

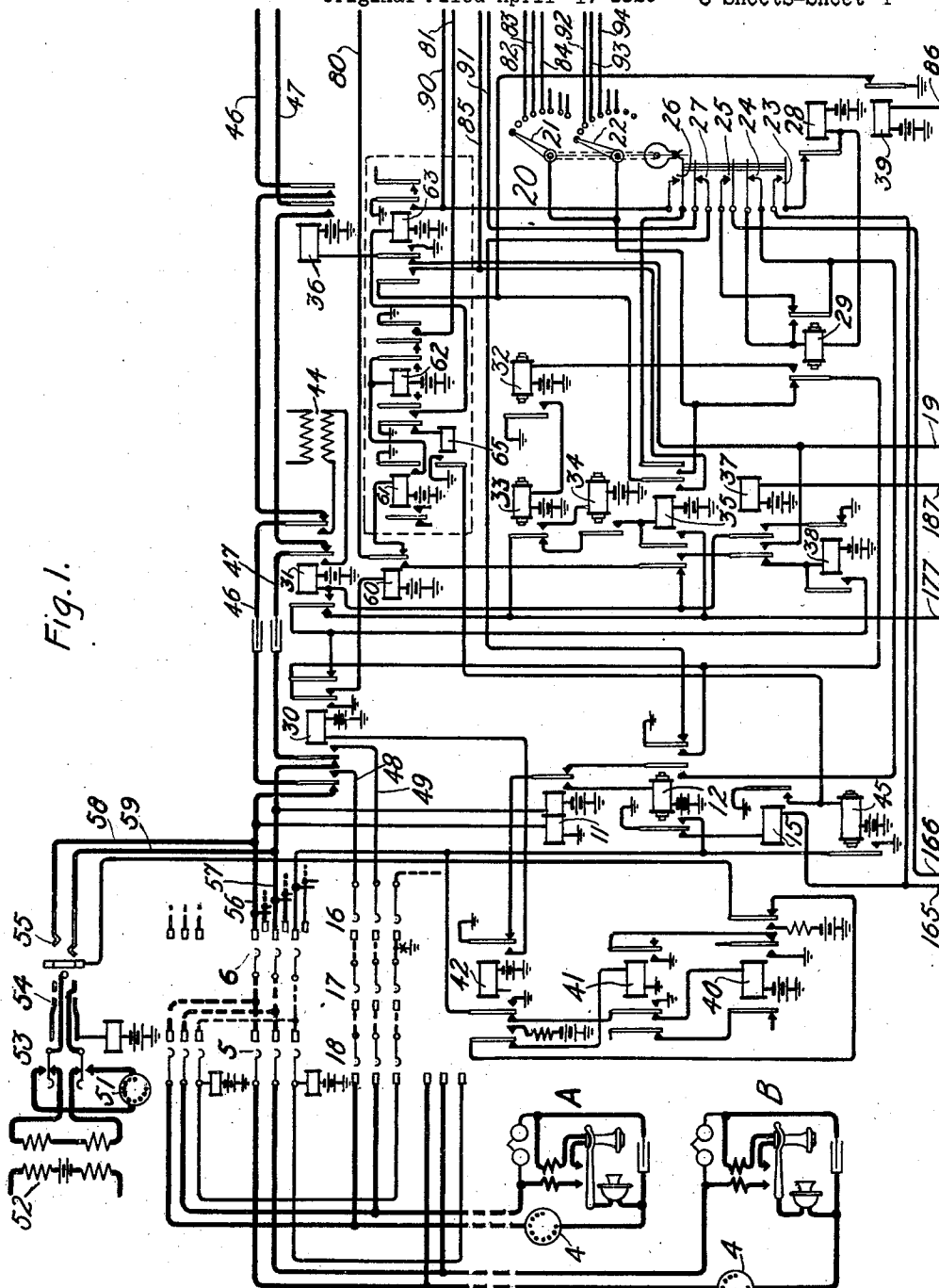
March 1, 1927.

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AUTOMATIC TELEPHONE HIGH FREQUENCY TRUNK

Original Filed April 1, 1920 8 Sheets-Sheet 1



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AUTOMATIC TELEPHONE HIGH FREQUENCY TRUNK

Original Filed April 1, 1920 8 Sheets-Sheet 2

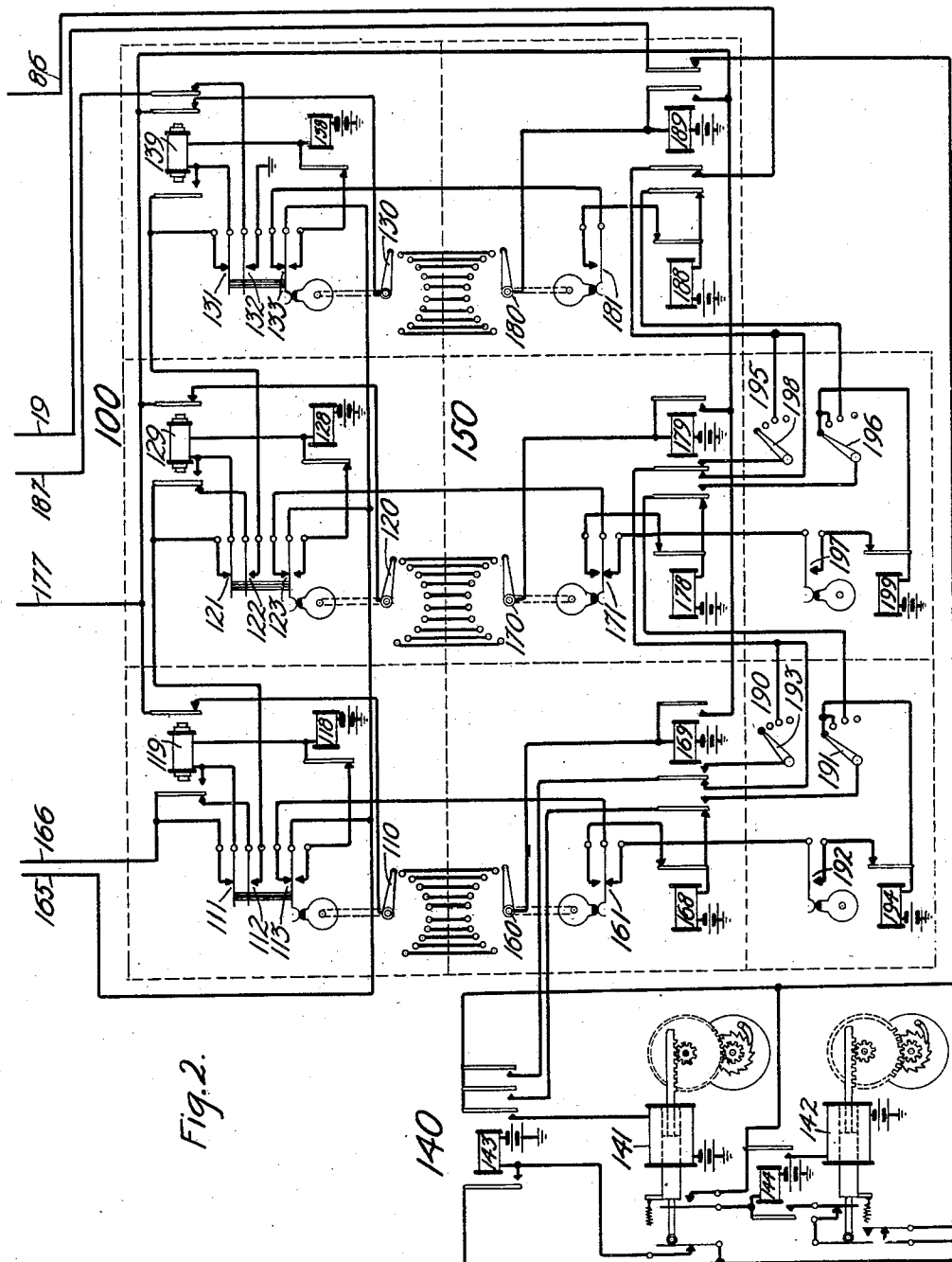


Fig. 2.

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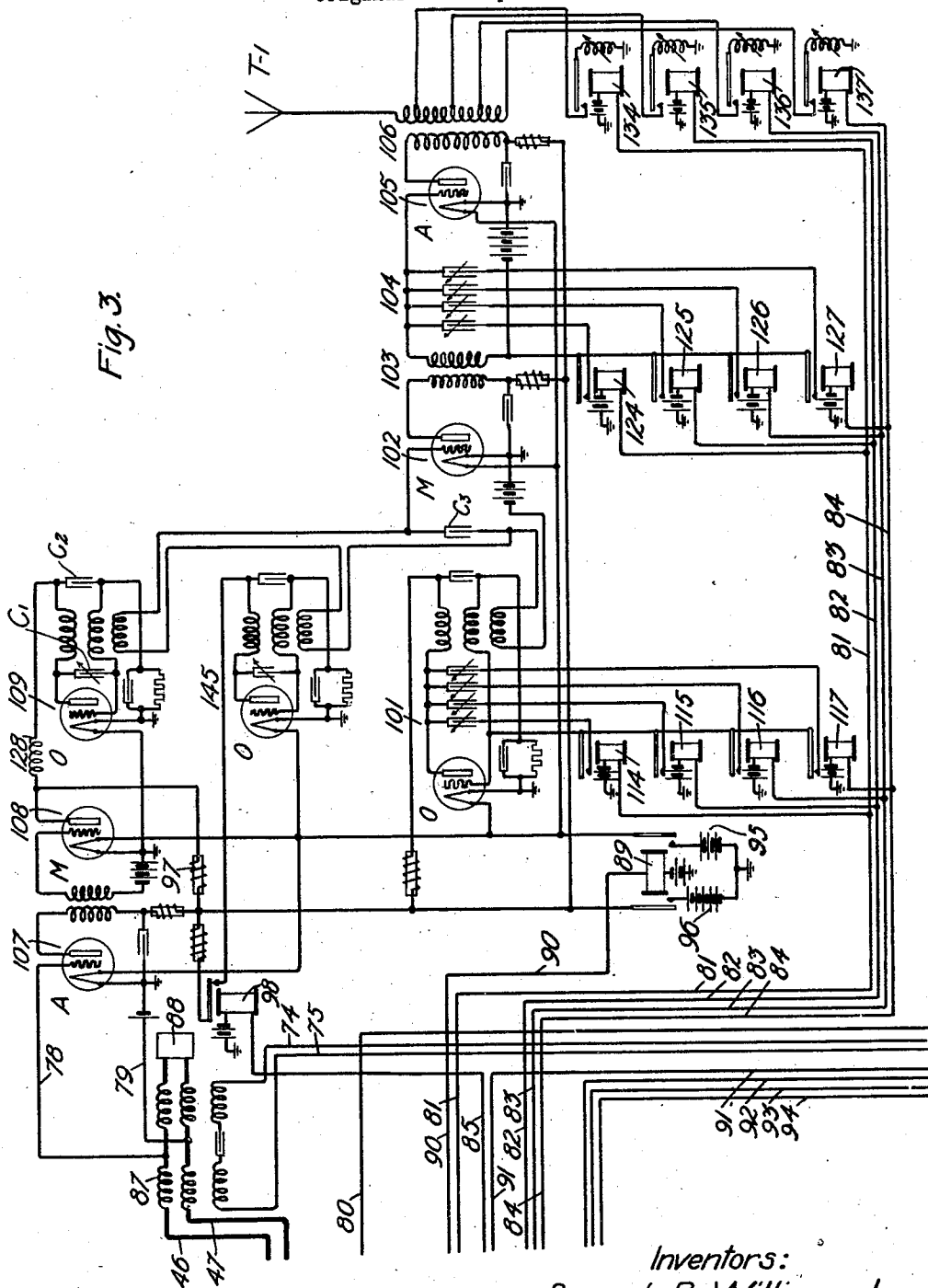
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AUTOMATIC TELEPHONE HIGH FREQUENCY TRUNK

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Fig. 3.



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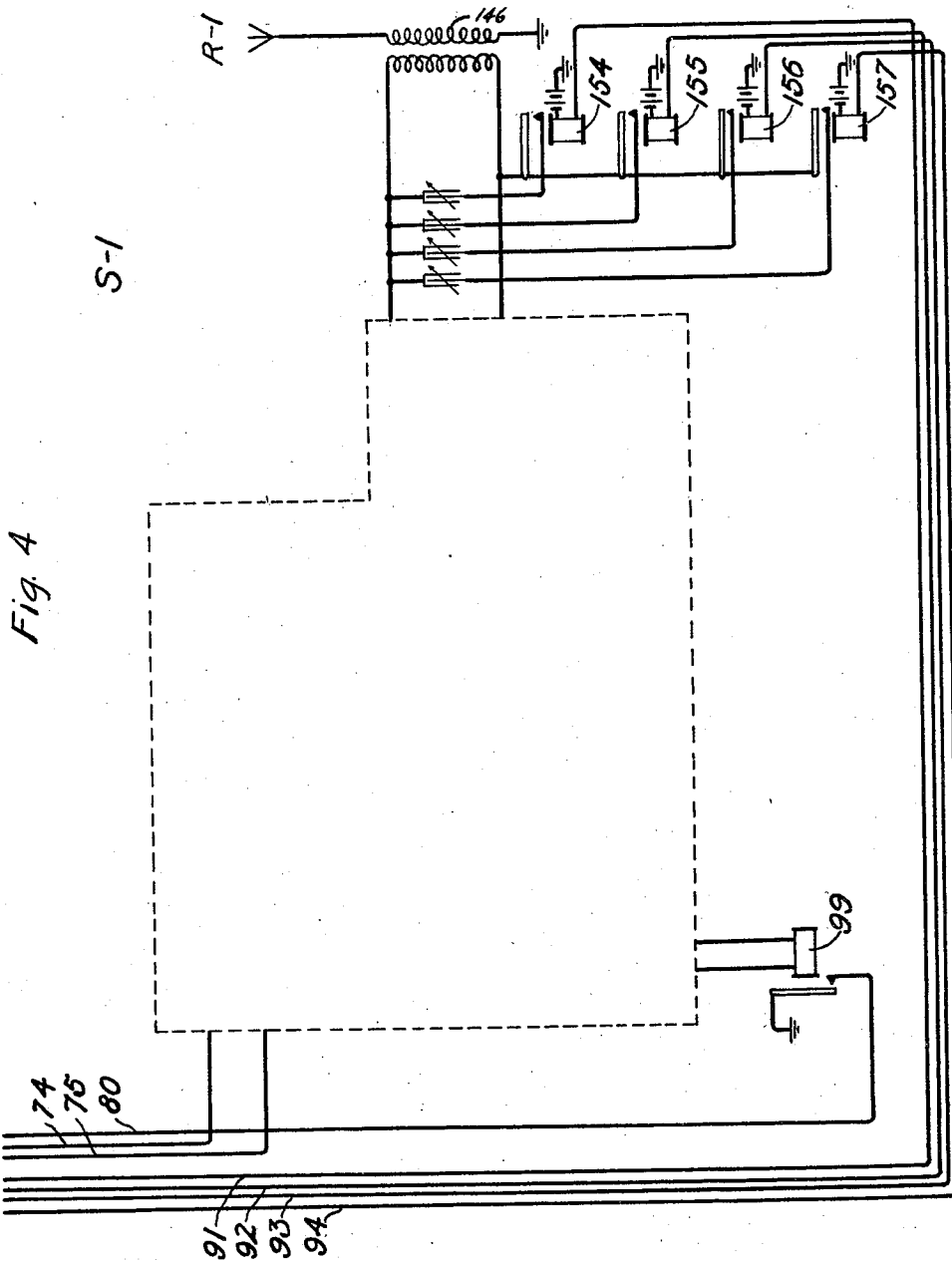
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AUTOMATIC TELEPHONE HIGH FREQUENCY TRUNK

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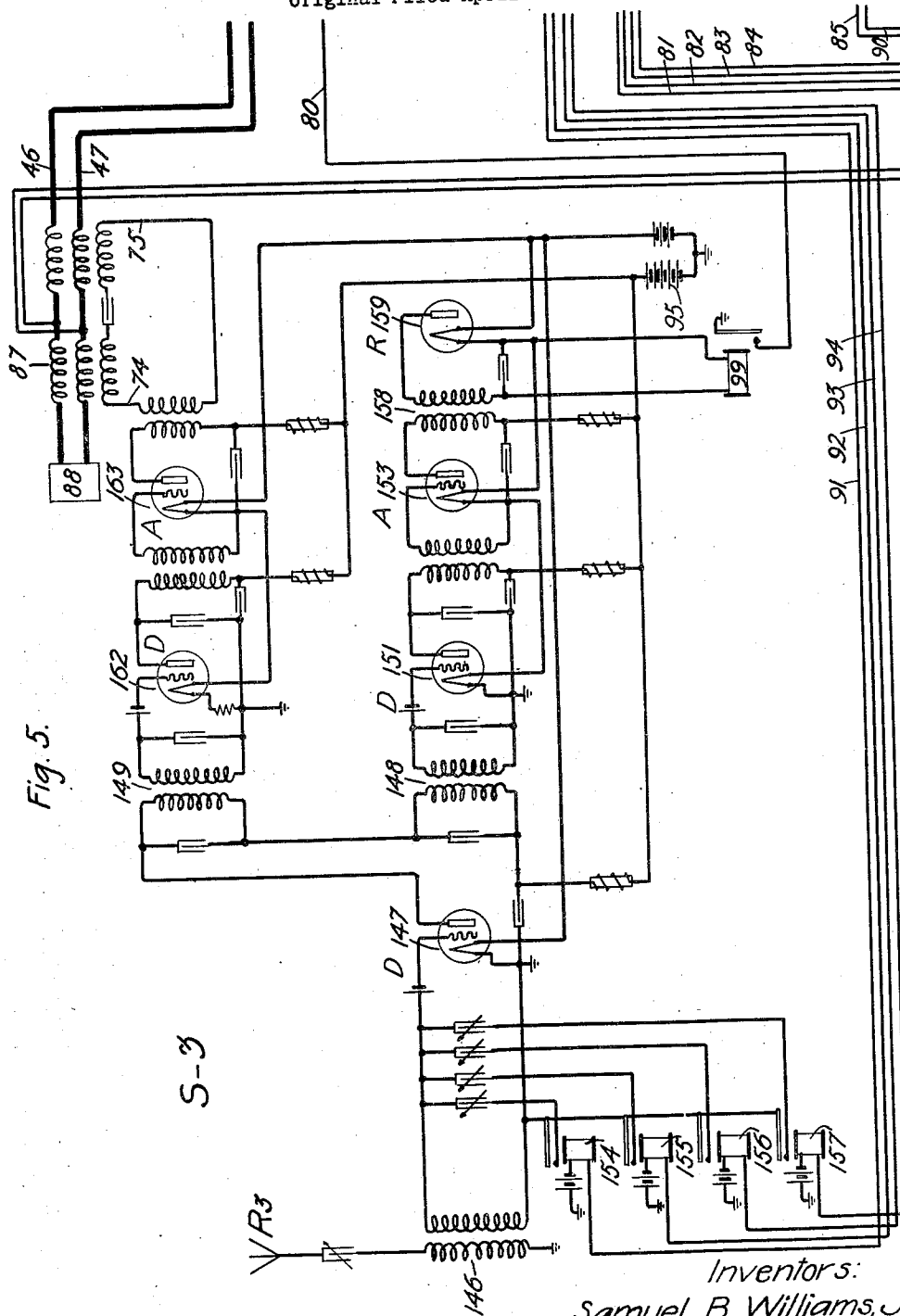
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AUTOMATIC TELEPHONE HIGH FREQUENCY TRUNK

