

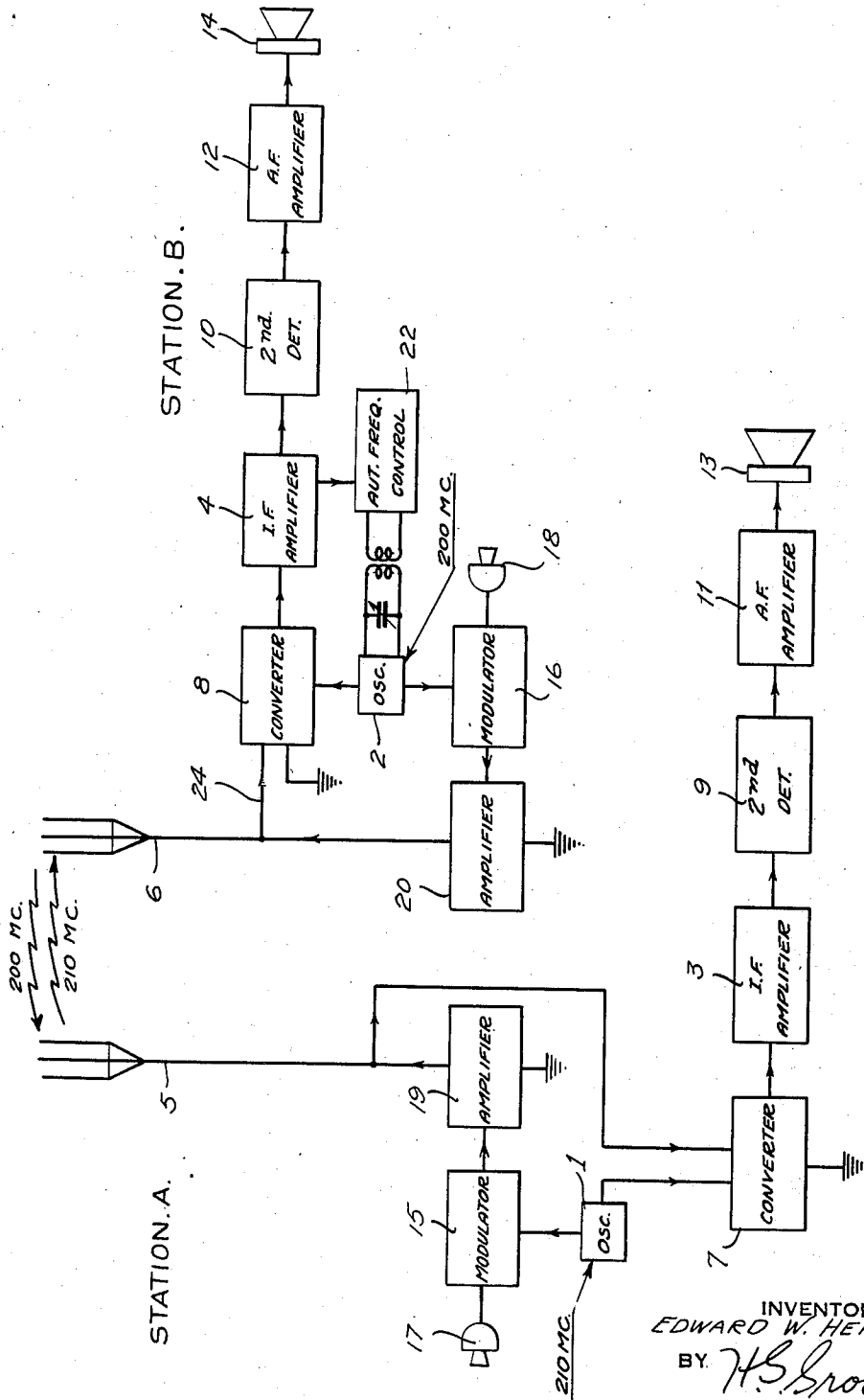
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TWO-WAY RADIO COMMUNICATION SYSTEM

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TWO-WAY RADIO COMMUNICATION
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This invention relates to a two-way communication system, and is particularly adapted for superheterodyne systems where it is desired to employ a predetermined frequency separation between the carriers used at two intercommunicating terminals.

