the distortion caused to the signal being received. Figure 8 illustrates one possible cause where 76 represents the central station and 77 and 78 sub-stations. If the field strengths of the radiations from 76 and 78 are equal at 77 then the carrier component at 77 will be reduced to zero each time the relative transmission paths of the two signals change by multiples of a wavelength, or if the radiations leave 76 and 78 in phase and the distance 76—77 and 78—77 differ by an odd number of half operating wave-lengths.

An additional circuit arrangement which may be added to the sub-station equipment to overcome this effect is shown in Figure 9 in which the same references as in Figure 6 are used for corresponding units. When receiving, the output of amplifier 58 is fed to a coupling circuit 79 and thence to unit 59 for the first demodulation.

Unit 79 is such that it enables part of the output of 58 to be fed to a filter 80, capable of passing the carrier frequency f_c only. The output from this filter is then fed to an amplifier 82 and also to a rectifying unit 81, the output from which is caused to back bias amplifier 82. The output from 82 is fed through a phasing circuit 83 to the coupling unit 79 where its output is effectively coupled to unit 59 and 80. The adjustment of unit 81 is such that when there is a strong carrier component in the received signal the bias applied to amplifier 82 is such as to completely kill it. When however the carrier amplitude falls below a predetermined value amplifier 82 becomes unbiassed and its output applied to unit 79 maintains the carrier component fed to demodulator 49 at the required level. This action continues until if the carrier component is reduced to zero the gain of the amplifier 82 together with selective circuit 80 phasing circuit 83 and coupling in circuit 79, form an oscillatory circuit, maintaining required input to 59.

When transmitting, all switches are changed to position T, switch 84 reduces the bias applied to amplifier 82 so enabling unit comprising 80, 82, 83 and 79 to oscillate so as to generate the required principal carrier amplitude to be fed to unit 59, now modified by means of switches to form a modulator stage. The output from 58 is removed from circuit 79, so that other side-band components are not re-transmitted, causing possible cancellation with them also.

In an intercommunication system as hereinbefore described, provision may readily be provided for emergency intercommunication between substations by arranging for oscillator 63 and filter 60, Figure 6, to have alternative preset corresponding frequency adjustments. Also, if desired arrangement might be made whereby a sub-station unit could be converted into a normal type of receiver by arranging for the H. F. amplifier 58 to be converted into a variably tuned unit with oscillator 64 ganged to form a local oscillator for superheterodyne reception using filter 60 as the intermediate frequency amplifier and in the

case of continuous wave reception oscillator 63 could readily be adjusted to form a local beat frequency oscillator.

It will be appreciated that the system according to the invention may be extended to provide intercommunication other than through the central station but multiplication of the arrangements as at the central station in the foregoing description would be necessary to a degree more or less depending on requirements.

Since the substations are distributed each is provided with a receiving aerial and also with a local oscillator of frequency f_c or alternatively a signal of frequency f_c may also be transmitted from the central station, amplified if necessary at the substations and utilised for heterodyning the incoming modulated waves.

Such a provision of intercommunication through more than one central station, if intended for normal use may tend to complicate unnecessarily the working of the system as a whole, especially if a very large number of channels are required.

The adjustment of the individual receivers to any channel is quite a simple operation thus permitting all the receivers to be identical, unless a very large number of channels are employed, in which case it might be advisable to limit the scope of the interchangeability of receivers into groups.

Whilst several embodiments of the invention have been described, others will occur to those skilled in the art and which fall within the scope of the appended claims.

What is claimed is:

1. In a radio communication system for communication between a central station and a plurality of sub-stations, transmitting means at the central station including a plurality of means for producing signal frequency waves, a plurality of means for producing a sub-carrier frequency wave, means for producing a principal carrier frequency wave, means for modulating the wave from each of the sub-carrier producing means with the waves from a signal producing means, means for modulating the principal carrier frequency wave with the modulated sub-carrier frequency waves and means for radiating at least one side-band of the modulated principal carrier frequency wave; at each of said sub-stations means for producing signal frequency waves, means for producing a sub-carrier frequency wave, means for producing a principal carrier frequency wave, means for modulating the sub-station sub-carrier frequency wave by the sub-station signal frequency waves, means for modulating the principal sub-station carrier frequency wave by the modulated sub-station sub-carrier frequency wave, and means for radiating at least one side-band of the modulated principal sub-station carrier frequency wave, frequency and side-band of the modulated principal sub-station carrier frequency wave being positioned so that the side-band radiated from the sub-station will cover a frequency band on the opposite side of the principal central station carrier frequency to that occupied by the side-band radiated from said central station.

2. In a radio communication system according to claim 1, receiving means at the central station including means for heterodyning the received wave by a sub-carrier frequency wave, and detecting means, and receiving means at a sub-station including means for heterodyning the re-

ceived wave by the sub-station sub-carrier frequency wave, and detecting means.

3. In a radio communication system according to claim 1, at the central station and at a sub-station, means for radiating alternately both side-bands of the same principal carrier frequency wave.

4. In a radio communication system according to claim 1, at the central station, means for radiating the principal carrier frequency wave, and, at a sub-station, means for producing a principal carrier frequency wave including means for receiving the principal central station carrier frequency wave, and means for deriving therefrom the principal sub-station carrier frequency wave.

5. In a radio communication system according to claim 1, at the central station: means for radiating the principal carrier frequency wave, and at a sub-station: means for producing a principal carrier frequency wave including means for receiving the principal central station carrier frequency wave and means for deriving therefrom the principal sub-station carrier frequency wave, means for deriving therefrom the sub-station principal carrier frequency wave, and additional means including a local oscillator for generating a principal sub-station carrier frequency wave whenever the received principal central station carrier frequency wave drops below a predetermined value.

6. In a radio communication system according to claim 1, at the central station: means for

radiating the principal carrier frequency wave, and at a sub-station: means for producing a principal carrier frequency wave including means for receiving the principal central station carrier frequency wave, means for deriving therefrom the principal sub-station carrier frequency wave, and additional means including a local oscillator, and a feed back path containing thermionic valve means back biased by at least a portion of the received principal central station carrier frequency wave to generate a principal sub-station carrier frequency wave whenever the received principal central station carrier frequency wave drops below a predetermined value.

7. In a radio communication system according to claim 1, at each station, filters and amplifiers for separating and amplifying sub-carrier frequency waves, and switching arrangements for enabling the same filters and amplifiers to be used selectively in transmission and reception.

8. In a radio communication system according to claim 1, means for producing a number of spaced sub-carrier frequency waves including means for an electrical wave of substantially sinusoidal wave form, means for producing an electrical wave having a wave form rich in harmonics of the fundamental frequency of said wave, means for modulating the former wave by the latter wave and means for separating the side-bands of the modulated wave to form sub-carrier frequency waves.

PRAFULLA KUMAR CHATTERJEA.
LESLIE WILFRED HOUGHTON.