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AUTOMATIC TELEPHONE HIGH FREQUENCY TRUNK

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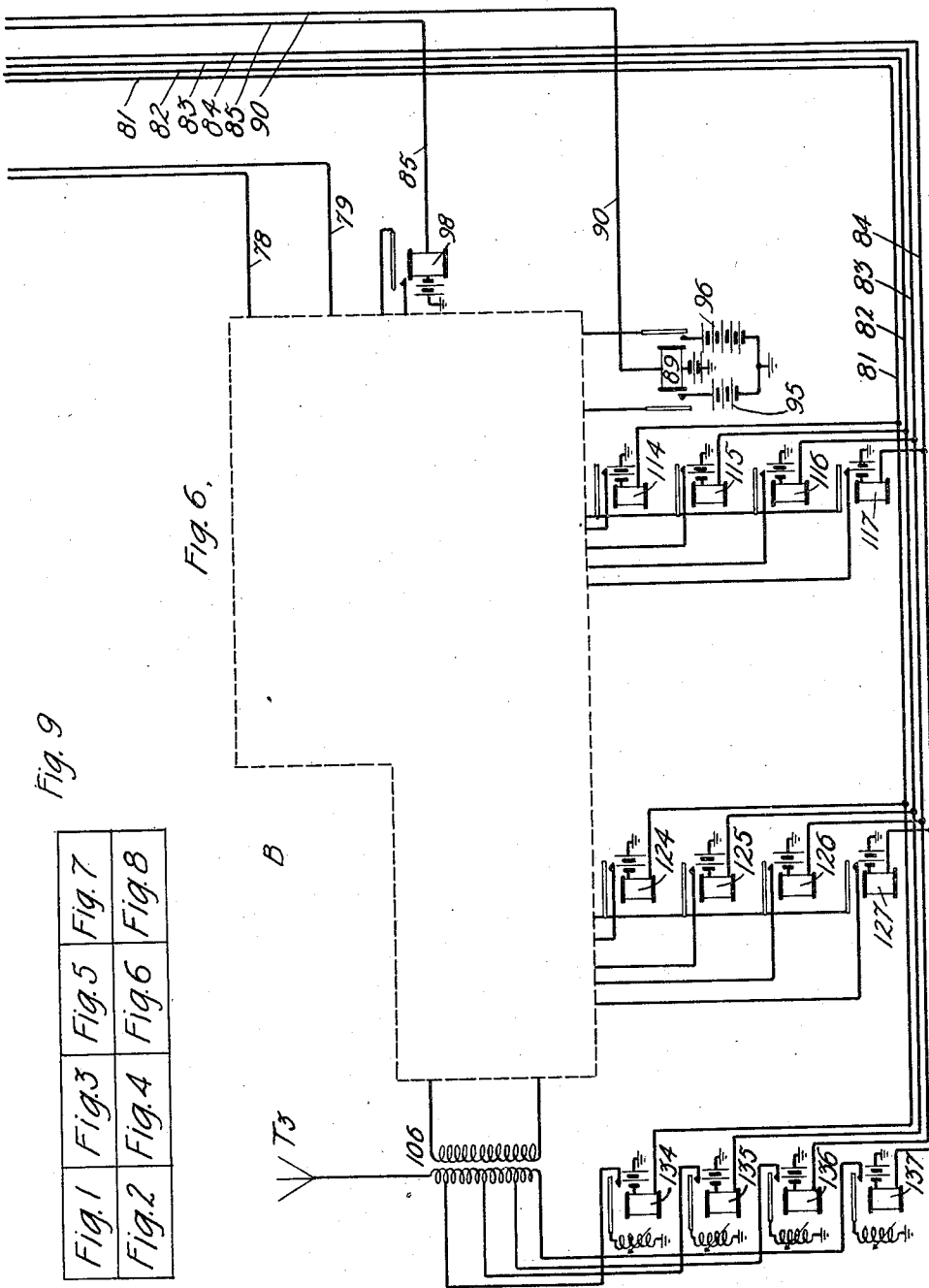


Fig. 9

Fig. 1	Fig. 3	Fig. 5	Fig. 7
Fig. 2	Fig. 4	Fig. 6	Fig. 8

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AUTOMATIC TELEPHONE HIGH FREQUENCY TRUNK

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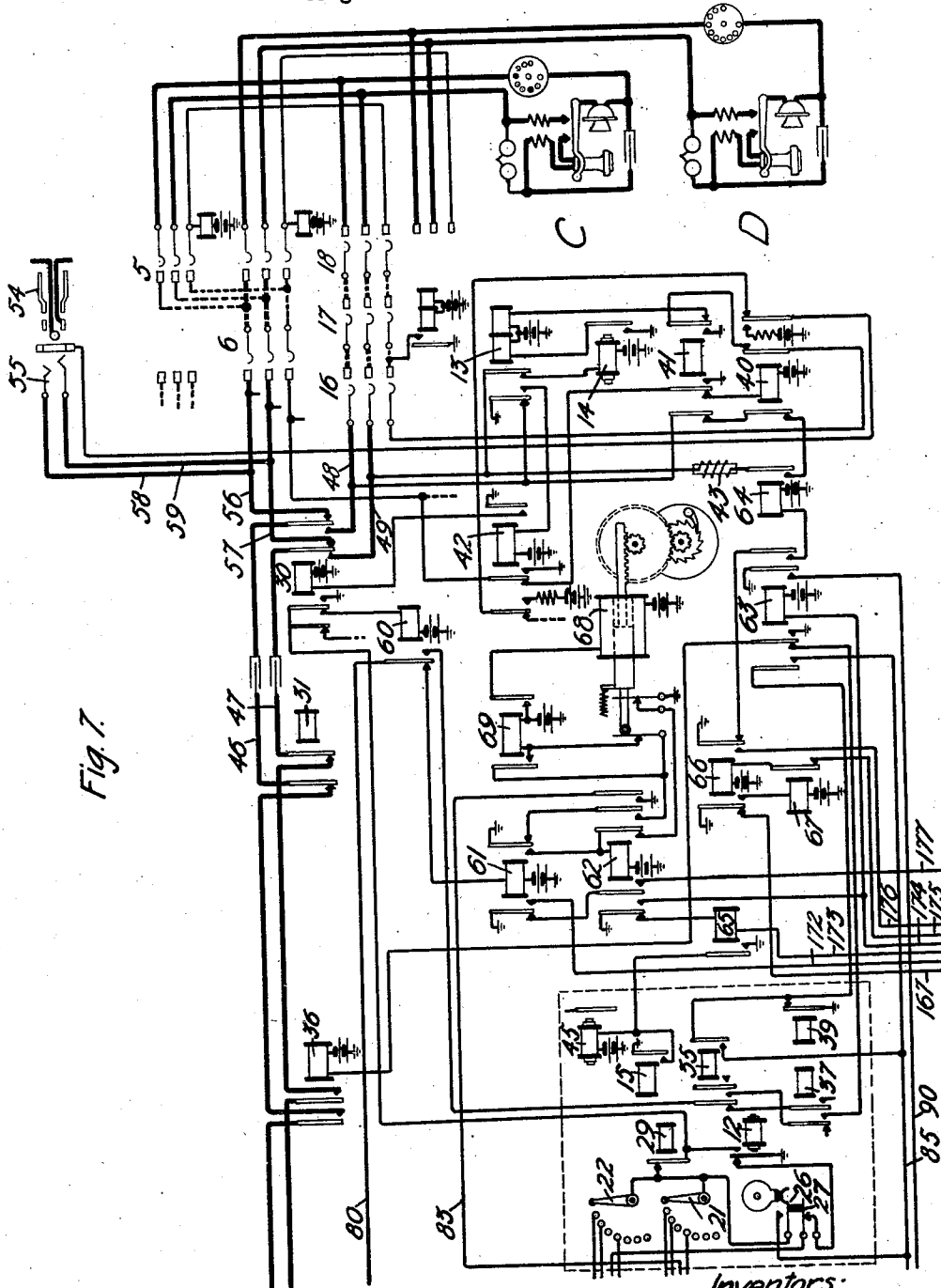


Fig. 7.

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AUTOMATIC TELEPHONE HIGH FREQUENCY TRUNK

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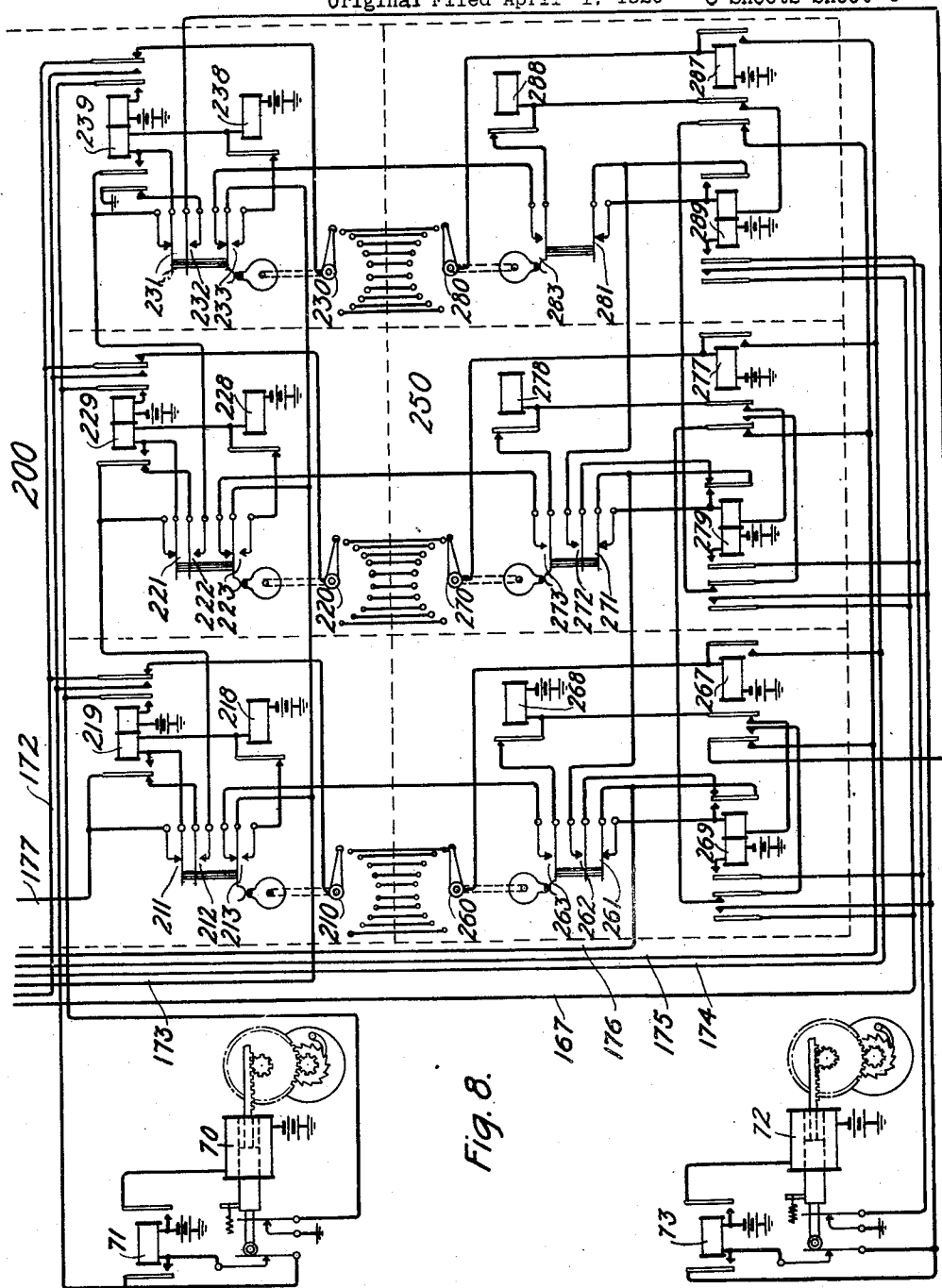


Fig. 8.

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1,619,228

UNITED STATES PATENT OFFICE.

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AUTOMATIC TELEPHONE HIGH-FREQUENCY TRUNK.

Application filed April 1, 1920, Serial No. 370,476. Renewed December 18, 1925.

This invention relates to an improved communicating system, and its principal object is to provide means for controlling switching mechanism and establishing communicating circuits through the medium of high frequency oscillations either transmitted through space in the form of electromagnetic waves or guided upon metallic conductors.

10 It is the object of this invention to provide a system in which high frequency waves may be used as the medium for establishing communication between any high frequency station and any other high frequency station of a number of associated stations and as the medium for controlling the operation of switching mechanism at the distant station; in which automatic switching mechanism associated with one high frequency station may be operated to place that high frequency station in operative relation with any one of a number of other high frequency stations; in which the calling high frequency station may have associated with it a number of local stations, which may be subscribers' telephone stations, with means under the control of each local station for extending its circuit to the associated high frequency trunk; in which two or more high frequency stations may be available for extending a connection from or to any one of an associated group of local stations; in which the automatic switching mechanism and high frequency station selecting mechanism of the calling high frequency station may be under the control of any local station that has extended its circuit to the calling high frequency station, so that the local station may establish operative relation through the associated high frequency station with any of the other high frequency stations; in which the distant or called high frequency station may be provided with switching mechanism for connecting it with any one of a number of associated local stations; in which this switching mechanism of the called high frequency station may be under the control of controlling mechanism at the calling high frequency station, which controlling mechanism at the calling high frequency station may in turn be under the control of controlling apparatus at the local station that

has become connected with the calling high frequency station, so that the local station associated with the calling high frequency station may select and establish operative relation with any one of the other high frequency stations, and may then select and establish operative relation with any of the local stations associated with the selected or called high frequency station; in which the calling local station may control the release at both high frequency stations; in which the calling high frequency station may be prevented from establishing communicating or controlling relation with a called high frequency station that is at the time in communication, either as a calling station or as a called station, with some other high frequency station, or has been appropriated by any of its associated local stations preparatory to being used to establish communication with some other high frequency station; in which any local station may be prevented from extending its circuit to the associated high frequency station if that station has been appropriated by some other local station; in which a called high frequency station is caused automatically to signal its accessible condition back to the calling high frequency station; in which the receipt of this signal by the calling high frequency station automatically brings about the operation of apparatus for completing the connection of the calling station with the called station, and in which the failure of such signal to be received prevents the apparatus of the calling station from completing the connection; in which the unavailable condition of the called high frequency station brings about the application of a busy signal to the circuit of the calling high frequency station; in which the impulses for effecting the control of the selecting and connecting switches at the called high frequency station may be stored up in register apparatus at the calling high frequency station, and may be released by the receipt of the signal from the called high frequency station indicating its non-busy or available condition; in which the register mechanism at the calling high frequency station may receive at their normal rate the impulses determined by the operation of the controlling switch at the local

station, and may translate these impulses into high frequency impulses succeeding each other at a different rate; in which the high frequency impulses received at the
 5 called high frequency station may be stored in register mechanism at the rate at which they are received, and may be translated into impulses at a different rate for operating the selecting and connecting switches that
 10 complete the connection with the desired local station associated with the called high frequency station; in which the register mechanism at the calling and called high frequency stations may automatically in-
 15 terpose a "change-over" interval between the groups of impulses transmitted; in which carrier waves of different frequencies may be employed as the media for selectively establishing operative relation between each
 20 high frequency station and the various other high frequency stations; in which each high frequency station has a normal carrier wave frequency for receiving and a different normal carrier wave frequency for transmitting,
 25 and in which the selection of any desired high frequency station is accomplished through the medium of automatic switching apparatus that operates to tune the trans-
 30 mitting system of the calling high frequency station to the normal carrier wave frequency of the called station, and the receiving system of the calling high frequency station to the normal transmitting carrier wave
 35 frequency of the called station; in which each carrier wave is multiplexed by having applied to it one intermediate frequency for talking or communicating and another intermediate frequency for signaling or controlling, the first intermediate frequency
 40 being modulated by the talking or communicating currents and the second intermediate frequency being modulated by the operation of the signaling or controlling apparatus; in which the receiving antenna system of each
 45 high frequency station is arranged to respond selectively to the two superposed intermediate frequencies and utilize one for the reproduction of the transmitted voice or communicating currents and the other
 50 for the reproduction of the transmitted signalling or controlling currents; and in which the circuit organization of each of the high frequency stations is so arranged that the circuit operates as a two-way trunk, and
 55 is automatically adapted for outgoing calls originating in the associated local stations, or for incoming calls originating in local stations associated with other high frequency stations. The foregoing are some of the
 60 principal objects that the system of the present invention is designed to attain. The manner in which the foregoing and other desirable objects are accomplished will be explained in the following description of
 65 the preferred embodiment of the system, and

the structures through which the novel features are realized will be defined in the appended claims.

The preferred embodiment of the invention is illustrated in the accompanying
 70 drawings, in which Figs. 1 to 8 inclusive show diagrammatically as much of the circuit organization as is necessary to enable the invention to be understood. The sheets of drawing are to be arranged side by side
 75 in the manner indicated in Figure 9.

As illustrated in the drawing, there are two radio stations or trunks, S—1 and S—3, each having associated with it certain local
 80 stations, A, B and C, D, respectively. It will be understood that there may be a plurality of such radio stations or trunks with their associated local stations. As the other radio stations may all be equipped similarly
 85 to those illustrated, it is not necessary to show them, and the stations S—1 and S—3 may be assumed to be representative of the other stations. Furthermore, in order to simplify the drawing, the organizations of
 90 the two radio stations illustrated are not shown in their entirety. As each of the radio station circuits is designed and adapted to operate as a two-way trunk, it is
 95 equipped with all of the apparatus required for enabling it to be used both for incoming and outgoing connections; and as it is assumed for the purposes of the present description that station S—1 is the calling
 100 station and station S—3 is the called station, certain of the apparatus at each station that is involved only when the conditions are reversed, or is involved under the conditions here assumed but is fully illustrated in connection with the organization
 105 of the other station, is omitted from the drawing or is partially indicated in areas bounded by broken lines. In the complete organization the apparatus and wiring fully
 110 shown at either of the radio stations illustrated, is also present at the other station.

Referring now to the organization as it is illustrated at the two stations S—1 and S—3, each of the radio trunks is provided
 115 with a radio terminal consisting of the antennæ, T—1 and R—1 (or T—3 and R—3); and also with certain conductive terminals, such as the spring jack 55, the passive terminals of automatic switches such as the selector switch indicated at 6, and the
 120 active terminals of a line switch as indicated at 16. At the spring jack terminals 55 of the radio trunk the connecting cord 52 may be connected with the trunk by means of the plug 54, the connecting cord
 125 being provided with the usual equipment including a calling dial 51. It is customary in the art to make a distinction between automatic systems, the switches of which
 130 are controlled from a subscriber's substation, and systems in which manual substations

may be connected to an automatic system through the medium of an operator's cord circuit, such as that shown having associated with it automatic switch-controlling means. The former type is called a full automatic system and the latter type a semi-automatic system. The present invention is equally well adapted to be used in connection with either a full automatic or a semi-automatic system and has been illustrated as having the necessary connections for both types. When the radio trunk is being used as an out-going trunk for calls originating in the associated local stations, as A, B, the local lines are connected with it through the medium of line switch 5 and the selector switch 6. The line switch 5 may be of the type commonly known as the Keith line switch, and the selector switch 6 may be a selector switch of the Strowger type, the associated circuits for the control of these switches being of the sort ordinarily used; or any other of the well-known arrangements used in the telephone art for extending the connection of a telephone line to the central office apparatus may be substituted.

When the radio trunk is used as an incoming trunk for the extension to one of the local lines of a call originating at some other radio station, the circuit of the trunk is extended through the medium of a line switch 16, a selector switch 17 and a connector switch 18, these switches being conveniently of the type and having the wiring arrangement of the switches referred to above.