Point to point communication, between two remote radio stations, for example, is frequently accompanied by difficulty in establishing contact, particularly when no time schedule has been arranged. At the ultra-high frequencies, furthermore, there is difficulty in maintaining an exact frequency of the carrier wave, and elaborate control apparatus is commonly needed at both receiving and transmitting ends. The system which I have devised overcomes these disadvantages to a large extent, since, by its use, any station may communicate in both directions with a "mate" station by simply tuning in a transmission from the "mate."

Accordingly, it is an object of my invention to provide a communication system in which the establishment of suitable carrier frequencies for two-way communication may be determined from either station alone.

It is another object of my invention to provide a communication system of the type described wherein the frequencies of the carriers used for two-way communication between two stations shall be maintained in fixed relation to each other and to a common intermediate frequency to be used by the superheterodyne receivers of both stations.

Other objects and advantages will be apparent in the description to follow. This description is accompanied by a drawing, the sole figure of which represents diagrammatically a preferred embodiment of the invention.

Briefly, the method which I employ is one which utilizes a predetermined frequency separation between the carrier used for transmission in one direction and the carrier used for transmission in the other direction. The determination of this frequency separation depends upon the intermediate frequency amplifiers which are used in the receivers of the two stations. Tuning the receiver at station A, for example, to the transmitter frequency at station B will simultaneously assure perfect tuning of the receiver at station B in response to the carrier which will then be effective at station A. The tuning of the local oscillator at one station may be only approximate, whereas the oscillator at the other station can, if desired, be made subject to automatic frequency control in accordance with the

received carrier. There appears to be a particular value in this method when the system is applied to communication between aircraft, or between aircraft and ground, and possibly for military uses.

Assume, for example, that the oscillator 1 at station A is tuned to a frequency of 210 megacycles and that the intermediate frequency tuning of the amplifier 3 is 10 megacycles. The incoming signal energy of 200 megacycles received on antenna 5 and applied to the converter 7 will develop a difference frequency of 10 megacycles which will be acceptable to the intermediate frequency amplifier 3. The output from the intermediate frequency amplifier may be detected by the device 9 and then amplified as audio frequency in the unit 11. The output from this amplifier may be utilized in any suitable manner as by means of the loud speaker 13 for example.

Since the oscillator 1 develops a frequency of 210 megacycles, this frequency can be used as a transmitting carrier for station A. The modulator 15 will, therefore, be arranged to accept this frequency and to combine therewith intelligence signals from the microphone 17. The transmitting amplifier is indicated at 19.

In accordance with my invention, it is not necessary for the oscillator 1 to be frequency-controlled provided some sort of frequency control is available at another station with which station A is to communicate. The advantage of this arrangement lies in the fact that station A may perhaps be located on an aeroplane where it is desired to minimize the weight and space factor of the apparatus employed. Accordingly, I have indicated station B, which may be a ground station, for example, as having in addition to a duplication of the apparatus shown in station A, an automatic frequency control device 22. The other equipment of station B may be briefly described as follows:

The local oscillator 2 may be tuned to 200 megacycles and used both for transmission and reception. The intermediate frequency amplifier 4 in the receiving section is again tuned to, say, 10 megacycles so that the incoming signals at 210 megacycles may be heterodyned by the converter 8 to produce a difference frequency of 10 megacycles. The output from the intermediate frequency amplifier 4 may then be fed to the second detector 10 and thence to the audio frequency amplifier 12. Any suitable utilization device such as a loud speaker 14 may be connected to the output of the audio frequency amplifier 12. Station

B when used for transmission employs a microphone 18, a modulator 16, and a transmitting amplifier 20. The antenna 6 is connected both to the converter 8 and the amplifier 20. In some instances, it may be unnecessary to apply the output from the oscillator 2 directly to the receiver converter 8 because the energy fed through the amplifier 20 may be combined with incoming signals and fed through the conductor 24 to the converter 8. Where the circuit arrangement is as just mentioned, it will, of course, be desirable to employ in the converter unit, or in a subsequent stage, filtering means for suppressing the carrier and the oscillations of the local source 2.