The radio terminal of the trunk may consist of two antennae T-1 and R-1. These antennae may be of any desired form, and should preferably be located at a sufficient distance apart to insure the selectivity of the receiving antenna with respect to the energy in the wave radiated by the transmitting antenna; or, if it is desired to locate the antennae closer together the irresponsiveness of the receiving antenna to the energy it receives from the transmitting antenna may be attained by any of the several methods that are available in the art.

The medium that is employed in the present instance for effecting radio communication between the transmitting antenna T-1 and the receiving antenna, as R-3, of the distant radio station is a high frequency carrier wave, the oscillatory current for producing which is generated in the high frequency oscillator 101. The oscillator circuit may be of a well-known type comprising a vacuum tube or thermionic amplifier with an oscillation circuit including inductively related inductances in the input and output circuits of the tube. The filament current for this oscillator is supplied by the filament current battery 95, and the plate current is supplied by the plate current battery 96.

The carrier wave produced by the high frequency oscillator 101 carries two intermediate frequencies, one of these intermediate frequencies being generated by the oscillator 109 and the other being generated by the oscillator 145. Both of these are vacuum tube oscillators having oscillation circuits of the same type as the carrier wave frequency oscillator 101 referred to above. The intermediate frequency oscillatory currents generated by the oscillator 109 are modulated by the voice currents transmitted from the telephone transmitter of the associated local station. The voice currents from the associated local station pass over the talking conductors 46 and 47 of the trunk and through the four equal windings of the two-way repeating coil 87 into the balancing network 88. The junction points of the two serially included repeating coil windings in each side of the line circuit are connected by way of conductors 78 and 79 with the input circuit of a thermionic amplifier 107, and the output circuit of the amplifier is inductively coupled with the input circuit of the modulator 108. The operation of the oscillating and modulating circuits herein disclosed is briefly as follows: The oscillator 109 and modulator 108 are supplied with plate current through the choke coil 97 which has sufficiently large inductance to prevent the passage therethrough of current fluctuations of frequencies as high as those used in transmission of speech. The plate current supply circuit for the oscillator 109 contains also a choke coil 128 which transmits voice frequencies but has sufficient inductance to prevent the passage of current fluctuations corresponding to the frequency of oscillator 109. Since the current supplied to the tubes 108 and 109 together in parallel is maintained constant whereas the current through the tube 108 alone is controlled by the impressed voice current, the current through the oscillator 109 is made to vary in a complementary manner and, therefore, the amplitude of the wave generated by the oscillator 109 varies in accordance with voice received over the line conductors. The frequency of oscillator 109 is controlled by the condenser C_1 , while the condenser C_2 , which is too large to have an appreciable effect on the period of the oscillator, serves to prevent short-circuiting of the battery 96.

The oscillators 109, 145 and 101 are all connected to and feed into the input circuit of the modulating tube 102. Condenser C_3 affords a high frequency by-pass for the radio frequency current from oscillator 101. The output coils from oscillators 109 and 145 are in series. However, the coupling of the oscillator circuits to the common work circuit may be made sufficiently loose to prevent reaction of one oscillator upon another

and to prevent the constants of the work circuit from affecting the period of the oscillators.

The action of the modulator 102 is somewhat different from that of 108 since all of the waves are impressed upon the grid circuit and the modulating action depends upon the variation of the tube impedance to the passage of the radio frequency current under control of the currents impressed from oscillators 109 and 145. The result is that the radio frequency wave is modulated by each of the waves from the intermediate frequency oscillators each of which is, in turn, modulated or controlled by currents or waves of lower frequencies, the one by voice frequency waves, as has been explained, and the other by control impulses as will now be described.

The operation of the intermediate frequency oscillator 145 is controlled at the contacts of the relay 98, which relay is governed in its operation by the controlling apparatus of the trunk circuit. When the relay 98 is operated, the oscillator 145 acts to generate oscillatory currents of the frequency predetermined by the adjustment of the inductance and capacity of its oscillating system; and when the relay 98 is inert, the oscillator ceases to generate these oscillatory currents.

The output circuit of the modulator 102 is inductively coupled with the tuned input circuit 104 of a power amplifier 105 of the thermionic type, and the output circuit of the amplifier is inductively coupled with the tuned transmitting antenna T—1 of the system. The tuning of the amplifier input circuit 104 and of the transmitting antenna T—1, as well as of the oscillating circuit of the carrier wave oscillator 101 is accomplished through the medium of a plurality of branches under the control of the relays 114, 115, 116, and 117; 124, 125, 126 and 127; and 134, 135, 136 and 137. The tuning branches of the carrier frequency oscillator 101 and of the amplifier 105 controlled by the relays 114, 115, 116, 117, and 124, 125, 126, 127, respectively, include condensers; and the tuning branches of the transmitting antenna T—1 controlled by the relays 134, 135, 136, 137 include tuning inductances. It is obvious that while inductances are shown for purpose of tuning condensers or both inductances and condensers might be provided where only a variable inductance is shown, and that they might be controlled by relays in the same manner as are the inductances. The capacities of the condensers and the tuning inductances are made variable so that they may be adjusted to produce the desired tuning effects in the associated circuits. The tuning effects are so regulated that when the relays 114, 124, 134, are operated a carrier wave of a certain frequency is propa-

gated from the transmitting antenna T—1, when the relays 115, 125, and 135 are operated a carrier wave of a different frequency is sent out; and in the same way for the other two sets of relays 116, 126, 136, and 117, 127, 137, each of which when operated causes another and different frequency of carrier wave to be transmitted. Each of the four sets of relays may be selected for energization at the contacts associated with the wiper 21 of the station-selecting switch 20 of the trunk circuit; and the wiper 22 of this switch correspondingly selects for energization any one of four relays 154, 155, 156, and 157 which control tuning branches of the receiving antenna R—1 of the station.

The radio receiving system of the station may be understood by reference to Fig. 5, which shows fully the radio receiving system of the station S—3, the circuit organization of which is exactly the same as that of the station S—1. The receiving antenna, as R—3, is inductively coupled with the tuned input circuit of a thermionic detector 147, and the tuning branches are under the control of relays 154, 155, 156, and 157, which in turn are controlled by means of the conductors extending to the contacts associated with wiper 22 of the station-selecting switch 20. The branches controlled by the relays 154, 155, 156 and 157 contain condensers the capacity of which is adjusted and set so that when any one of the branches is closed the receiving system is made responsive to a particular one of the carrier wave frequencies with which the system is designed to cooperate. The output circuit of the detector 147 includes serially the two frequency filters 148 and 149; and also has bridged across the filament and plate circuit a condenser for eliminating the unmodulated carrier frequency. The filter 148 has its constants so adjusted as to select the signaling intermediate frequency and to pass the talking intermediate frequency, and the filter 149 is adjusted to select the talking intermediate frequency and to pass the signaling intermediate frequency. The filter 149 is inductively coupled with the input circuit of the detector 162, and the output circuit of the detector 162 is inductively coupled with the input circuit of the amplifier 163. The output circuit of the amplifier is inductively coupled with a circuit including two windings of the two-way repeating coil 87. The inductive relation of these two windings with the other windings of the repeating coil 87 is such that the voice currents flowing in the circuit of the conductors 74 and 75 are repeated into the trunk talking conductors 46 and 47 connected with the other windings of the repeating coil, but are not repeated into the branch connection with the amplifier 107 of the station of Fig. 6 by way of the conduc-

tors 78 and 79. As a result of this arrangement, which is well-known in the art, the voice current modulations that reach the called station through its receiving antenna are prevented from re-acting upon the radio transmitting system of that station and causing similar voice current modulations of the oscillatory currents passing to its transmitting antenna.

10 The filter 148 which selects the signalling intermediate frequency of the received oscillation is inductively coupled with the input circuit of the thermionic detector 151, and the output circuit of this detector is inductively coupled with the input circuit of the amplifier 153, the output circuit of which in turn is inductively coupled with the circuit of the rectifier 159. The circuit of the rectifier includes the winding of relay 99, and this relay acts through the medium of conductor 80 to govern the operation of certain switching mechanism of the associated trunk.

25 The apparatus which is used to transmit and receive by means of any one high frequency wave as distinguished from that which is used only when a wave of a different frequency is employed, is commonly known as a channel or a high frequency communication channel. It will be seen that each terminal apparatus is capable of transmitting or receiving through any one of a number of channels and that one such channel may be selected and appropriated for use by a pair of stations, to the exclusion of all other stations of the system and that the channels, by virtue of the different frequencies which they employ respectively, do not interfere with one another, but enable independent simultaneous communication between different stations of the system.

Each of the radio stations is normally tuned to utilize two carrier wave frequencies, the transmitting system being tuned to transmit one carrier wave frequency and the receiving system being tuned to respond to another carrier wave frequency. These pairs of frequencies are different for each of the radio stations of the system. When a call is received by any of the stations it is received at the carrier wave frequency that is normal to the receiving system of that station; and under these circumstances the carrier wave that is transmitted from the transmitting system of the called station is the frequency that is normal for that transmitting system. When any of the radio stations is calling another station, the associated switching apparatus is operated to tune the transmitting system of the calling station to the carrier wave frequency to which the called station normally responds, and to tune the receiving system of the calling station to the carrier wave frequency that the called station normally transmits. For ex-

ample, the carrier wave length that four radio stations may normally be tuned to transmit and receive may be as follows:

Radio station	Transmitting wave	Receiving wave
	Meters	Meters
S-1.....	100	150
S-2.....	225	275
S-3.....	350	425
S-4.....	475	575

Thus, for instance, in the above arrangement, if radio station S-1 is calling radio station S-3, station S-1 operates its switches to tune its transmitting system to a wave length of 425, which is the wave length to which the receiving system of station S-3 normally responds; and to tune the receiving system of station S-1 to a wave length of 350, which is the wave length that station S-3 normally transmits. If radio station S-3 were the calling station and station S-1 were the called station, then station S-3 would adjust its transmitting system to the wave length 150 to which the receiving system of station S-1 normally responds, and its receiving system to the wave length 100 which station S-1 normally transmits. In like manner any radio station in calling any other radio station operates its station-selecting switch 20 to change the tuning of its transmitting and receiving systems from their normal wave lengths to the wave lengths of the receiving and transmitting systems respectively of the called station. The switch 20 thus in effect selects the trunk branch communicating with the called station. The carrier wave lengths referred to in the above table are merely typical, as any desired combination of noninterfering wave lengths may be employed and noninterfering communication between as many radio stations may be effected as there are such combinations of wave lengths to which the radio stations may be made selectively responsive.

The tuning of the transmitting system of each station is controlled through the medium of conductors 81, 82, 83 and 84, and the tuning of the receiving system of each station is controlled through the medium of conductors 91, 92, 93 and 94. At each of the radio stations the particular conductors of these two groups that control the tuning of that station to its normal transmitting and receiving wave lengths are not extended to the corresponding contact points of the wipers 21 and 22 of the associated station-selecting switch 20, but instead are extended to other contacts of the switching apparatus that are closed when the associated station is receiving a call from some other station. Thus, in the case of station S-1 the conductor 91 of the receiving system tuning group is not extended to the first

contact point of the wiper 22 of the station-selecting switch, but is normally closed through the medium of contact 27 of the station-selecting switch and a back contact of the relay 12, so that normally the receiving system is tuned to the frequency to which the radio station S—1 is adapted to respond. Likewise the conductor 81 of the transmitting system tuning group is not connected with the first contact of the wiper 21 of the station selecting switch, but is extended to a front contact of relay 62, which, as will hereinafter be explained, is energized to close its contacts when the station S—1 is called by some other radio station. In like manner at station S—2 the tuning conductors 82 and 92 are disconnected from the station-selecting switch and have normal connections as described above, at station S—3 the tuning conductors 83 and 93 are disconnected from the contacts of the station-selecting switch and have normal connections as described above, and at station S—4 the tuning conductors 84 and 94 are disconnected from the station-selecting switch and have normal connections as described above.

As has been stated, each carrier wave in the embodiment of the system disclosed carries two intermediate radio frequencies, one of which is modulated to carry the speech frequencies and the other of which is modulated or controlled to carry the signalling and controlling impulses. These intermediate frequencies may have any desired value above audio-frequency and below the carrier wave frequency range. For example, the talking intermediate frequency may be 20,000 and the signalling intermediate frequency may be 50,000. The talking and signalling intermediate frequencies may be the same for all of the carrier waves employed, as the non-interference between simultaneously communicating pairs of radio stations is effected by the different carrier wave lengths that are employed.

Each of the radio trunks has associated with it a receiving register switch 100 and a transmitting register switch 150, employed when the associated radio station is calling another radio station; and a receiving register switch 200 and transmitting register switch 250, employed when the associated radio station is being called by some other radio station. In the present instance these receiving and transmitting register switches are each made up of as many single motion step-by-step switches as there are groups of impulses in the impulse train, or digits in the number that is being called, together with certain controlling relays. Such step-by-step switches are well known in the art, and need not be particularly described. The movement of the switch wipers of each of these step-by-step switches is effected by

means of an associated stepping magnet which is first operated to advance the wiper to the desired one of its associated contact points; and the return of the switch to normal is brought about by further energizations of the stepping magnet which cause the wiper to continue its movement over the row of contact points until it again rests on its normal contact point. This same type of switch is used for the station selecting switch 20 associated with the trunk circuit, and also for the auxiliary switches 190 and 195 associated with the transmitting register switch 150. The associated circuits of these various switches may be controlled in a series of off-normal contacts operated by cams on the same shafts that carry the wipers of the switches.

Associated with the trunk in the form herein disclosed, are also a number of plunger relays, as 68, 70, 72, 141 and 142, which are employed to introduce relatively large time intervals into the operation of certain parts of the organization. As indicated, the plungers of these relays are retarded in their inward movement and are permitted to move freely on their return movement. They may be of the type disclosed in the United States Patent No. 1,337,680, granted April 20, 1920, to Williams et al.

Briefly stated the operation of the particular embodiment of the system here disclosed is as follows: When a subscriber wishes connection with another subscriber whose station must be reached through a radio trunk, the taking of his telephone receiver from its hook causes his line switch to extend the circuit of his line to a selector switch; and this switch is operated in response to the first transmitted group of impulses to bring its switch wipers into engagement with the terminals of the first of the radio trunks. If the first radio trunk is in use, either in establishing an outgoing connection to some other radio station or in establishing an incoming connection from such a station, there is a busy test potential on the terminals of the trunk, and the selector switch is prevented from making connection with this trunk, and proceeds to the next radio trunk. If the trunk is not in use, the selector switch establishes connection with the trunk terminals. The second group of impulses from the calling subscriber's station causes the operation of the radio station selector switch associated with the selected radio trunk to connect with a certain one of the sets of associated terminals, depending upon the number of impulses in the second group sent from the calling subscriber's line. The cessation of this second or station-selecting group of impulses energizes the selected set of switch terminals and effects a characteristic tuning of the high frequency oscillator, the power amplifier, and the transmitting

antenna of the transmitting system of the radio trunk, this tuning being such as to cause the radio frequency carrier wave applied to the transmitting system to be of the frequency to which the receiving antenna of the called radio station is normally tuned. The receiving antenna of the calling radio trunk is also, by the same operation, tuned to respond to the carrier wave that the called radio station is normally adapted to apply to its transmitting antenna.

As soon as the receiving antenna of the calling radio trunk has been brought into tune with the transmitting antenna of the called radio trunk or station, the calling trunk is in condition to respond to the normal carrier wave of the called trunk. If the called trunk has been called by some other radio trunk, the transmitting antenna of the called trunk is active and is sending out its normal or characteristic carrier wave with an intermediate signaling frequency impressed upon it. Therefore, under these circumstances, the receiving system of the calling radio trunk responds to the carrier wave and intermediate signaling frequency of the called trunk and operates apparatus that applies a busy tone to the calling subscriber's line and prevents that line from becoming extended to the called radio trunk. But if the called radio trunk is not at the time receiving a call from some other radio trunk, this busy tone is not applied; and an instant later apparatus made operative a predetermined time interval after the cessation of the second or radio station selecting group of impulses, applies the selected carrier wave with its talking and signaling intermediate frequencies; and the called radio trunk, responding to the signaling intermediate frequency, applies its own normal carrier wave with the superposed intermediate signaling frequency to its transmitting antenna system, thus making itself unavailable to any other calling radio trunk, and also rendering itself busy to calling ones of its associated lines. At the same time, the called radio trunk, in response to the intermediate signaling frequency applied by the calling trunk, extends its circuit to a selector switch for presently completing connection with the local called line.

Following the second group of impulses, the subsequent impulse groups are applied to the line as were the former groups of impulses by means of the dial at the calling subscriber's station; and each of these groups produces a corresponding displacement of a corresponding member of a receiving register switch associated with the calling radio trunk. At the end of the last group of impulses the radio trunk operates apparatus to extend the talking conductors of the trunk to the radio transmitting system of the trunk, and also to start the send-

ing, under the control of a transmitting register switch, of switch controlling radio impulses in accordance with the setting of the receiving register switch of the calling trunk.

But this operation is made dependent upon another busy test that is completed by the calling trunk in the interval between the cessation of the second group of received impulses and the end of the last group of received impulses. This busy test is made to determine whether or not the called radio trunk is in use as the calling station of some other radio connection. If the called radio trunk is thus busy, it follows that its radio station selecting switch has been moved to bring the radio transmitting and receiving system of the called trunk into tune with the radio trunk that it is calling, and that consequently the receiving antenna of the called radio trunk does not have its normal tuning, and thus is not responsive to the trunk that is now calling it. Therefore, when at the termination of the second group of impulses the carrier wave frequency corresponding to the receiving antenna frequency of the called trunk is applied to the transmitting antenna of the calling trunk, the called trunk does not respond to the superposed intermediate signaling frequency of the carrier wave, and does not send out over its transmitting antenna the carrier wave to which the receiving antenna of the calling trunk is now tuned. The result of this failure to receive a response from the called radio trunk is that at the end of the last group of impulses the calling radio trunk brings about the application of busy tone to the calling subscriber's line and prevents the extension of the line to the called trunk. But if during this interval the called trunk is in its normal condition, and responds to its normal frequency as applied by the calling trunk, then the called trunk sends out a return signal that is effective, at the end of the last group of impulses, to bring about the closure of a circuit that starts the transmission of the switch selecting impulses from the calling radio station and closes the talking conductors at that station.

The transmission of the switch selecting radio impulses from the calling to the called radio station is effected by successively withdrawing the signalling intermediate frequency from and applying it to the carrier wave at the calling station. The radio impulses are controlled by the transmitting register switch at the calling radio station under the control of the associated receiving register switch, the apparatus operating to transmit the radio impulses at a rate slower than that at which the impulses are received from the calling subscriber's station; and the apparatus also operating to separate the groups of radio impulses by "change-over"

intervals. At the called radio station the received radio impulses produce a corresponding setting of the switch elements of a receiving register switch; and when the reception of the radio impulses is complete, an associated transmitting register switch at the called station operates to send to the associated line selecting switches, groups of impulses corresponding to and determined by the setting of the receiving register switch at the called radio station. The transmitting register switch at the called radio station and its associated apparatus operate to send operating impulses to the line selecting switches at the normal calling rate, a rate faster than that at which the radio impulses are received from the calling radio station.

These registers, if desired, could be made to transmit the radio impulses at the normal calling rate but it is preferred to send them more slowly than switch-controlling impulses as normally transmitted over wire lines. One reason for this is to insure a more positive action of the radio-receiving apparatus and to avoid the effects of static disturbances. For this purpose the relay that is actuated by the radio-controlling impulses is preferably made slow-to-respond in any well-known manner, so that a more or less sustained current is necessary to effect its complete operation. The sending registers are then set to send sufficiently long radio impulses to insure the energization of the receiving relay, but a static impulse being of irregular frequency and of comparatively short duration will not ordinarily be sufficiently sustained to cause a false operation of the relay. In case the high frequency waves are transmitted over line wires as in the carrier wire systems, this precaution is not so necessary and the sending registers may, therefore, be set to transmit the high frequency control impulses at a greater rate of speed.

These impulses act to build up the connection through the line selecting switches to the called subscriber's line in the usual way. The dis-establishment of the connection is under the control of the calling subscriber at the calling radio station. When the calling subscriber hangs up his telephone receiver, the circuits at the calling radio station controlled by the subscriber's switch hook are released and the various switches are returned to normal. The return of the switches to normal withdraws the local busy test from the calling radio trunk, re-establishes the normal tuning of the receiving system of the trunk, and interrupts the carrier wave with its applied intermediate talking and signalling frequencies. The cessation of the received carrier wave and its signalling intermediate frequency at the called radio station releases the radio trunk at that

station and restores the associated relays and switches to normal, thus again rendering the trunk available for transmitting a local originated call or receiving a call from a distant radio station.

Specifically, the operation of the system is as follows: When the calling subscriber, who may be assumed to be the subscriber at station A or B, takes his telephone from its hook, the resultant operation of the associated line switch 5 connects the circuit of the calling line with an idle trunk extending to a first selector switch 6. The means for effecting this operation are well known in the art, and need not be described in detail. The calling subscriber then proceeds to operate his dial 4 to produce the groups of impulses that control the operation of the automatic selecting switches. For the purpose of illustration, it may be assumed that the terminals of the associated radio trunks are located in the first contact level of the first selector switch 6, the terminals of the other levels being connected with trunks extending to second selector switches in the same or other automatic exchanges, in the usual manner. Upon the above assumption, the calling subscriber, in order to gain access to the terminals of a radio trunk, operates his calling dial so as to produce one impulse of current, as a result of which the wipers of the first selector switch 6 are brought in a well-understood way into engagement with the terminals of an idle radio trunk. When the calling line thus seizes the radio trunk, a circuit is closed through the station apparatus and over the conductors of the calling line that brings about the energization of the line relay 11. Relay 11 in operating closes a circuit that extends from battery through the winding of slow-release relay 12, front contact and armature of relay 11, and right-hand back contact and armature of relay 42 to ground. Relay 12 in operating opens at its outer right-hand armature and back contact the normal energizing circuit of the relay 154 of the associated receiving antenna system, which extends by way of conductor 91 and normally closed contact 27 of the station selecting switch 20. It is the normal closure of this circuit that maintains the normal tuning of the receiving antenna R-1; therefore the opening of the circuit upon the response of relay 12 immediately changes the tuning of the receiving antenna and makes the associated station unavailable for receiving calls from other radio stations.

At its left-hand armature and front contact relay 12 in operating closes a circuit that applies ground to the test terminal of the radio trunk upon the first selector switch 6, thus making the trunk test busy to other calling local stations. This same ground is applied by way of inner left-hand armature

and back contact of relay 42 and inner left-hand armature and back contact of relay 41 to the winding of relay 40. Relay 40 in operating produces a busy test condition upon the test terminals of the trunk jack 55 of the radio trunk. Relay 12 in operating also at its inner right-hand armature and front contact partially prepares a path for the transmission of stepping impulses to the stepping magnet 28 of the station selecting switch 20.

Upon the production of the second group of impulses by the operation of the dial 4 at the calling station, the interruptions of the line circuit cause an intermittent retraction and attraction of the armature of line relay 11. This serves to open and close the energizing circuit of the associated relay 12. But as that relay is of a slow releasing type, it maintains its armatures attracted during the intermittent operation of relay 11. The first retraction of the armature of relay 11 closes a circuit that extends from battery through the winding of stepping magnet 28 of the station selecting switch 20, winding of slow release relay 29, normally closed contact 24 of switch 20, inner right-hand armature and front contact of relay 12, back contact and armature of relay 11, and right-hand back contact and armature of relay 42 to ground. This causes the station selecting switch 20 to take one step, thus opening the normally closed contact 24; but the operation of relay 29 has closed a locking path for itself at its right-hand front contact and armature, in shunt of the path by way of the contacts 24 of switch 20, so that relay 29 maintains an energizing path for itself and stepping magnet 28. Subsequent retractions and attractions of the armature of relay 11 alternately open and close the energizing path through the windings of stepping magnet 28 and relay 29 in series. Stepping magnet 28 is therefore intermittently operated to cause the advance of the wipers of switch 20; but relay 29, being slow to release, maintains its front contacts closed until, at the end of the group of impulses, the relatively long attraction of the armature of relay 11 opens the energizing circuit of relay 29 long enough to permit it to release. When the relay 29 releases it extends the stepping circuit controlled at back contact and armature of relay 11 and front contact of relay 12, to the operating mechanism of the receiving register switch 100 by way of right-hand armature and back contact of relay 29 and contact 25 of station switch 20 to control the operation of the receiving register, as will subsequently be described; and also, at its left-hand back contact and armature, applies ground from the outer right-hand armature and front contact of relay 12 to the wipers 21 and 22 of the station selecting switch 20. The grounding of wipers 21 and 22 of the

switch 20 closes a path for the operation of the set of tuning relays that controls the tuning of this radio trunk or station to the radio trunk or station that is being called.

In the present instance, it is assumed that it is the radio station S—3 with which the radio station S—1 associated with the calling line is to be operatively related. This being the case, the wipers 21 and 22 of station selecting switch 20 are resting on their third contact points, that is, they have taken three steps and consequently the ground controlled by these wipers is applied to the tuning relays 116, 126 and 136 of the transmitting antenna system, and to the relay 156 of the receiving antenna system. The relays 116, 126 and 136 close tuning branches of the high frequency oscillator 101, of the power amplifier 105 and of the transmitting antenna T—1 which give the radio transmitting circuit such characteristics that the carrier wave that it produces and transmits has a frequency corresponding to the frequency to which the receiving antenna R—3 of radio station S—3 is normally tuned to respond. The operation of relay 156 closes a branch which tunes the receiving antenna R—1 to respond to the frequency of carrier wave that the called radio station S—3 normally transmits. Therefore, as a result of the movement of wipers 21 and 22 of selecting switch 20 to their third contact position, due to the impulses relayed from the calling subscriber's dial, the transmitting antenna T—1 and the receiving antenna R—1 of the associated radio station S—1 are tuned respectively to the receiving antenna R—3 and the transmitting antenna T—3 of the called radio station S—3.

As soon as the receiving antenna R—1 of station S—1 is brought into tune with the transmitting antenna T—3 of station S—3, if the called station S—3 is busy as a result of being in communication with some other station that has called it, the transmitting antenna T—3 of station S—3 will be energized and sending out the normal carrier wave of station S—3 upon which is superposed an intermediate signaling frequency. The way in which this comes about will be described hereinafter. To this carrier wave from the called radio station S—3, with its superposed intermediate signaling frequency, the receiving antenna system of the calling radio station S—1 is now responsive; and as a result the carrier wave from the called station brings about the energization of relay 99, in a manner hereinafter described. The operation of relay 99 closes a circuit that extends from battery through the winding of busy tone relay 31 (see Fig. 1), outer left-hand back contact and armature of relay 35, front contact and armature of relay 60, conductor 80, and armature and front contact of relay 99 of the receiving

antenna system to ground. It should be noted at this point that the relay 60 was operated immediately upon the seizure of the radio trunk by the calling line, over a circuit extending from battery through the winding of relay 60, inner right-hand back contact and armature of relay 30, and outer right-hand front contact and armature of relay 12 to ground. As a result of the closure of the energizing circuit of busy tone relay 31, relay 31 disconnects the talking conductors 46 and 47 of the radio trunk from their normal extensions to the radio transmitting system of the trunk, and connects them with a source of busy tone current 44, as a result of which busy tone is applied to the calling subscriber's line, thus notifying the calling subscriber that the radio station with which the called line is associated, is busy. Relay 31 in operating also, at its left-hand front contact and armature, closes a locking circuit for itself that extends by way of the outer right-hand back contact and armature of relay 30, and outer right-hand front contact and armature of relay 12 to ground. This insures the maintained energization of relay 31 and the continued application of busy tone current until the calling subscriber hangs up and releases relay 12.

The interval during which the busy tone relay 31 may be energized by the response of relay 99 to the carrier wave and signaling frequency of the busy called radio station is but of brief duration. This interval commences at the instant the receiving antenna system of the calling radio station is brought into tune with the transmitting system of the called radio station upon the energization of the tuning relays by the release of relay 29, and the breaking of the energizing circuit of busy tone relay 31 at outer left-hand back contact and armature of relay 35 by the operation of that relay upon the release of relay 29. The operation of relay 35, however, is retarded by the interposition of certain slow relays between the contacts of relay 29 and the energizing circuit of relay 35. When relay 29 first operates, at the beginning of the station selecting group of impulses, it closes a circuit which extends from battery through the winding of relay 32, left-hand front contact and armature of relay 29 and outer right-hand front contact and armature of relay 12 to ground. Relay 32 in operating operates relay 33; and that relay in operating closes a circuit for energizing relay 34 by way of the front contact and armature of relay 33, left-hand back contact and armature of relay 31, outer right-hand back contact and armature of relay 30, and outer right-hand front contact and armature of relay 12 to ground. Relay 34 in operating closes one break in the energizing circuit of relay 35. But there is another break in this energizing circuit that is not closed until relay 33 releases. At the end of the station selecting group of impulses, the release of relay 29 (which instantly brings the receiving system of the calling radio station S-1 into tune with the transmitting system of the called station S-3, as has been described), breaks the energizing circuit of relay 32. That relay releases slowly and breaks the energizing circuit of relay 33. That relay in turn releases slowly and closes at its back contact the second break in the energizing circuit of relay 35 before the first break in that energizing circuit is opened by the slow release of relay 34. Therefore, the operation of relay 35, which opens at its outer left-hand armature and contact the energizing path to the busy tone relay 31, lags for a predetermined interval behind the tuning of the calling radio station to the called radio station; and in this interval the operation of the busy tone relay 31 by the response of the relay 99 may take place in case the called radio station is busy.

When the relay 35 operates a moment after the termination of the second group of impulses, it not only closes a locking path for itself by way of its inner left-hand front contact and armature, but also closes a circuit that extends from battery through the winding relay 89 (Fig. 3), conductor 90, closed contacts 26 of switch 20, outer right-hand armature and front contact of relay 35, left-hand back contact and armature of relay 29, and outer right-hand front contact and armature of relay 12 to ground. The operation of relay 89 closes the main leads over which current is supplied from the source of filament current 95 and the source of plate current 96 to the radio transmitting apparatus. Relay 35 in operating also closes a circuit that extends from battery through the winding of relay 98 (see Fig. 3), conductor 85, right-hand front contact and armature of relay 35, and back contact and armature of relay 39 to ground. Relay 98 in operating as a result of the closure of this circuit, completes the path for the application of the plate current to the signaling intermediate frequency oscillator 145. This causes the oscillator 145 to generate currents of an intermediate frequency and to apply them to the circuit of the modulator 102 where they are superposed upon the currents that are being generated by the high frequency carrier wave oscillator 101, and the resultant or component current is passed through the intermediate train of apparatus to the transmitting antenna T-1, from which the wave is transmitted to the receiving antennae of the various other radio stations.

As the carrier wave component of the

modulated wave that is being transmitted is of the frequency for which the receiving antenna of the called station S—3 is normally tuned, and as the receiving antennae of the other radio stations are not normally tuned to this frequency, the receiving system of radio station S—3 is the only one the detector 147 of which responds. The current in the output circuit of the detector 147 passes to the frequency filters 148 and 149, the signaling frequency component passing through the series of detecting, amplifying and rectifying devices, as has already been described, and causing the operation of the associated relay 99. This relay, in operating, closes a circuit that extends from battery through the winding of relay 61 (reference now being had to the apparatus at the called radio station S—3), back contact and armature of relay 60, conductor 80, and armature and front contact of relay 99 to ground. Relay 61 in operating closes at its right-hand front contact and armature an energizing circuit for relay 62, and relay 62 in operating closes a locking circuit for itself by way of its inner right-hand front contact and armature and the inner normally closed contacts of the plunger relay 68.

When relay 62 operates it energizes devices to tune the transmitting system of the called radio station S—3 to its normal carrier wave frequency, to close the main leads for supplying filament and plate current to the radio transmitting devices of the called station and to close the circuit for applying the intermediate signaling frequency to the called station carrier wave. This is accomplished as follows: The operation of relay 62 applies ground to the conductor 83 for the energization of tuning relays 116, 126 and 136 that are associated respectively with the output circuit of the high frequency oscillator 101, the input circuit 104 of the power amplifier 105, and with the circuit of the transmitting antenna T—3 of the called station S—3. These relays in operating close the particular branches of the associated tuning circuits that adapt the radio transmitting apparatus to the production and transmission of a carrier wave having the frequency which is normal to this particular station S—3. In its operation relay 62 also closes at its outer left-hand armature and front contact the energizing circuit of relay 63; and relay 63 in operating closes a circuit that extends from battery through the winding of relay 89 (see Fig. 6), conductor 90, and inner right-hand front contact and armature of relay 63 to ground. This operates relay 89, which in operating closes the current supply leads from the source 95 of filament current and the source 96 of plate current and causes the production and transmission of the normal carrier wave with its superposed talking intermediate frequency. Relay 63 in operating also closes a circuit that extends from battery through the winding of relay 98 associated with the signaling intermediate frequency oscillator 145 of station S—3, conductor 85, outer left-hand armature and front contact of relay 63, back contact and armature of relay 39 to ground. Relay 98 in operating completes the circuit for the application of plate current to the associated signaling intermediate frequency oscillator 145, thus causing the signaling intermediate frequency to be superposed upon the carrier wave.

Relay 63 of station S—3 when it operates as a result of the receipt of the signal from the calling radio station, also closes a circuit that extends from battery through the winding of relay 64, outer right-hand front contact and armature of relay 63 and right-hand back contact and armature of relay 66 to ground. Relay 64 in operating closes a circuit that extends through the winding of relay 14 associated with the line switch 16 of the called station radio trunk (see Fig. 7), inner back contact and armature of relay 13, retardation coil 43, armature and front contact of relay 64, left-hand back contact and armature of relay 40, outer left-hand back contact and armature of relay 41, and outer back contact and armature of relay 13 to ground. Relay 14 in operating energizes the associated relay 13 by way of its left-hand winding, and relay 13 operates the plunger (not shown) which extends the conductors of the radio trunk by way of the line switch 16 to a preselected trunk extending to a first selector switch. When relay 13 operates the line switch 16 it closes a circuit that extends from battery through its right-hand winding, right-hand back contact and armature of relay 41, inner right-hand back contact and armature of relay 40, and the test terminal and corresponding contact of the line switch 16 to ground by way of the test conductor of the trunk to the first selector. Closure of this circuit maintains relay 13 energized. Relay 13 in operating disconnects relay 14 from the talking conductor 49 of the radio trunk, disconnects ground from conductor 48 of the trunk, and applies ground by way of outer left-hand armature and front contact of relay 13 for the energization of relay 42. Relay 42 in operating applies battery by way of the outer left-hand front contact and armature of relay 42 and outer right-hand back contact and armature of relay 40 to the test terminal of trunk spring jack 55 to make the trunk test busy at this point. Relay 42 also, at its inner left-hand front contact and armature, applies ground to the test terminal of the radio trunk at the first selector

switch 6 to make the radio trunk test busy at this point. It also, at its right-hand armature and front contact closes a circuit for energizing relay 30. Relay 30 in operating disconnects the trunk talking conductors 46 and 47 from the branches 56, 57, and 58, 59, over which the local calls have access to the radio trunk, and connects the talking conductors 46 and 47 with the conductors 48 and 49 over which the incoming calls from distant radio stations are extended through to the local lines associated with the trunk. Relay 30 also at its left-hand armatures and their resting contacts disconnects the ground controlled at the front contact of relay 12 from conductors extending to various relays that are involved in the operation of the trunk on connection with calls incoming from local lines,—including the conductor extending to relay 60, which is thus rendered incapable of shifting the connection of the conductor 80, controlled by relay 99 of the receiving antenna system, from the winding of relay 61 which controls the call-receiving operation of the radio trunk.

Another function performed by the relay 63 of the called radio station upon the receipt of the radio signal from the calling station is that of completing the connection of the talking conductors 46 and 47 of the associated trunk with the radio transmitting and receiving apparatus of the trunk. This it does by closing the circuit that extends from battery through the winding of relay 36 (see Fig. 7) and inner left-hand armature and front contact of relay 63 to ground. Relay 36 in operating completes the connection of the talking conductors 46 and 47 with the two-way repeating coil 87, and through it to the radio transmitting and receiving apparatus of the trunk.

From the foregoing, it may be seen that the result of the application of the signaling intermediate frequency to the carrier wave of the calling radio station at the end of the second group of impulses at the calling station, is to cause the called station to send out its normal frequency carrier wave upon which is superposed the talking and signaling intermediate frequencies; and to cause the radio trunk of the called station to close its talking circuit, disconnect the talking circuit from the branches over which local calls may be received and extend the trunk to a first selector trunk, and make the local branches of the radio trunk test busy.

Returning now to the operations that are taking place in the circuit of the calling radio trunk, the end of the second or station selecting group of impulses brings about the release of relay 29, so that at the retraction of the armature of relay 11 at the beginning of the next group of impulses, a circuit is

closed that extends from battery through the winding of stepping magnet 118 of the first switch of receiving register 100 (see Fig. 2), winding of associated relay 119, normally closed switch contact 111, conductor 166, contact 25, now closed, of the station selecting switch 20, right-hand back contact and armature of relay 29, inner right-hand front contact and armature of relay 12, back contact and armature of relay 11, and right-hand back contact and armature of relay 42, to ground. The first impulse opens register switch contact 111; but in the meanwhile relay 119 is operated to close an alternate path by way of its left-hand front contact and armature, so that subsequent impulses produced by the operation of the relay 11 pass to the stepping magnet 118 over this path. Relay 119 is so constructed as to be slow to release, as a result of which it maintains the circuit of itself and the stepping magnet 118 closed as long as the impulses are passing, and opens it when relay 11 becomes continuously energized at the end of the group of impulses. For each of the impulses that pass through the stepping magnet 118, the associated switch wiper 110 moves forward one step, and at the end of the impulses is left resting upon an associated contact corresponding in number to the number of impulses in the group sent by the calling subscriber's station.

When the relay 119 is released at the termination of this group of impulses it extends the stepping circuit controlled by relay 11 to the next switch of the receiving register 100, so that when relay 11 next releases at the first impulse of the succeeding group, it closes a circuit that extends from battery through the winding of relay 128, winding of relay 129, normally closed contact 121 of the second switch, contact 112, now closed, of the first switch, left-hand back contact and armature of relay 119, and thence over the path already traced by way of contact 25 of the station selecting switch and contacts of relays 29, 12, 11 and 42 to ground. The operation of the apparatus of the second switch is exactly like that of the first register switch and need not be described in detail. As a result of this operation, the second switch advances its wiper 120 to a contact corresponding in number to the number of impulses in the particular group that is being received. At the conclusion of the impulses in this group, the relay 129 of the second switch releases and extends the stepping circuit by way of contact 122, now closed, of the second switch to the operating magnet of the third receiving register switch. The stepping circuit that is closed upon the release of relay 11 at the start of the next and last group of impulses, extends from battery through the windings of

stepping magnet 138 and relay 139, and normally closed contact 131 of the third switch, contact 122, now closed, and left-hand back contact and armature of relay 129 of the second switch, contact 112 now closed, and left-hand back contact and armature of relay 119 of the first switch, and thence to ground, over the path already traced through the back contact and armature of relay 11. The operation of the third switch of the receiving register is also like that of the first switch, as already described; and at the end of the group of impulses the wiper 130 of the third switch is left resting upon a contact corresponding in number to the number of impulses in the last group.