The oscillator 2 may be frequency-controlled by the incoming signals in accordance with well-known practice. The automatic frequency control device 22 is, therefore, shown conventionally for this purpose. Although automatic frequency control devices are well known, reference is here made to United States Patent No. 2,121,103, granted June 21, 1938, to S. W. Seeley for a comprehensive disclosure of how they may be constructed and operated.

I will now present a mathematical discussion of the theory of operation of my invention:

Let f_a = the frequency of the oscillator 1 of station A, say 210 megacycles, for example.

Let f_b = the frequency of the oscillator 2 at station B, say 200 megacycles.

Let f_i = the frequency to which the intermediate frequency amplifiers 3 and 4 are tuned, say 10 megacycles. Then,

$$f_a = f_b + f_i$$

and

$$f_b = f_a - f_i$$

Now if station A is transmitting, then station B can place itself in two-way communication with station A merely by tuning its own oscillator 2 so that reception of station A's signals will be properly received. By the same tuning operation at station B, the signals transmitted therefrom will be suitable for reception by station A. It is essential to the successful operation of my system, however, that both stations maintain an agreed-upon tuning of their intermediate frequency amplifiers, both to the same frequency.

If it is desired to change the intermediate frequency tuning in accordance with a prearranged schedule, based on agreement as to time of change, or any other system, then an element of secrecy is introduced into the communication. Not knowing what intermediate frequency is to be used, an unauthorized receiver would be unable to pick up the incoming signals without considerable search for the transmitting carrier, and most probably would not be able to answer back.

It is not necessary that the same antenna 5 or 6 should be used both for transmission and reception, but it has been shown as a single antenna at each station merely for the sake of simplicity.

It may not always be necessary to employ an automatic frequency control such as the unit 22 at either of the stations, but should any drift in frequency occur at one terminal, adjustment of the tuning of the oscillator at the other terminal will automatically assure perfect two-way communication, provided the intermediate frequency amplifiers 3 and 4 of the corresponding stations are similarly tuned.

In connection with automatic tuning, it should be noted that correction of the local oscillator serves additional purposes as compared with those previously contemplated. That is to say, auto-

matic frequency control was generally used only for correction of the heterodyne oscillator in the receiver at one station. In accordance with my invention, however, this automatic frequency control not only compensates for drift in the incoming carrier frequency but also provides control of the transmitter carrier in such manner as to maintain proper tuning of the remote receiver.

Where it is desired to provide a number of inter-communicating stations, one of which would be a master station for frequency control, it is apparent that exclusive communication between the master station and any one outlying station could be obtained by the use of differently tuned intermediate frequency amplifiers and differently tuned oscillators at the outlying stations. Where this idea is carried out, station B can receive selectively from any outlying station such as A, A', etc., but would need to select a local intermediate frequency for its own intermediate frequency amplifier to be in agreement with the fixed frequency of the I. F. amplifier at the selected outlying station. After making this adjustment, two-way communication would be established simply by listening to the signals from the selected outlying station and causing the local oscillator frequency at station B to be thereafter automatically frequency controlled. In order to tune the local station to a frequency which the remote station will accept, while at the same time adjusting the tuning of the local station to the frequency which the remote station radiates, it is, of course, necessary to select an intermediate frequency for the local station which corresponds with the intermediate frequency of the remote station. This one consideration determines the adaptability of the system for unit control of both stations from the one master station.