When relay 139 releases at the end of the last group of impulses, it closes a circuit that extends from battery through the winding of relay 37 (see Fig. 1), outer right-hand armature and back contact of relay 139, and contacts 132, now closed, of the third switch to ground. The operation of relay 37 is adapted to effect the control of two paths, one of which is for operating the busy tone relay 31, and the other of which is for starting the sending of radio impulses in accordance with the setting of the receiving register switch, and also for completing the talking circuit of the trunk to the telephonic radio transmitting and receiving apparatus. The closure of the path that operates the busy tone relay 31 is subject to the control of relay 38; and that relay is arranged to respond to the return signal transmitted from the called radio station if that station is not in use, and, in responding, to prevent the operation of the busy tone relay 31 and permit the sending of the impulses and the closing of the telephonic radio circuit at the calling station. The manner in which this is accomplished is as follows: When the called radio station S—3 responds to the transmitted signaling intermediate frequency and sends out its own return signal, as has previously been described, that signal operates through the receiving antenna system of the calling radio station S—1 to cause the operation of the associated relay 99 (see Fig. 4). Relay 99, in responding, closes a circuit that extends from battery through the winding of relay 38 (see Fig. 1), outer back contact and armature of relay 37, outer front contact and armature of relay 35 (that relay having been energized, as previously described, at the end of the station selecting group of impulses), front contact of relay 60, conductor 80, and armature and front contact of relay 99 to ground. Therefore, if the called radio station S—3 is in its normal condition and sends out a return signal in response to the signal from the calling station, the relay 38 is operated, and in operating locks up over a circuit by way of its

left-front contact and armature, outer right-hand back contact and armature of relay 30, and outer right-hand front contact and armature of relay 12 to ground. When relay 37 is operated at the conclusion of the series of impulse groups from the calling subscriber's station, as has been described, it is prevented by the operation of relay 38 from closing at its inner front contact and armature a path for the energization of the busy tone relay 31, as the path is opened at the right-hand back contact and armature of the operated relay 38.

But if the called radio station is itself a calling station and is engaged in communicating with some other radio station at the time calling radio station S—1 sends its signal, then the called station S—3 has its receiving antenna system tuned to the frequency of the radio station with which it at the time is communicating and not to its own normal frequency. Therefore, it does not respond to the calling signal from the calling station S—1, and does not send out the return radio signal that brings about the response of relay 99, and the energization of relay 38 at the calling station. As a result, when relay 37 operates at the end of the series of groups of impulses from the calling subscriber's station, it closes by way of its inner front contact and armature, and right-hand back contact and armature of relay 38, now inert, a circuit for the energization of the busy tone relay 31, which relay then operates to apply the busy tone to the calling subscriber's line and to open the locking circuit of relay 35.

Assuming that the called station S—3 is found in an available condition, then the operation of relay 37 at the end of the train of impulse groups closes a circuit that extends from battery through the winding of relay 143 (see Fig. 2), outer resting contact of plunger relay 141, outer resting contact of plunger relay 142, outer right-hand back contact and armature of relay 189, outer front contact and armature of relay 37, outer front contact and armature of relay 35, front contact and armature of relay 60, conductor 80, and armature and front contact of relay 99 to ground. The closure of this circuit starts the operation of the plunger relays 141 and 142, and the associated relays 143 and 144, which together form a group for producing a slow succession of impulses for operating the transmitting register 150, and sending out over the radio transmitting system of the calling station S—1 groups of impulses corresponding to the groups of impulses recorded on the receiving register 100. When relay 143 operates as a result of the closure of the above-described energizing path, it closes a locking circuit for itself by way of its left-hand front contact and armature and outer resting contact of the plunger

relay 142 to the circuit that has caused the initial energization of relay 143. Relay 143 in operating also closes the energizing circuit of the plunger relay 141, which thereupon slowly draws in its plunger and, after a predetermined time interval, effects the closure of the inner contacts of relay 141. When this occurs a circuit is closed that extends from battery through the winding of relay 144 and the inner contacts of plunger relay 141 to ground at the end of the previously-traced energizing path of the impulse producing devices 140. Relay 144 in operating closes the energizing circuit of the associated plunger relay 142, and that relay at the outset of the inward movement of its plunger opens its outer contacts included in the locking circuit of relay 143, and at the same time closes at these contacts a locking circuit for relay 144 by way of the left-hand front contact and armature of relay 144 and the previously-traced energizing path to ground. When the locking circuit of relay 143 is opened, that relay releases and thus deenergizes the plunger relay 141. That relay thereupon permits its plunger to move outwardly and to close its outer contacts at the end of its movement. This has the effect of closing at one point the energizing path for the winding of relay 143, the other point being closed when plunger relay 142, after opening the locking circuit of relay 144 at the limit of the inward movement of the plunger, is deenergized by the retraction of the armatures of relay 144, and permits the return of its plunger and the closure of the associated outer contacts at the end of the outward movement of the plunger. This restores the original condition of the relays 141, 142, 143 and 144, whereupon the process is repeated, and continues as long as the energizing circuit for the group 140 remains closed at the outer right-hand back contact and armature of relay 189.

The effect of the intermittent operation of relay 143 under the control of the slow-acting plunger relays 141 and 142, is to intermittently apply ground to and withdraw it from the conducting paths extending from the middle and outer right-hand front contact of the relay 143, this ground being supplied over the initial energizing path by way of the outer right-hand armature of relay 189. When relay 143 operates it closes a circuit that extends from battery through the winding of stepping magnet 168 of the first switch of the transmitting register 150, outer back contact and armature of relay 169, and middle right-hand front contact and armature of relay 143 to ground by way of the impulse group energizing circuit. At the same time a circuit is closed from battery through the winding of relay 39 (see Fig. 1), inner left-hand back contact and armature of relay 189, inner left-hand

back contact and armature of relay 179, inner left-hand back contact and armature of relay 169, and outer right-hand front contact and armature of relay 143 to ground by way of the impulse group energizing circuit. Consequently upon the energization of relay 143 the stepping magnet 168 of the first switch of the transmitting register 150 and relay 39 are both operated. Stepping magnet 168 in operating causes the first switch to advance its wiper 160 one step, and at the same time relay 39 in operating opens the energizing path of the relay 98 (see Fig. 3) that controls the application of plate current to the signaling intermediate frequency oscillator 145. Subsequent steps of the wiper 160 of the first switch of the transmitting register are accompanied in like manner by corresponding intermissions of the signaling intermediate frequency applied to the radio transmitting system of the calling station, each of the slow retractions of the armatures of relay 143 causing the wiper 160 of the transmitting register to advance one step and the transmitting system to send out one signaling impulse in the form of an intermission of the signaling intermediate frequency. This continues until the wiper moves on to the contact corresponding in number to the contact upon which the wiper 110 of the first switch of the receiving register is resting. When this occurs, a circuit is closed that extends from battery through the winding of relay 169, wiper 160 and the contact to which it is now advanced, the corresponding contact to which wiper 110 has been advanced and that wiper, right-hand back contact and armature of relay 119, left-hand back contact and armature of relay 31, outer right-hand back contact and armature of relay 30 and outer right-hand front contact and armature of relay 12 to ground. This energizes relay 169, which locks up over a circuit by way of its right-hand armature and front contact, and thence to ground over the above-traced path by way of left-hand back contact and armature of relay 31. Relay 169 in operating disconnects the middle impulse contact of relay 143 from the winding of the stepping magnet 168, and connects it by way of the outer left-hand armature and front contact of relay 169, and wiper 191 and normal contact of auxiliary switch 190 with the winding of the stepping magnet 194 of that switch. Relay 169 in operating also disconnects the outer impulse contact of relay 143 from the previously-traced path leading to the winding of relay 39, and connects it, at the inner left-hand armature and front contact of relay 169, with wiper 193 of the auxiliary switch 190.

As a result the impulse circuit through the winding of relay 39, which controls the energization of the relay 98 for controlling

the transmission of the signaling radio impulses, is kept open until the auxiliary switch 190 has taken two steps. These steps are taken as a result of the next two energizations and deenergizations of the relay 143, acting through the medium of the stepping magnet 194 of the auxiliary switch. The object of the interposition of this auxiliary switch in the impulse circuit for operating the radio impulse controlling apparatus, is to interpose a certain time interval between the impulses of the succeeding groups, so as to allow certain changes to be effected in the impulse-receiving apparatus at the called radio station S-3, as will hereinafter be described. This time interval may be made of any desired value by increasing or decreasing the number of steps that must be taken by the auxiliary switch 190 before it shifts the circuits that it controls.

In the present instance, as the auxiliary switch 190 completes its second step in response to the operation of the impulse relay 143, it breaks the energizing path of the stepping magnet 194 at the first contact from normal of wiper 191, and extends the path controlled by the middle impulse contact of relay 143 through the winding of stepping magnet 178 of the second switch of the transmitting register, this path being by way of the outer left-hand armature and front contact of relay 169, wiper 191 and its second contact from normal, and outer left-hand armature and back contact of relay 179 associated with the second switch. In moving its wiper 193 to its second contact point from normal, the auxiliary switch 190 closes a circuit from the outer impulse contact of relay 143 by way of inner left-hand armature and front contact of relay 169, wiper 193 and the contact upon which it is resting, inner left-hand armature and back contact of relay 179, and inner left-hand armature and back contact of relay 189, to the relay 39 that controls the energizing circuit for the radio signaling impulse apparatus. Therefore, the succeeding impulses determined by the operation of the slowly-acting relay 143 serve to advance step by step the wiper 170 of the second switch of the transmitting register 150, and at the same time correspondingly to operate the relay 39 to produce intermissions of the application of the signaling intermediate frequency to the radio transmitting system through the agency of relay 98.

The operation of the second switch of the transmitting register and the stopping of the wiper 170 upon the contact point corresponding to the contact point upon which the wiper 120 of the second receiving register switch is resting, are effected in exactly the same manner as has been described in connection with the operation of the first switch of the transmitting register. When this contact point is reached and the relay 179 is op-

erated, the outer impulse contact of relay 143 is disconnected from the relay 39 and the middle impulse contact of relay 143 is extended to the stepping magnet 199 of the auxiliary switch 195 by way of wiper 196 of that switch. The next two impulses delivered by the relay 143 therefore do not cause the operation of the relay 39, but are utilized to advance the wiper of the auxiliary switch 195 and thus interpose a brief pause in the sending of the radio impulses.

When the auxiliary switch 195 has advanced its wipers two steps, the energizing path for the stepping magnet 188 of the third switch of the transmitting register is extended through at the wiper 196 and its second contact point from normal, and the energizing path for the relay 39 is extended through by way of the wiper 198 and its second contact point from normal. Thereafter the impulses controlled by the relay 143 are effective to cause the stepping of the third switch of the transmitting register 150, and to produce a corresponding succession of radio impulses as a result of the operation of the relay 39. When the wiper 180 of the third switch encounters the contact that is connected with the contact terminal upon which the wiper 130 of the associated receiving register switch is resting, relay 189 is energized and locks up by way of its inner right-hand front contact and armature and the connection to the holding ground conductor controlled at the outer right-hand front contact and armature of relay 12. Relay 189 in operating not only opens the energizing circuits of the stepping magnet 188 and impulse-controlling relay 39 to put a stop to the stepping of the third transmitting register switch and the sending of the radio impulses of the corresponding group; but it also opens at its outer right-hand armature and back contact the main path over which up to this moment the circuit has been afforded for the energization of the impulse devices 140. Thus the completion of the operation of the third transmitting register switch stops the radio impulse-sending operation.

We may now consider the effect of the receiving of this train of radio impulses at the called radio station S-3. After the calling radio station S-1 has established operative relation with the called station S-3, the relay 99 of the called station (see Fig. 5) is continuously energized, as a result of the superposed signaling intermediate frequency sent out upon the carrier wave that is being transmitted by the calling radio station. This signaling intermediate frequency is controlled by relay 98 at the calling station; and this relay, as has been described, is under the control of relay 39, being operated to steadily apply the signaling intermediate frequency when relay 39

is inert. At each attraction of the armature of relay 39, therefore, the relay 99 at the called radio station S-3 releases its armature. This causes relay 61, controlled by relay 99 through the medium of conductor 80, to release its armatures. This closes a circuit that extends from battery through the winding of relay 69, outer normally closed contact of plunger relay 68, middle right-hand front contact and armature of relay 62, and right-hand back contact and armature of relay 61 to ground. As a result relay 69 operates and closes a circuit that energizes relay 68 and causes it to start the inward movement of its plunger. The rate of the inward movement of the plunger is so adjusted that it requires for its completion a materially longer time than that which is consumed in the sending of a single impulse of the radio signal. Therefore, before the plunger of relay 68 is able to move far enough to open its inner contacts, and thus release relay 62 (which became locked up at the initial operation of relay 61), relay 61 is again energized at the end of the radio impulse and releases relay 69, which in turn releases relay 68 and permits the immediate return of the plunger to its original condition. Therefore the passage of the radio impulses, and the consequent alternate retractions and attractions of the armatures of relay 61, does not bring about the release of relay 62, this relay remaining steadily energized until the connection between the radio stations is finally released.

As relay 61 retracts and attracts its armatures as a result of the receipt of the signaling impulses, it closes and opens a circuit that extends from battery through the winding of stepping magnet 218 of the first switch of the receiving register 200, left-hand winding of relay 219, resting contact 211 of the first switch (and, after the first impulse, through the left-hand front contact and armature of relay 219), inner left-hand armature and front contact of relay 62, and left-hand back contact and armature of relay 61 to ground. Each impulse of the first group of selecting impulses transmitted, therefore, causes the wiper 210 of the first switch of the receiving register to advance one step; so that at the end of the group of impulses the wiper is left resting on the contact corresponding in number to the number of impulses in the group. During the receipt of the selecting impulses of the first group, the relay 219 is held operated and is released to transfer the stepping circuit controlled by relay 61 to the stepping magnet of the next switch of the receiving register at the end of the group of impulses. This is accomplished as follows: When the relay 219 is energized upon the first retraction of the armatures of relay 61, a circuit is closed for continuing its energization by way of its right-hand winding, inner right-hand front contact and armature, and the inner normally closed contacts of the plunger relay 70 to ground. The operation of relay 219 also prepares a path for the energization of relay 71 that is completed upon the following energization of relay 61. This path extends from battery through the winding of relay 71, outer normally closed contacts of plunger relay 70, outer right-hand front contact and armature of relay 219, and left-hand front contact and armature of relay 61 to ground. Therefore at each energization of relay 61 between impulses transmitted to the stepping magnet 218 of the first switch, relay 71 is energized and closes at its right-hand front contact and armature an energizing circuit for plunger relay 70. This relay thereupon starts the inward movement of its plunger. But the rate of movement is so adjusted that the plunger is unable to move far enough to cause the opening of its inner contacts in the interval between impulses during which relay 61 remains energized. Therefore when relay 61 is again released to cause the first switch of the receiving register 200 to take another step, relay 71 is released by the opening of its energizing circuit at the left-hand front contact and armature of relay 61, and in releasing opens the energizing circuit of plunger relay 70. When this happens, the plunger of relay 70 is immediately restored to its original position.

This intermittent partial movement of the plunger of relay 70 continues as long as the impulses of the group are passing. At their termination the auxiliary switch 190 associated with the first transmitting register switch at the calling radio station acts to interpose a delay before the impulses of the next group are started, as has hereinbefore been described. The interval required for the complete operation of plunger relay 70 is so adjusted as to be shorter than the interval between impulse groups interposed by the auxiliary switch at the calling radio station. Therefore relay 61 at the receiving station at the end of the impulse group maintains its armatures attracted long enough to permit the plunger relay 70 to move its plunger all the way in and open the associated inner contacts at the end of the inward movement. When this occurs, the locking circuit of relay 219 by way of its right-hand winding and inner right-hand front contact and armature is opened at the inner contacts of relay 70, and relay 219 is released. This releases relay 71, which in turn releases relay 70 and permits the return of the plunger to its original position.

When relay 219 releases it extends the stepping control circuit to the stepping magnet of the second switch of the receiving register; so that when the relay 61 is

again released at the start of the second group of impulses a circuit is closed that extends from battery through the winding of stepping magnet 228 of the second switch of the receiving register, left-hand winding of relay 229, resting contact 221 of the associated switch (and after the first step of the switch, by way of left-hand front contact and armature of relay 229), contact 212, now closed, of the first receiving register switch, left-hand back contact and armature of relay 219, inner left-hand front contact and armature of relay 62, and left-hand back contact and armature of relay 61 to ground. The impulses of this group thereupon cause the advance of the wiper 220 of the second switch in the same manner as was described in connection with the operation of the apparatus of the first switch; and the relay 61 also controls the plunger relay 70 through the medium of outer right-hand armature and front contact of relay 229 in the same manner that it controlled relay 70 through the medium of the outer right-hand armature and front contact of relay 219 of the first switch, the relatively long attraction of the armature of relay 61 at the end of the second group of impulses bringing about the full operation of plunger relay 70 to release relay 229 in the same manner as was described in connection with the operation of the first switch.

When the relay 229 of the second switch releases it extends the stepping circuit controlled by relay 61 through to the third switch of the receiving register 200, so that upon the release of relay 61 at the first impulse of the third group, a circuit is closed that extends from battery through the stepping magnet 238 of the third switch, left-hand winding of associated relay 239, resting contacts 231, contacts 222, now closed, of the second switch, left-hand back contact and armature of relay 229, closed contacts 212 of the first switch, left-hand back contact and armature of relay 219, inner left-hand armature and front contact of relay 62, and left-hand back contact and armature of relay 61 to ground. The third group of impulses causes the wiper 230 of the third switch to be advanced to a contact point corresponding in number to the number of impulses in the group, and the termination of this group of impulses operates plunger relay 70 to release relay 239 in the same manner as that heretofore described.

When relay 239 releases at the termination of the third and last group of impulses, it closes a circuit for starting the production of a series of groups of impulses for the operation of the associated transmitting register switch 250, and for the transmitting of corresponding impulses to the selecting switches that serve to complete the con-

nection of the trunk circuit of the called radio station S-3 to the particular local line that is being called. The circuit thus closed extends from battery through the winding of relay 66, back contact and armature of relay 67, conductor 175, outer left-hand back contact and armature of relay 267, closed contact 232 of third receiving register switch, and outer left-hand back contact and armature of relay 239 to ground. When relay 66 operates as a result of the closure of this circuit, it operates relay 67, which releases relay 66, which releases relay 67, and so continues to effect the intermittent operation of these relays as long as the main energizing circuit is closed.

Relay 66 in operating alternately operates relay 64 to make and break the connection of retardation coil 43 across the line conductors of the trunk, and stepping magnet 268 of the first transmitting register switch to cause the advance of wiper 260 of that switch. The circuit for the operation of the first transmitting register switch extends from battery through the winding of stepping magnet 268, inner left-hand back contact and armature of relay 267, right-hand winding of relay 269, normally closed contact 261 of the first transmitting register switch, conductor 176, and right-hand front contact and armature of relay 66 to ground. Relay 269 in operating locks up by way of a path through its right-hand front contact and armature in parallel with the path through the normally closed contact 261; so that the energizing path of the stepping magnet 268 is maintained after the advance of the switch opens contact 261. Relay 269 in operating also locks up by way of its left-hand winding and inner left-hand front contact and armature, and the inner contact of the plunger relay 72. At the same time a circuit is closed at the outer left-hand front contact and armature of relay 269 that is effective upon the release of the impulse relay 66 at the end of the first impulse to energize relay 73, this circuit extending from battery through the winding of relay 73, normally closed outer contact of plunger relay 72, outer left-hand front contact and armature of relay 269, conductor 167, and left-hand back contact and armature of relay 66 to ground. When relay 73 operates, it locks up by way of its left-hand front contact and armature, and at its right-hand front contact and armature it closes the energizing circuit of the plunger relay 72. That relay thereupon starts the inward movement of the plunger. But an instant later relay 66 is energized to produce another impulse of current over the stepping circuit, and in its operation breaks the energizing circuit of the relay 73, thus releasing that relay and deenergizing relay 72 to

release its plunger, which thereupon returns to normal.

As long as relay 66 is operating to produce impulses of current in the stepping circuit, relays 73 and 72 are not permitted to remain energized long enough to complete the inward movement of the plunger of relay 72. The stepping continues until wiper 260 of the first transmitting register switch has been advanced into engagement with the contact corresponding with the complementary contact of the first receiving register switch upon which wiper 210 is resting. When this occurs a circuit is closed that extends from battery through the winding of relay 267, wipers 260 and 210 and the contacts on which they are resting, outer right-hand back contact and armature of relay 219, conductor 172 and left-hand front contact and armature of relay 61 to ground. This operates relay 267, which thereafter remains locked up by way of its right-hand armature and front contact and the outer left-hand front contact and armature of relay 62 to ground. Relay 267 in operation opens, at its inner left-hand back contact and armature, the energizing circuit of the stepping magnet 268; and the same time, at its outer left-hand armature and back contact, opens the energizing path by way of conductor 175 for the interrupting or impulse producing relays 66 and 67. Therefore, the result of wiper 260 engaging the contact identified by wiper 210 of the receiving register switch 250, is to stop the production of the stepping impulses and bring the wiper 260 of the first transmitting register switch to rest.

When the operation of the impulse relays 66 and 67 is stopped, the energizing circuit of relay 73 remains closed steadily at the left-hand back contact and armature of relay 66; and therefore plunger relay 72 remains energized to complete the inward movement of its plunger. The rate of movement of the parts of the plunger relay 72 is so adjusted that the time required for the plunger to complete its inward movement and open its inner contact is equal to the interval normally interposed between successive groups of impulses in the operation of automatic switches. When the plunger opens the associated inner contact at the limit of its inward movement, relay 269 is released, and a circuit is closed that extends from battery through the winding of relay 66, back contact and armature of relay 67, conductor 175, outer left-hand back contact and armature of relay 277 associated with the second transmitting register switch, middle left-hand back contact and armature of relay 269, outer left-hand front contact and armature of relay 267, closed contacts 232 of the third receiving register switch, and outer left-hand back contact and

armature of relay 239 to ground. This causes the impulse relay 66 and 67 again to start their operation, and the intermittent ground applied at the right-hand front contact of relay 66 is effective to cause the operation of stepping magnet 278 of the second transmitting register switch, this circuit extending from battery through the winding of stepping magnet 278, inner left-hand back contact and armature of relay 277, right-hand winding of relay 279, normally closed contact 271 of the second transmitting register switch (and after the first impulse, by way of right-hand front contact and armature of relay 279), contact 262, now closed, of the first transmitting register switch, right-hand back contact and armature of relay 269, conductor 176, and right-hand front contact of relay 66 to ground.

The advance of the second transmitting register switch wiper 270, the stopping of the switch wiper and the deenergizing of the impulse relays 66 and 67 when the wiper reaches the contact identified by wiper 220 of the receiving register switch, and the operation of the plunger relay 72 to interpose the change-over interval and then release the relay 279, are in all respects as have been described in connection with the operation of the first transmitting register switch. When the relay 279 is released at the end of the change-over interval, the impulse relays 66 and 67 are again energized over a circuit that extends by way of conductor 175, outer left-hand back contact and armature of relay 287 of the third transmitting register switch, outer left-hand back contact and armature of relay 279 of the second transmitting register switch, outer left-hand front contact and armature of relay 277 of that switch, intermediate left-hand back contact and armature of relay 269 of the first transmitting register switch, outer left-hand front contact and armature of relay 267 of that switch, closed contact 232 of the third receiving register switch, and outer left-hand back contact and armature of relay 239 to ground. The impulse relays 66 and 67 are thereupon again set into operation, and the intermittent closing and opening of the circuit at the right-hand front contact and armature of relay 66 controls the stepping circuit that is now extended by way of right-hand armature and back contact of relay 279, closed contact 272 of the second transmitting register switch, normally closed contact 281 of the third transmitting register switch, right-hand winding of relay 289, and inner left-hand back contact and armature of relay 287 to stepping magnet 288 of the third transmitting register switch, this circuit after the first step of the switch being maintained at the right-hand front contact and armature of relay 289.

The advance and stopping upon the identified contact of the wiper 280 of the third transmitting register switch is similar to the corresponding operation described in connection with the first and second transmitting register switches. When relay 287 of the third transmitting register switch is operated upon the finding of the identified contact by wiper 280, the energizing circuit for the impulse relays 66 and 67 is broken at the outer left-hand back contact and armature of relay 287, and thereafter the impulse sending operation of the relays 66 and 67 ceases. Relays 267, 277 and 287 of the three transmitting switches are now energized, and are held energized by way of the path to ground over conductor 174 and the outer left-hand front contact and armature of relay 62 as long as that relay remains energized; and wipers 210 and 260, 220 and 270, and 230 and 280, respectively of the receiving and transmitting register switches remain at rest upon the contacts to which they have been advanced. The deenergization of impulse relay 66 also closes steadily the energizing circuit of relay 64, which relay holds the retardation coil 43 bridged across the talking conductors 48 and 49 of the trunk.

It is unnecessary to describe in detail the manner in which the groups of impulses determined by the operation of the transmitting register switch 250 control the automatic switches for building up the connection to the called subscriber's line as this is something that is well understood in the automatic telephone art. Each step taken by the transmitting register switch 250 is accompanied by an interruption of the normally closed circuit by way of the retardation coil bridged across the talking conductors 48 and 49 of the trunk; and each such interruption causes a corresponding step to be taken by one or another of the train of selector and connector switches 17 and 18 that are operatively associated with the trunk circuit at successive stages of the operation; the final step taken by the connector switch completing the extension of the trunk circuit to the called subscriber's line, at which time the connection through these switches either is released if the called line is busy, or ringing current is applied in the ordinary and well-known way if the called line is idle. If the called line is found to be busy, the calling subscriber will be apprised of that fact by the receipt of the usual busy tone transmitted from the usual source at the final connector switch, or elsewhere in the system to which the called line has connection, back over the voice conductors and through the radio link to the talking conductors of the calling subscriber's station. The path over which this busy tone is transmitted is the same as that, heretofore traced, over which the voice is transmitted, and in-

cludes the two modulators associated respectively with the talking intermediate frequency oscillator and with the radio frequency oscillator at the called radio station, and at the calling radio station it includes the two detectors for the radio wave and the talking intermediate frequency wave respectively together with associated amplifiers and the like.

When the called line subscriber at station C or D responds to the ringing of his bell and removes his telephone receiver from its hook, conversation may proceed between the calling station and the called station through the medium of the conductive connections of the stations with the respective radio trunks and the radio connection of these trunks with each other, the voice currents being produced and propagated in the manner described in a preceding portion of this specification.

As long as the calling subscriber's station and called subscriber's station are in communication, the relays 98 of both the calling radio station and the called radio station are energized to cause the application of the signalling intermediate frequency of the corresponding station to the carrier wave that station is transmitting; and the relays 99 of the calling radio station and called radio station, respectively, are held energized as a result of this intermediate signalling frequency component present in the composite wave received from the other radio station.

The disconnection and return to normal of the radio trunks at the calling and called radio stations are under the control of the calling subscriber. When the calling subscriber replaces his telephone receiver on its switch hook, relay 11 is released, and releases relay 12. The release of relay 12 closes, at its left-hand back contact and armature, a circuit for effecting the restoration to normal of the station selecting switch 20 and the various switch elements of the receiving register switch 100 and the transmitting register switch 150. This restoring circuit includes in parallel branches receiving register stepping magnets 118, 128 and 138, with their respective armatures and back contacts and corresponding register switch closed contacts 113, 123 and 133; and also the stepping magnet 28 of the station selecting switch 20 with its armature and back contact and the closed contact 23 of the switch 20. Therefore when the release of relay 12 closes the switch restoring circuit, all of these stepping magnets operate under the control of their own vibratory contacts to step the associated switches on around to normal position, in which position the energizing circuits of the stepping magnets are opened in the associated switch contacts 113, 123, 133 and 23, respectively.

Upon the restoration of the switches of the receiving register 100 to normal, the restoring circuit controlled at the left-hand armature and back contact of relay 12 is extended by way of contacts 113, 123 and 133 of the receiving register switches to the stepping magnets 168, 178 and 188 of the transmitting register switches, the energizing circuits of these magnets being completed by way of their armatures and back contacts and their associated switch contacts 161, 171 and 181, respectively, and the resting contacts 113, 123 and 133, respectively, of the receiving register switches to the switch restoring circuit. The wipers 160, 170, and 180 of the transmitting register switch 150 are thereupon returned to normal. Upon the return of these elements of the transmitting register switch, the restoring circuit is further extended to the stepping magnets 194 and 199 of the associated change-over switches 190 and 195, the connection with the restoring circuit being by way of the armatures and back contacts of the magnets and contacts 192 and 197 respectively of the associated switches, and thence by way of the contacts 161 and 171 respectively of the transmitting register switch, and the contacts 113 and 123 respectively of the receiving register switch. The extension of the restoring circuit to the stepping magnets 194 and 199 causes the stepping around to normal of the associated switches.

As long as any of the branches of the restoring circuit are closed, the low resistance relay 15 included in the common portion of the restoring circuit is held energized to maintain operated the slow releasing relay 45. This relay as long as it is operated maintains a busy test condition upon the various branches of the associated radio trunk, so that it may not again be seized until the restoration of the trunk to normal has been fully effected.

In the restoration of the station selecting switch 20 to normal, the particular tuning control branches that have been held closed by way of wipers 21 and 22, and which in the present instances have been assumed to be the branches associated with the conductor 83 extending to the transmitting antenna system and the conductor 93 extending to the receiving antenna system, are opened, and the associated relays 116, 126, 136 and 156 are released. At the same time the contact 26 of station selecting switch 20 is opened to deenergize relay 89, and thus withdraw current supply from the radio transmitting system; and contact 27 is closed to complete an energizing path by way of conductor 91 to operate relay 154 and thus establish the normal tuning of the receiving antenna system so that it may be responsive to calls from other radio stations.

The removal of this ground connection at the outer right-hand armature and front contact of relay 12, breaks also the holding circuit traced by way of the back contact of relay 30 for relays 38, 169, 179, 189 and 35. These relays thereupon release. Relay 35 in releasing releases relay 98, thereby opening the path for the application of current for energizing the signaling intermediate frequency oscillator 145. Therefore, when slow-releasing relay 12 deenergizes upon the hanging up of the calling subscriber, the signaling intermediate frequency is withdrawn from the carrier wave, and the withdrawal of this intermediate frequency at once brings about the deenergization of the relay 99 at the called radio station.

When relay 99 at the called radio station S-3 is deenergized it releases relay 61; and relay 61 in releasing closes a circuit that extends from battery through the winding of relay 69, outer contacts of plunger relay 68, middle-right-hand front contact and armature of relay 62, and right-hand back contact and armature of relay 61 to ground. Relay 69 in operating closes a locking circuit for itself, and also closes a circuit for energizing the plunger relay 68. Relay 68 thereupon starts the inward movement of its plunger; and as relay 61 is now continually deenergized, relay 69 remains energized and relay 68 completes the inward movement of its plunger and opens, at its inner contacts, the energizing circuit of relay 62 at the end of the inward movement of the plunger. The resultant release of relay 62 opens, at its outer right-hand armature and front contact, the energizing circuit for the tuning relays 116, 126 and 136 of the transmitting antenna system, thus releasing these relays and causing them to open their branches of the tuning circuit. Relay 62 in releasing also opens the energizing circuit of relay 69 to permit the retraction of the plunger of relay 68, opens at its outer left-hand armature and front contact the locking circuit that is maintaining the energization of relays 63, 267, 277, and 287, and closes at its outer left-hand armature and back contact a circuit for causing the stepping of the receiving and transmitting register switches 200 and 250 back to normal. The last mentioned circuit is completed in parallel branches through the windings and vibratory contacts of stepping magnets 218, 228 and 238 of the receiving register switches, thence by way of contacts 213, 223 and 233 of these switches, respectively, conductor 173, and the winding of the low resistance relay 65 to ground at the outer left-hand back contact and armature of relay 62. The closure of these parallel branches causes the stepping of the switch wipers 210, 220 and 230 back to normal. When the switch wipers reach their normal position the switch restoring circuit is extended by

way of contacts 213, 223 and 233, respectively, of the three receiving register switch elements and the contacts 263, 273 and 283 of the corresponding transmitting register switches to the stepping magnets 268, 278 and 288, respectively, of the transmitting register switch. Therefore the three stepping magnets are operated to move the corresponding switch wipers 260, 270 and 280 on around until the stepping magnet circuits are opened at contacts 263, 273 and 283 when the corresponding transmitting register switch wipers reach normal. The low resistance relay remains active until the switch restoring circuit is opened at the completion of the restoration of all the switches, and maintains energized the relay 45 (see Figs. 7 and 1) thus keeping the busy test condition on the trunk until the switch restoration is completed.

When relay 63 is released by the release of relay 62, it opens the energizing circuit of relay 36 to interrupt the talking conductors of the trunk, opens the energizing circuit of relay 89 to disconnect the current supply leads from the transmitting antenna system, opens the energizing circuit of relay 98 to de-energize the signaling intermediate frequency oscillator 145, and opens the energizing circuit of relay 64 to interrupt the bridge of the trunk talking conductors 48 and 49 by way of the retardation coil 43. The interruption of this bridge across the talking conductors 48 and 49 effects in a well-known way the release and restoration of the line and selector switches that have operated to establish the connection of the radio trunk with the called subscriber's line, the connector switch at the end of the series being released in the usual manner by the hanging up of the called subscriber. This completes the restoration to normal of the apparatus that has been involved in the establishment of the connection between the calling subscriber's line associated with one radio trunk or station and the called subscriber's line associated with another distant radio trunk or station.

In the foregoing description no specific location has been assigned to the radio or high frequency stations of the system. These stations may be located at widely separated points, and each may have associated with it a plurality of local stations constituting an exchange, between which exchanges interconnection is had through the medium of the associated radio trunks. But, if desired, two or more radio trunks or high frequency stations may be associated with and available to the local stations of each exchange system, so that the local station of any exchange may have two or more avenues or channels of communication for establishing connection with a local station

of another exchange. In such case, if one of the channels is in use communication may be established by way of another of the channels extending between the two exchanges. The procedure under these circumstances would be for the calling subscriber, upon receiving the busy signal informing him that the channel first tried is in use, to hang up and then initiate a second call which he would dial in such a manner as to select another of the available channels between his exchange and the distant exchange in which the local station that he is calling is located.

Where the system of the present invention is employed in this manner, and two or more of the high frequency or radio stations are located within the limits of the same telephone exchange, the means for enabling each radio station to tune its transmitting and receiving antenna systems to the other radio station or radio stations included in the same exchange area may of course be eliminated, and only means be provided for tuning such radio stations of the same exchange system to radio stations of the other distant exchange systems.

It will be understood that by the use of a wire or conductive connection between the two distant stations for guiding the high frequency waves or oscillations between these stations, in place of the unguided transmission of these waves or oscillations through space as herein disclosed the present system may be employed as a system of wire communication.

Since the apparatus at either station would be of the same nature, whether the system were a high frequency wire system or a radio system, the claims are directed to a high frequency system and are intended to cover systems of both types. In general the frequencies employed on a high frequency wire line or a carrier line, would be lower than the numerical values hereinbefore given. These values, however, are given merely as examples, and frequencies much lower than these could be used in a radio system, if desired. By "high frequency" is meant a frequency high as compared with the frequency of the signal which is transmitted by the high frequency wave and no limiting values can be given. It may be said, however, that for satisfactory high-frequency telephony the frequency of the carrier wave should be near or above the upper limit of audibility and frequencies from about 10,000 cycles upwards have proved satisfactory in practice. For telegraphy or other types of signaling employing lower frequencies than telephony, still lower carrier frequencies can be used. For convenience the frequency of the signaling currents themselves, such as voice currents, tele-

graph currents or other signaling currents are referred to in certain of the claims as low frequencies to distinguish them from the high frequencies or carrier frequencies.

5 In order fully to disclose the present invention in its preferred form it has been necessary to disclose certain features in connection with the production and propagation of the high frequency waves that are the
10 subject of co-pending applications Serial No. 81,980, filed March 3, 1916, Serial No. 131,868, filed November 17, 1916, and Serial No. 181,581, filed July 19, 1917, of various
15 inventors assigned to the assignee of the present application. Such features include for example the specific oscillators 101, 109, 145, the transmission of a plurality of intermediate frequencies by means of the same
20 high frequency carrier wave, each of which intermediate frequencies may be separately controlled, the specific modulating systems, the specific detecting arrangements, and the general circuit arrangements embodying
25 these elements in a high frequency system. The structure and operation of these elements will, however, be evident to all those skilled in the art to which these elements pertain, especially in view of the description
30 hereinbefore given. Since these elements by themselves form no part of the present invention, they are not specifically claimed herein. Certain features that are specifically adapted to an automatic telephone
35 switching system likewise form no part of the present invention and are claimed in co-pending applications Serial No. 418,191, filed October 20, 1920, and Serial No. 304,212, filed June 14, 1919.

What is claimed is:

40 1. The combination with two automatic telephone systems comprising telephone stations and automatic switches for interconnecting the same, of high frequency carrier
45 telephone transmitting and receiving apparatus associated with each system, and means controlled by any station of one system for causing the operation of said high frequency
50 apparatus to establish connection with any station of the other system.

50 2. In a high frequency telephone system, the combination with a high frequency station, of a telephone line connected with said
55 station and having a telephone station provided with switch controlling mechanism, a high frequency transmitting system for said high frequency station, means for tuning
60 said transmitting system to produce and transmit any one of a number of wave frequencies, other high frequency stations each having high frequency receiving means normally
65 set to be responsive to a different one of said wave frequencies, and means under the control of said switch controlling mechanism and controlled over said line for selectively operating said tuning means to select

any desired one of said other high frequency stations.

3. In a high frequency telephone system, the combination with a high frequency station, of a telephone line connected with said
70 station and having a telephone station provided with switch controlling mechanism, a high frequency receiving system for said high frequency station, means for tuning
75 said receiving system to render it responsive to any one of a number of wave frequencies, other high frequency stations each having means for producing and transmitting a different one of said wave frequencies, and
80 means under the control of said station mechanism and controlled over said telephone line for selectively operating said tuning means to render the receiving system of the associated high frequency station responsive to any one of said wave frequencies. 85

4. The combination with a high frequency station provided with means for producing a plurality of carrier waves of other high
90 frequency stations having means for receiving and responding to said carrier waves, each station being normally set to respond to a different wave, automatic switch mechanism at said first mentioned high frequency
95 station for selecting a particular one of said carrier waves for transmission, a telephone line having a subscriber's station, and switch controlling mechanism at said subscriber's station for controlling said automatic switch mechanism.