Other modifications of the principle I have outlined will be readily apparent to those familiar with superheterodyne reception. For example, a receiver may be adapted to receive both signals which are lower in frequency than the local oscillator and those which are higher than the oscillator (the so-called image response). Thus, a group of stations may intercommunicate and any given station may act as a type A to some of the other stations and as a type B to the remainder. When two such systems operate with different I. F. amplifier frequencies only those stations within a given system can establish two-way communication.

The practical adaption of my idea is readily apparent to those skilled in the art and there appears to be no need for further description of modulation and power-amplification equipment. The system may be applied with amplitude, frequency or phase modulation and the intelligence to be transmitted may be sound, television, facsimile or of any other type capable of being converted into electrical currents or potentials. In complexity, the system may range from the simplest transceiver employing a single-tube, self-oscillating frequency converter with local modulation on the oscillator and a one-tube intermediate frequency system, to a highly complex system with master oscillators, power amplifiers and modulators, radio frequency amplification and multi-stage intermediate frequency amplification with automatic frequency control.

My invention is to be understood as comprehending the various modifications suggested above as well as others which might suggest themselves to those skilled in the art. The scope of the invention is, therefore, defined by the claims.

I claim:

1. A two-way communication system operable between two radio stations, each station comprising a transmitter, a superheterodyne receiver, an oscillator common to the transmitter and the receiver, and an intermediate frequency amplifier in the receiver, the intermediate frequency amplifiers at the two stations being tuned to the same frequency, and means located at one of said stations for maintaining a frequency separation between the output energies of the two said oscillators equal to the frequency to which said intermediate frequency amplifiers are tuned.

2. A system in accordance with claim 1 and including an automatic frequency control device in the means for maintaining frequency separation.

3. A system in accordance with claim 1 and including an automatic frequency control device in the means for maintaining frequency separation and operable in accordance with variations in the frequency of the received carrier wave.

4. A two-way communication system in accordance with the invention defined in claim 1, wherein the oscillator at one station is adjusted to operate at a frequency above the signal frequency received by said station and the oscillator at the other station is adjusted to operate at a frequency below the signal frequency received by said other station.

5. In a two-way radio communication system wherein each of two stations comprises a transmitter, a superheterodyne receiver, an oscillator common to the transmitter and the receiver, and an intermediate frequency amplifier in the receiver, the method of adjusting the tuning conditions at one station only, to satisfy the tuning conditions at both stations necessary for two-way communication therebetween, which method comprises tuning the intermediate frequency amplifier at said one station to the same frequency as that of the intermediate frequency amplifier at the other station, and maintaining a frequency separation between the oscillators at the two stations equal to the tuning frequency of said intermediate frequency amplifiers.

6. In a two-way radio communication system operable between two radio stations, each station comprising a transmitter, a superheterodyne receiver, an oscillator common to the transmitter and the receiver, and an intermediate frequency amplifier in the receiver, means for adjusting the tuning conditions at only one of the stations to satisfy the tuning conditions at both stations necessary for two-way communication therebetween, said means comprising means for tuning the intermediate frequency amplifier at said one station to operate at the same frequency as that of the intermediate frequency amplifier at the other station and additional means for maintaining a frequency separation between the oscillators at the two stations equal to the operating frequency of said intermediate frequency amplifiers.

7. The method according to claim 5 and including the step of causing the carrier wave received at said one station to automatically control the frequency of the oscillator thereat.

8. In a radio communication system having a master station and a plurality of outlying respondent stations, wherein each station comprises a transmitter, a superheterodyne receiver, an oscillator common to the transmitter and the receiver and an intermediate frequency amplifier, and wherein said master station includes an automatic frequency control device operable upon its oscillator to control the frequency thereof in accordance with an incoming carrier wave, the method of adjusting the tuning conditions at said master station to satisfy the tuning conditions thereat and simultaneously to establish two-way communication between said master station and a selected one of said respondent stations, which method comprises tuning the intermediate frequency amplifier at the master station to the same frequency as that of the intermediate frequency amplifier at said selected station, and tuning the oscillator of the master station so that a frequency separation is maintained between itself and the oscillator of the selected station equal to the selected intermediate frequency.

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