5. The combination with a station having
100 means for producing high frequency oscillations, an automatic switch for adjusting the wave length of said oscillations to any one of a number of different values, a plurality of other stations, each having apparatus
105 normally set to respond to a different wave length, a telephone line having an associated station, and a switch at said last-named station for controlling the operation of said automatic switch to adjust the wave
110 length of said high frequency oscillations to a particular value and thereby select a particular one of said other high frequency stations.

6. The combination with two automatic
115 telephone systems, of a radio trunk associated with each system, each of said radio trunks having a conductive terminal and a radio terminal, means under the control of any station of one of said systems for connecting said station with the conductive
120 terminal of the associated radio trunk, means for operating said radio trunk to bring its radio terminal into operative relation with the radio terminal of the radio trunk of the other system, and means associated with said
125 last-mentioned radio trunk and operated under the control of said first-mentioned radio trunk for bringing the conductive terminal of said last-mentioned radio trunk into op- 130

erative relation with any station of the system with which said last-mentioned trunk is associated.

7. The combination with a high frequency carrier wave signaling trunk having conductive terminals and high frequency terminals, of a plurality of stations having conductive terminals, a plurality of stations having high frequency carrier wave terminals, switching means controlled at each of the first-mentioned stations for establishing connection between the conductive terminals of said station and the conductive terminals of said high frequency trunk and means for bringing the high frequency terminals of said trunk into operative relation with the high frequency carrier wave terminals of a selected one of the aforesaid high frequency stations.

8. The combination with a high frequency trunk having conductive terminals and high frequency terminals, of a plurality of stations adapted for connection with said conductive terminals, a plurality of high frequency stations adapted for continuous two-way operative relation with said high frequency terminals, and means associated with said trunk and controlled by said various stations for causing said trunk to establish connection between any high frequency station and any of said other high frequency stations.

9. The combination with a plurality of stations each having impulse mechanism, of a common high frequency sending apparatus adapted to be controlled in its operation by the impulse mechanism of any of said stations, other high frequency apparatus at a distant point, an automatic switch controlled by said last-mentioned high frequency apparatus under the control of said first-mentioned high frequency apparatus, and a plurality of stations with any one of which said automatic switch is adapted to make connection.

10. The combination with a plurality of stations, each provided with mechanism for sending impulses, a high frequency trunk common to said stations, means for connecting a calling one of said stations with said high frequency trunk, means for translating said impulses into high frequency variations, a plurality of high frequency stations, and means associated with said high frequency trunk, including said translating means, and controlled by said impulse mechanism of the calling station for bringing said high frequency trunk into operative relation with any of said high frequency stations.

11. The combination with a calling station and a called station, of high frequency transmitting apparatus and high frequency receiving apparatus at each station, a telephone line associated with the calling station, means for extending said line to said

station, means controlled over said line for energizing the high frequency transmitting apparatus of the calling station, a plurality of telephone lines associated with the called station, switching mechanism at the said called station for selecting one of said telephone lines and connecting said called station thereto, and means controlled by the high frequency receiving apparatus of the called station under the control of the high frequency transmitting apparatus of the calling station for effecting the operation of said selecting and connecting switch mechanism.

12. The combination with a plurality of stations each having a plurality of associated telephone lines, and each having high frequency transmitting apparatus and high frequency receiving apparatus, of automatic switch mechanism at each station for interconnecting the associated station with any of the associated telephone lines, means at each station for selecting any other station, and means at the selected station controlled by the high frequency receiving apparatus of that station under the control of the high frequency transmitting apparatus of the distant station for controlling the operation of the associated automatic switch mechanism.

13. The combination with two stations each having a plurality of associated telephone lines, and each having high frequency transmitting apparatus and high frequency receiving apparatus, of automatic switch mechanism at each station for effecting the interconnection of the station with any of the associated telephone lines, means under the control of any of the associated telephone lines of one of said stations for extending the circuit of that line to that station, means controlled by the extended telephone line for controlling the operation of the high frequency transmitting apparatus of the station to which the line is extended, and means at the distant station controlled by the response of the receiving apparatus of that station for controlling the operation of the associated automatic switch mechanism to connect that station to any one of the associated telephone lines.

14. The combination with a plurality of high frequency stations each having an associated plurality of communicating circuits, of a selecting switch at each of said stations for selecting a particular one of said communicating circuits and connecting the associated high frequency station therewith, a calling high frequency station having means to transmit any one of a plurality of high frequency waves, a selecting switch at said calling station, means under the control of said switch at the calling station for bringing said calling station into high frequency communication with a particular one of said other high frequency stations

through the medium of a selected one of said high frequency waves, and controlling means associated with said calling station for first controlling the selecting switch of said calling station to select a particular one of the other high frequency stations, and then operating the selecting switch of the selected high frequency station to select a particular one of the associated communicating circuits.

15. The combination with a plurality of high frequency stations, each having a plurality of associated communicating circuits, of controlling apparatus associated with a communicating circuit of one of said high frequency stations, switching mechanism under the control of said controlling apparatus for connecting said communicating circuit with the associated high frequency station, a source of high frequency waves at said high frequency station, switching mechanism at said high frequency station and under the control of said controlling apparatus for bringing said high frequency station into operative relation with one of the other high frequency stations by means of the high frequency wave from said source, and switching mechanism at said other station and under the control of said controlling apparatus for connecting that high frequency station with a particular one of its associated communicating circuits.

16. The combination with two high frequency stations, each having associated high frequency carrier telephone transmitting and receiving apparatus, adapted for two-way communication between said stations, of a telephone line associated with one of said stations and having switch mechanism at the substation thereof, and means under the control of said switch mechanism for controlling the energization and deenergization of the high frequency carrier telephone transmitting apparatus of both of said high frequency stations.

17. The combination with two stations, each provided with high frequency transmitting and receiving apparatus, of a telephone line having a telephone station provided with a switch hook, said telephone line being associated with one of said stations, means for establishing operative relation between the high frequency transmitting and receiving apparatuses of said stations, and means made operative by the placing of the receiver on said switch hook at said telephone station for deenergizing the high frequency transmitting apparatus of the distant station.

18. The combination with two radio stations, each provided with radio frequency transmitting and receiving apparatus, of a telephone line having a telephone station provided with a switch hook, said telephone line being arranged for connection with one

of said stations, means for establishing operative relation between the radio frequency transmitting and receiving apparatuses of said stations, and means made operative by the placing of the telephone receiver on said switch hook at said telephone station for deenergizing the radio frequency transmitting apparatus of the associated station.

19. The combination with a plurality of telephone lines, a high frequency trunk common thereto, and a source of high frequency waves for transmission through said trunk, of a plurality of high frequency stations, means for connecting a calling one of said telephone lines with said high frequency trunk, means for variably controlling transmission of said waves to cause said high frequency trunk to select and establish operative relation with any of said high frequency stations, means for establishing a busy condition of any of said stations, and means responsive to the busy condition of a selected high frequency station for preventing said high frequency trunk from establishing connection between said busy high frequency station and said calling line.

20. The combination with a plurality of high frequency stations, of means for producing a characteristic high frequency condition of each of said stations when it is busy as a called station, means for producing another characteristic high frequency condition when the station is in use as a calling station, high frequency means for establishing operative relation between any two of said stations, and means responsive to the existence of either of said characteristic conditions at a called high frequency station for preventing a calling high frequency station from establishing operative relation therewith.

21. The combination with two high frequency stations, each provided with communicating apparatus and controlling apparatus, and each provided with means for generating, transmitting and receiving certain communicating oscillations and certain other controlling oscillations, means for rendering one of said high frequency stations busy and at the same time causing it to transmit said controlling oscillations, and means at said other station responsive to said controlling oscillations for operating the associated controlling apparatus to prevent the establishment of communicating relations between said two stations.

22. The combination with two high frequency stations, of means for establishing high frequency communication between said stations, means made operative in the establishment of communication between said stations for changing the high frequency condition of each station, a third high frequency station, and means associated with said third station and responsive to the

altered high frequency condition of said stations to prevent said third station from being brought into communicating relation therewith.

23. The combination with a calling high frequency station and a called high frequency station, of means for establishing high frequency communication between said stations, means associated with the called high frequency station for changing the high frequency condition thereof when said station is called, a third high frequency station, and means associated with said third high frequency station and responsive to the changed high frequency condition of said called high frequency station for preventing said third station from being brought into communicating relation with said called station.

24. The combination with a calling high frequency station and a called high frequency station, of means for establishing high frequency communication between said stations, means associated with said calling high frequency station for changing the high frequency condition thereof in calling, a third high frequency station, and means associated with said third high frequency station and responsive to the changed high frequency condition of the calling high frequency station for preventing said third station from being brought into communicating relation with said calling radio station.

25. The combination with a high frequency trunk having low frequency terminals and high frequency terminals, of high frequency stations and other stations provided with means for establishing operative relation with said trunk, and means including circuits for impressing a test potential on the low frequency terminals and a high frequency wave on the high frequency terminals upon the establishment of operative relation between said trunk and any of said high frequency or other stations for preventing any other high frequency or other station being brought into operative relation with said trunk.

26. The combination with a calling high frequency station, a called high frequency station, and a high frequency generator at each station, of high frequency controlled means for changing the high frequency electrical condition of said called station when it is called, other stations adapted to be brought conductively into operative relation with said called high frequency station, and means responsive to the changed high frequency electrical condition of said high frequency station when it is called for preventing the conductive connection of said other station with said high frequency station.

27. The combination with a high frequency station having a telephone circuit

adapted for connection therewith, of another high frequency station, means for changing the high frequency condition of the same when it is unavailable for connection, means at the first high frequency station for producing a busy indication, and high frequency controlled means associated with said first high frequency station and responsive to the changed high frequency condition of said second high frequency station when it is unavailable, for bringing said busy indicating means into operative relation with said telephone circuit.

28. The combination with a high frequency station and a telephone line connected thereto, of a second high frequency station, a source of busy tone current, and high frequency controlled means responsive to an unavailable condition of said second high frequency station and dependent upon the transmission of a high frequency wave from said second high frequency station for applying said source of busy tone current to said telephone line.

29. The combination with a calling high frequency station and a telephone line adapted for connection therewith, of a called high frequency station, a third high frequency station with which said called high frequency station is adapted to be brought into operative relation, a source of busy tone current, and high frequency controlled means responsive to the existence of operative relation between said called station and said third station and dependent upon the transmission of a high frequency wave from said called high frequency station for applying said source of busy tone current to said telephone line.

30. The combination with a high frequency station having a telephone line connected thereto, said telephone line being provided with a telephone station having a switch hook, of other high frequency stations, means associated with said first-mentioned high frequency station for creating a normal high frequency condition of said station to render it responsive to calls from said other high frequency stations, and means made operative by the closure of said telephone station switch hook for changing the high frequency condition of said first mentioned high frequency station to render it unresponsive to calls from said other high frequency stations.

31. In a high frequency telephone system, the combination with a high frequency station having a high frequency receiving system, of means for tuning said receiving system to be normally responsive to a certain wave frequency, other high frequency stations provided with means for transmitting waves of said frequency, a telephone line connected with said first-mentioned high frequency station and having a telephone sta-

tion provided with a switch hook, and means operated by the closure of said switch hook to change the normal tuning of the receiving system of the associated high frequency station to make it unresponsive to the afore-
 5 said wave frequency.

32. The combination with a calling high frequency station and a called high frequency station, of means at said called high
 10 frequency station for generating a high frequency wave to which said calling high frequency station is responsive, means at said calling station for generating and transmitting a different high frequency wave to
 15 which said called station is responsive, and means at the called station for transmitting the called station high frequency wave under control of the transmission of the high frequency wave at the calling station.

33. The combination with a calling station and a called station, each provided with high frequency transmitting apparatus and high frequency receiving apparatus, means
 20 at the calling station for energizing the high frequency transmitting apparatus of that station upon the initiation of a call, and means at the called station controlled by the high frequency transmitting apparatus at the calling station for energizing the high
 25 frequency transmitting apparatus at the called station.

34. The combination with a calling high frequency station and a called high frequency station, of means for changing the
 35 high frequency condition of the called station as a result of the calling station making high frequency connection therewith, a communicating circuit associated with said called station, and means responsive to the changed
 40 high frequency condition of the called station for bringing said communicating circuit into operative relation with said calling high frequency station.

35. The combination with a calling high frequency station and a called high frequency station, of means responsive to the calling of said called station for changing the high frequency condition thereof, a third
 45 high frequency station, communicating circuits associated respectively with said calling high frequency station and said third high frequency station, means for bringing an associated communicating circuit into operative
 50 relation with said calling high frequency station, and means responsive to the changed high frequency condition of said called station and dependent upon the emission of a high frequency wave from one of said stations other than said calling high
 55 frequency station for preventing a said associated communicating circuit from being brought into operative communicating relation with said third high frequency station.

36. The combination with two high frequency stations, of means actuated upon the

initiation of a call at one of said stations for producing a high frequency signal, means at the other station responsive to said high frequency signal for producing a return
 65 high frequency signal, connection-controlling switch mechanism at the first station, and means at the first station controlled in response to said return signal for actuating said switch mechanism.

37. The combination with a calling high frequency station and a called high frequency station, of a communicating circuit associated with the calling station, means actuated upon the initiation of a call at said
 70 calling station for producing a high frequency signal, means at the called station responsive to said high frequency signal for producing a return high frequency signal, and means at the calling station responsive to said return high frequency signal for establishing operative relation between said
 75 calling station and said associated communicating circuit.

38. The combination with two high frequency stations, of a communicating circuit
 80 associated with each station, means at one of said stations for producing a high frequency signal in the initiation of a call from the associated communicating circuit of that station, means at the other high frequency station
 85 actuated in response to said high frequency signal for establishing operative relation between said station and its associated communicating circuit and for producing a return high frequency signal, and means at
 90 said first-mentioned high frequency station responsive to said return high frequency signal for establishing operative relation between said station and its associated communicating circuit.

39. The combination with a calling high frequency station and a called high frequency station, of a communicating extension circuit associated with said called station, means responsive to the initiation of the
 95 call at said calling station for transmitting a high frequency wave, and means at said called high frequency station responsive only to said high frequency wave for establishing operative relation between said called station and its associated communicating extension
 100 circuit.

40. The combination with a high frequency station having a communicating circuit associated therewith, of a second high
 105 frequency station, means at the first station operated upon the initiation of a call by the associated communicating circuit for producing a high frequency signal, means at the second station responsive to said high frequency signal for producing a return high
 110 frequency signal, means at the second high frequency station made operative by an unavailable condition of said second station for preventing the production of said return signal
 115

65

nal, means at the first high frequency station responsive to the production of said return signal for establishing operative relation between said communicating circuit and said first high frequency station, and means at the first high frequency station controlled by the non-production of said return signal to prevent the establishment of said operative relation and apply a busy indication to said associated communicating circuit.

41. The combination with two high frequency stations, of a communicating circuit associated with each of said stations, means at the first station for producing a high frequency signal in response to the initiation of the call by the associated communicating circuit, means at the second station responsive to said high frequency signal for producing a return high frequency signal and establishing operative relation between said second station and its associated communicating circuit, means at the second station for preventing the production of said return high frequency signal, and means at the first station controlled by the production or non-production of said return signal for establishing operative relation between said first station and its associated communicating circuit if said return signal is produced, and for preventing the establishment of operative relation and applying a busy indication to said communicating circuit if said return signal is not produced.

42. The combination with a calling station and a called station, of means at the calling station for producing direct current impulses, means for translating said conductive impulses into impulses of a high frequency wave and transmitting the same, means for receiving said high frequency impulses and translating them into direct current impulses, a step-by-step switch selectively controlled by said direct current impulses for completing connection with the called station, and means for thereafter utilizing said high frequency wave in the transmission of signals to the connected called station.

43. The combination with a calling high frequency station and a called high frequency station, of a plurality of telephone lines associated with said called station, impulse operated switches for selectively connecting said called high frequency station with any of said associated telephone lines, station designating receiving register apparatus at the called station, impulse-sending apparatus at the calling high frequency station, means responsive thereto for controlling the setting of said receiving register apparatus at the called station, and impulse-sending apparatus at the called station operated in accordance with the setting of said receiving register apparatus to effect

a selective operation of said impulse operated switches.

44. The combination with a calling high frequency station and a called high frequency station, of a plurality of telephone lines at said called station, impulse-operated switch mechanism at the called station for selectively connecting said called station with any of the associated telephone lines, means at the calling high frequency station for generating a high frequency wave and controlling the same to produce characteristic successions of impulses, registering mechanism at the called high frequency station for receiving such characteristics successions of impulses, and means controlled by said registering mechanism for transmitting to said impulse operated switch mechanism successions of impulses corresponding to those received to bring about the selective operation of said mechanism, and means for utilizing said high frequency wave to transmit speech.

45. The combination with a calling high frequency station and a called high frequency station, of means at the calling high frequency station for generating a high frequency carrier wave having an intermediate signaling frequency, impulse producing means at the calling station and impulse receiving means at the called station cooperating through the medium of said signaling intermediate frequency, registering apparatus at said called station set by the received impulses, impulse-operated selecting switches at the called station, means controlled by said registering apparatus in accordance with its setting for supplying impulses for the selective operation of said switches, and a plurality of telephone lines with which said called high frequency station may be brought into connection through the medium of said selecting switches.

46. The combination with a calling high frequency station and a called high frequency station having high frequency transmitting and receiving apparatus, of a plurality of lines associated with said called station, switch mechanism for connecting said called station selectively with any one of the associated lines, an automatic impulse sending device at the calling high frequency station, means at the called station responsive to the impulses sent by said impulse sending device for effecting the operation of said switch mechanism, and means controlled from the called high frequency station for releasing said automatic impulse sending device to send its impulses.

47. The combination with a calling high frequency station and a called high frequency station having high frequency transmitting and receiving apparatus, of switching mechanism at said called station, coop-

erating controlling mechanism at said calling station, and means controlled from said called station through the medium of the high frequency transmitting apparatus thereat for rendering said controlling mechanism operative.

48. The combination with a calling high frequency station and a called high frequency station having high frequency transmitting and receiving apparatus, of an automatic signal sending device at said calling station, a cooperating signal receiving device at said called station, means at said calling station for setting said signal sending device in accordance with the signal to be sent, and means controlled from said called station through the medium of said high frequency apparatus for releasing said sending device to transmit its signal.

49. The combination with a calling high frequency station having high frequency transmitting apparatus, of a called high frequency station having high frequency receiving apparatus, a plurality of lines associated with said called station, switch mechanism for connecting said called station selectively with any one of the associated lines, an automatic impulse sending device at the calling high frequency station for sending impulses of a high frequency wave, means at the called station responsive to the impulses of high frequency sent by said impulse sending device for effecting the operation of said selective switch mechanism and means for thereafter variably controlling the high frequency waves transmitted from said calling high frequency station to transmit signals to the connected line.

50. The combination with two stations each having a plurality of associated telephone lines, of an impulse producing device associated with a calling telephone line of one station, a receiving impulse-storing register at said station set by said impulses, a transmitting register at that station operated under the control of said receiving register to transmit corresponding impulses of a high frequency wave to the other station, a receiving impulse-storing register at said other station set by the received high frequency impulses produced by the transmitting register of the first station, a transmitting register at the said other or second station operating under the control of the associated receiving register to transmit corresponding impulses, and automatic switch mechanism controlled by the impulses sent by the transmitting register of said second station for selectively connecting said station with the particular one of the associated telephone lines that is being called.

51. In a high frequency communicating system, the combination with two stations, a high frequency transmission path connecting said stations, slow-acting high-frequency

wave impulse-producing means at one of said stations, quick-acting direct-current-impulse-operated switches at the other station, and receiving and sending impulse-storing register mechanism at said last-mentioned station for receiving the slow high frequency wave impulses produced at the first station and translating them into rapid direct-current impulses for operating said automatic switches.

52. The combination with a calling high frequency station and a called high frequency station, of registering apparatus comprising a receiving impulse-storing register and a transmitting register associated with each station, a calling line connected with said calling high frequency station, means associated with said line for setting the receiving impulse-storing register of the calling station, means associated with said receiving impulse-storing register for controlling the operation of the associated transmitting register, high frequency transmitting apparatus controlled by said transmitting register, high frequency receiving apparatus responsive to said transmitting apparatus to effect the control of the receiving register of the called high frequency station, means controlled by the called station receiving impulse-storing register for controlling the called station transmitting register, a plurality of local lines associated with the called high frequency station, and selecting switch mechanism controlled by said called station transmitting register for selecting any desired one of said lines.

53. The combination with a station provided with communicating apparatus, of means for generating a carrier wave having a communicating intermediate frequency and a signaling intermediate frequency, means for applying said signaling intermediate frequency to said carrier wave when said station is in use, a calling station also having communicating apparatus, and means at said calling station responsive to said carrier wave with its superposed intermediate signaling frequency for preventing the establishment of communicating relation between said calling station and said first-mentioned station.

54. In a telephone system, the combination with two stations each having means for generating a characteristic carrier wave to which the other station is responsive and for generating and superposing upon the carrier wave a communicating intermediate frequency and a signaling intermediate frequency, of telephone apparatus associated with each station having associated means for modulating the communicating intermediate frequency generated by that station in accordance with the telephone voice currents and for responding to the modulated communicating intermediate frequency of the

other station, means at each of said stations for controlling the associated signaling intermediate frequency, and telephonic switching apparatus at each station responsive to the controlled signaling intermediate frequency of the other station.

55. In a telephone system the combination with two stations each having means for generating a characteristic carrier wave to which the other station is responsive and for generating and superposing upon the carrier wave a communicating intermediate frequency and a signaling intermediate frequency, of communicating apparatus associated with each station having associated means for modulating in accordance with the communicating currents the communicating intermediate frequency generated by that station and for responding to the modulated communicating intermediate frequency of the other station, means at each station for controlling the associated signaling intermediate frequency, and a communicating apparatus controlling switch at each station responsive to the controlled signaling intermediate frequency of the other station.

56. The combination with two high frequency stations, each provided with communicating apparatus and controlling apparatus therefor, of means at each station for generating, transmitting and receiving certain characteristic currents for establishing operative relation between the communicating apparatuses and other characteristic currents for establishing independent operative relation between the controlling apparatuses of the two stations, and means for operatively relating the communicating apparatuses, and controlling apparatuses of the two stations through the medium of their respective characteristic currents.

57. The combination with two stations, of means at one station for producing and transmitting waves of different frequencies, receiving means at the other station selectively responsive to said waves, communicating apparatus and controlling apparatus at each station, means for operatively relating the communicating apparatuses of the two stations with each other through the medium of one of said waves, and means for operatively relating the controlling apparatuses of the two stations with each other through the medium of the other wave.

58. The combination with two stations, each having communicating apparatus and controlling apparatus associated therewith, of means at each of said stations for producing a carrier wave having two intermediate frequencies, means at each station for modulating the two intermediate frequencies, of its carrier wave, means at each station responsive to the modulations of one intermediate frequency of the carrier wave of the other station for controlling the as-

sociated communicating apparatus, and means at each station responsive to the modulations of the other intermediate frequency of the carrier wave of the other station for controlling said associated controlling apparatus.

59. In a telephone system, the combination with two stations, each having associated telephonic communicating apparatus, of means at one of said stations for producing a carrier wave having two intermediate frequencies, means at said station controlled by the associated telephonic apparatus for modulating one of said frequencies, controlling apparatus at said station for modulating the other intermediate frequency, means at the distant station responsive to the modulations of the first-mentioned intermediate frequency for actuating the associated telephonic communicating apparatus, and switching mechanism at the distant station responsive to the modulations of said other intermediate frequency.

60. The combination with a station having associated communicating apparatus and controlling mechanism therefor, of a distant station provided with means for producing a high frequency wave having two intermediate frequencies, high frequency receiving apparatus at said first-mentioned station selectively responsive to said two intermediate frequencies and adapted to control said communicating apparatus and said controlling mechanism, means at said distant station for modulating one of said frequencies to operate said communicating apparatus, and means at said distant station for modulating the other frequency to control said controlling mechanism.

61. The combination with a station having associated communicating apparatus and controlling mechanism therefor, of a distant station provided with means for producing a high frequency wave having two intermediate frequencies, communicating apparatus at said distant station for modulating one of said intermediate frequencies, means responsive to said modulated frequency for operating the communicating apparatus at the first-mentioned station, a switch at said distant station for modulating the other intermediate frequency, and means responsive to said other modulated frequency for operating said controlling mechanism at the first mentioned station.

62. The combination with two high frequency stations, of separate communicating circuits and controlling circuits with included communicating and controlling apparatus at each station, means at one of said stations for producing and at the other station for receiving a carrier wave having two intermediate frequencies, and means for establishing independent operative relation between the communicating circuits of the

two stations and the controlling circuits of the two stations over said single high frequency wave.

63. The combination with a calling line, of a radio trunk, an automatic switch under the control of said calling line for connecting said line to said trunk, a second radio trunk, radio frequency means for establishing operative relation between said trunks, a called line, an automatic switch for connecting said called line with said second trunk, and means controlled by said calling line for restoring both said automatic switches.

64. The combination with two stations, each having high frequency transmitting and receiving apparatus, of a calling line associated with one of said stations, a called line associated with the other station, a selecting switch, for connecting said other station with the associated called line, means controlled from the first mentioned station over the calling line for transmitting to the distant station impulses of a high frequency wave to operate selectively said switch, means for transmitting said wave continuously during the establishment of the connection, and means dependent upon the continuous transmission of said wave to maintain said switch in its operated condition.

65. The combination with two stations, each having high frequency carrier telephone transmitting and receiving apparatus, of a called line associated with one of said stations, a selecting switch at said station, means for operating said switch to connect said called line with the associated station, switch mechanism at said other station, and means at said first mentioned station controlled by said switching mechanism through the medium of said high frequency carrier telephone apparatus for releasing said selecting switch.

66. In a signaling system, a line, a plurality of high frequency signaling stations to which said line has access, each of said high frequency stations having apparatus for transmitting a number of high frequency waves of different frequency, means controlled over said line for automatically selecting an idle one of said high frequency stations and for thereafter selecting for use a high frequency wave that has not at that instance been appropriated for use, and means dependent for its operation upon the idle condition of the selected high frequency wave for operatively connecting said line with the high frequency apparatus of the selected station and of the selected high frequency wave whereby signals on said line control the said high frequency wave.

67. A communicating system including a high frequency wave system having high frequency transmitting and receiving apparatus at each terminal, low frequency lines

adapted for connection to each of said terminals, means controlled over a low frequency line for connecting it to a terminal of said high frequency wave system and for controlling the wave transmitted from said terminal, and means including said receiving apparatus at the other terminal responsive to said transmitted wave for connecting said last mentioned terminal to a desired low frequency line whereby communication can be carried on between said low frequency lines connected through the medium of said high frequency wave system.

68. In a signaling system, a line, a plurality of high frequency signaling stations to which said line has access, there being a series of high frequencies assigned to each of said high frequency stations for enabling selective communication with distant similar stations, and means controlled over said line for automatically selecting an idle one of said stations and for thereafter selecting and appropriating for its exclusive use any one of such high frequencies comprising means for preventing appropriation by a station of a wave that is in use by other stations.

69. A system of communication comprising a telephone system and a distant telephone system and a high frequency wave signaling system for interconnecting said telephone systems, said high frequency wave system employing waves of preassigned high frequencies, and means controlled over one telephone system for selecting for use a particular one of said high frequency waves and for controlling the distant telephone system by means of the selected high frequency wave.

70. A system of communication comprising a telephone system, and a distant telephone system, and a high frequency wave signaling system for interconnecting said telephone systems, said high frequency wave system employing waves of preassigned high frequencies, means controlled from a station in one telephone system for selecting and appropriating for use a high frequency wave, and means responsive to the appropriation for use of the selected high frequency wave for preventing any other station of either telephone system from selecting for use a wave of the same frequency.

71. A system of communication comprising a telephone system, and a distant telephone system, and a high frequency wave signaling system for interconnecting said telephone systems, said high frequency wave system employing waves of preassigned high frequencies, means controlled from a station in one telephone system for selecting and appropriating for use a high frequency wave, means responsive to the appropriation for use of the selected high frequency wave for preventing any other station of either telephone system from selecting for use

a wave of the same frequency, and means at said station for controlling said selected high frequency wave to place said station in communication through said high frequency wave system with another station in the distant telephone system.

72. A high frequency system comprising a number of high frequency communication channels for transmitting waves of respectively different distinctive frequencies and having respective terminals, low frequency lines having access to said terminals, means controlled over a calling low frequency line for seizing an idle high frequency channel, means responsive to such seizure for rendering the seized terminal of the high frequency channel busy to other calling lines and for rendering the distant terminal of the seized high frequency channel busy to calling lines accessible to that terminal.

73. A high frequency system comprising a number of high frequency communication channels arranged to transmit waves of respectively different distinctive frequencies and having respective terminals, low frequency lines having access to said terminals, means controlled over a calling low frequency line for seizing an idle high frequency channel, means responsive to such seizure for rendering the seized terminal of the high frequency channel busy to other calling lines and for rendering the distant terminal busy to high frequency transmitting apparatus of other high frequency channels.

74. A system of communication comprising a number of two-way high frequency communication channels terminating at each end in transmitting and receiving apparatus, low frequency lines adapted to be associated with each end of said channels, and two-way repeating means adapted to be connected between the apparatus of each terminal of each high frequency channel and an associated low frequency line for enabling signals to be repeated between said channel and line, switching means controlled over a calling low frequency line for associating it through said two-way repeating means with a selected high frequency channel, and other switching means controlled over said calling low frequency line and the selected high frequency channel for selecting a low frequency line adapted to be associated with the distant terminal of the selected high frequency channel and for associating said selected line with said distant terminal through the two-way repeating means at said terminal.

75. In a high frequency signaling system, a high frequency channel having transmission circuits adapted to be operatively associated therewith, means to transmit a high frequency wave through said high frequency channel and to control the wave in accord-

ance with the designation of the desired circuit to be connected with, selective switching means responsive to said high frequency wave for selecting and connecting a desired transmission circuit with said high frequency channel, and means for thereafter exercising a different kind of control over said high frequency wave to transmit signals to said selected circuit.

76. In a high frequency signaling system, a high frequency channel having transmission circuits adapted to be operatively associated therewith, means to transmit a high frequency wave through said high frequency channel, selective switching means responsive to said high frequency wave for selecting and connecting a desired transmission circuit with said high frequency channel, and means for thereafter controlling said high frequency wave to transmit speech to said selected circuit and for controlling said high frequency wave to disconnect said circuit from said channel.

77. An automatic or semi-automatic telephone system comprising a high frequency channel and low frequency telephone lines, adapted to be connected thereto, switching means controlled by the high frequency wave transmitted through said high frequency channel for selecting a desired low frequency telephone line and connecting it to said high frequency channel, and means for thereafter controlling said high frequency wave to transmit speech through said high frequency channel and for repeating the speech so transmitted into the selected low frequency telephone line.

78. An automatic or semi-automatic telephone system comprising a high frequency channel and low frequency telephone lines adapted to be connected thereto, switching means controlled by the high frequency wave transmitted through said high frequency channel for selecting a desired low frequency telephone line and connecting it to said high frequency channel, and means for thereafter controlling said high frequency wave to transmit speech through said high frequency channel and for controlling said high frequency wave to disconnect automatically the selected low frequency line from said channel.

79. In a system of communication including lines, means for extending a long distance connection, comprising means to transmit direct current impulses over one of said lines, means controlled by said impulses for automatically extending the connection a portion of the distance, means for controlling a high frequency wave by impulses similarly transmitted to extend automatically the connection further through the medium of said high frequency wave, and means to transmit intelligence over said long distance by currents transmitted from

said line and by the energy of the high frequency wave controlled in turn by said currents.

80. In a system of communication including a line, a high frequency station to which said line has access, a distant high frequency station, means to transmit high frequency waves between said stations, said line being adapted to have operative connection with said distant high frequency station through said first station and through the medium of a said high frequency wave transmitted between said stations, means for automatically connecting said line to said first station, and means responsive to a said wave sent out from said distant station for preventing extension of the operative connection between said line and said distant station.

81. In a system of communication including a line, a high frequency station to which said line has access, a distant high frequency station, means to transmit high frequency waves between said stations, said line being adapted to have operative relation with said distant station through said first station and through the medium of a said high frequency wave transmitted between said stations, means for automatically connecting said line with said first station, and means under control of said line for transmitting control waves to said distant station, said last mentioned means being made operative or inoperative to transmit said waves under control of a wave transmitted from said distant station according as said distant station is idle or busy.

82. A system of communication comprising a high frequency channel and low frequency lines, means for transmitting a high frequency wave to select a desired low frequency line and automatically to connect said high frequency channel to the selected low frequency line, and for thereafter transmitting a high frequency wave carrying speech variations through said high frequency channel and repeating speech into said low frequency line.

83. In a system of communication, low frequency lines and a high frequency system, means for transmitting low frequency control currents over a low frequency line to connect said low frequency line automatically with said high frequency system, and for transmitting other similar control currents and translating them into high frequency control energy for automatically selecting a distant low frequency line and connecting said distant low frequency line to said high frequency system.

84. In a system of communication, low frequency lines and a high frequency system, means for transmitting low frequency control currents over a low frequency line to connect said low frequency line automat-

ically with said high frequency system, and for transmitting other similar control currents and translating them into impulses of high frequency control energy for automatically selecting a distant low frequency line and connecting said distant low frequency line to said high frequency system and for utilizing said high frequency energy to maintain the connection between said two low frequency lines and said high frequency system under control of one of said low frequency lines.

85. In a system of communication, low frequency lines and a high frequency system, means for transmitting low frequency control currents over a low frequency line to connect said low frequency line automatically with said high frequency system, and for transmitting other similar control currents and translating them into high frequency control energy for automatically selecting a distant low frequency line and connecting said distant low frequency line to said high frequency system and for maintaining the connection between said two low frequency lines and said high frequency system under control of one of said low frequency lines, and means for thereafter transmitting speech through said two connected low frequency lines and high frequency system in series, including means to translate speech into high frequency wave variations.

86. In a system having high frequency channels, terminals for said channels and extension circuits adapted to be connected to each terminal of said channels, means for transmitting control current over a said circuit to connect automatically said circuit to a said channel, and for transmitting similar control current and translating the control current into energy of a definite high frequency for transmission through said high frequency channel, to control the automatic connection of said high frequency channel to a second of such circuits, means for utilizing said energy of said definite high frequency to maintain under control of one of said connected circuits said connections so made, and for causing the high frequency channel so connected to exhibit a busy condition at both of its terminals to prevent other circuits from connecting with either terminal.

87. The method of controlling a high frequency system which comprises transmitting a high frequency wave, superposing two intermediate frequency waves upon said high frequency wave, controlling one of said intermediate frequency waves to control connections of said high frequency system to desired circuits, and controlling said other intermediate frequency wave to transmit intelligence through said high frequency system and the connected circuit.

88. The method of controlling a high fre-

quency system which comprises transmitting a high frequency wave, superposing two intermediate frequency waves upon said high frequency wave, controlling one of said intermediate frequency waves to control connection of said high frequency system to desired circuits, maintaining when made the said connection under control of the intermediate frequency wave by which the connection was effected, and controlling the other said intermediate frequency wave to transmit intelligence through said high frequency system to the connected circuit.

89. In a communicating system, the combination with a plurality of high frequency stations, of means at each station for transmitting and responding to a plurality of high frequency waves, and means for automatically preventing any of said stations from transmitting a high frequency wave of a wave length on which any other of said stations has started to signal.

90. In a radio trunking system, a vacuum tube detector, a circuit for impressing received radio frequency waves thereon, a switch for automatically extending a telephone connection, and a circuit controlled by said detector for controlling the stepping of said switch in accordance with said high frequency impulses.

91. In combination, a telephone line circuit, other circuits, a repeating coil operatively associated therewith, a switch for automatically extending the connection of said line circuit to other of said circuits, a stepping relay for controlling the actuation of said switch and a vacuum tube detector having its output side operatively associated with both said repeating coil and said stepping relay for both controlling actuation of said relay and impressing speech currents on said repeating coil.

92. In a carrier telephone system, means for transmitting a high frequency wave and controlling the wave in accordance with speech waves, and with switch-controlling impulses, a detector for deriving from said wave, components resulting from the control of said high frequency wave in accordance with speech and other components resulting from the control of said high frequency wave by said switch controlling impulses, a telephone receiver circuit, and a connection-extending switch-operating circuit operatively associated with the output side of said detector for controlling said telephone receiver circuit in accordance with said other components.

93. A high frequency transmitting circuit, and a high frequency receiving circuit at the same station, a source of low frequency variations at said station to be impressed upon said high frequency transmitting circuit, and means dependent upon energization of said receiving circuit for impressing

said low frequency variations upon said transmitting circuit.

94. In combination, telephone lines, a high frequency transmitting circuit, and a high frequency receiving circuit associated with one of said lines at a station on said line and in neutral relation as to each other, and means controlled from said receiving circuit for automatically extending the connection of said associated line to another of said lines.

95. In a telephone system, a plurality of telephone lines, a high frequency transmitting circuit associated with one of said lines at a station on said line, a high frequency receiving circuit associated with said line and arranged in neutral relation with said high frequency transmitting circuit, automatic switching arrangements for interconnecting said one line and another of said plurality of lines, and means to repeat signals between said high frequency circuits and the connected line.

96. In a communicating system, a two-way high frequency station comprising high frequency transmitting apparatus, high frequency receiving apparatus, and a low frequency circuit continuously associated in speech transfer relation with both mentioned apparatus, and arranged for two-way communication through said high frequency apparatus, telephone lines, and an automatic switching apparatus for automatically connecting said low frequency circuit and one of said telephone lines for two-way communication between the connected line and said high frequency apparatus.

97. In a carrier telephone system employing high frequency waves, a station, means thereat for receiving from said station a voice modulated high frequency wave and deriving speech variations therefrom, a plurality of outlying telephone stations, lines connecting said outlying stations with said first-mentioned station, and means controlled by a high frequency wave received at said station from said system for selecting a said outlying station and repeating said speech variations thereto through the medium of one of said telephone lines.

98. In a carrier telephone system, two distantly separated stations, oppositely directed conjugately related carrier wave communication channels between said stations, means at one station to transmit a high frequency wave through an outgoing channel, and means at the other station actuated in response to the receipt of said wave from the first station for transmitting a high frequency wave through the oppositely directed channel to the first station.

99. In a carrier telephone system employing high frequency waves for the transmission of speech, a carrier telephone station, a second carrier telephone station arranged to

communicate therewith, outlying stations, lines extending between said outlying stations and said first carrier telephone station, means at said first carrier telephone station controlled from said second carrier telephone station for automatically selecting a desired outlying station and extending an operative connection thereto from said first carrier telephone station through the medium of one of said lines, and means for effecting telephonic communication between said second carrier telephone station and the connected outlying station through the medium of a said high frequency wave and the connected line.

100. In a high frequency communicating system, three or more stations, any one of which is arranged for communicating with any other of the stations through the medium of a high frequency wave, a switch at one station automatically controlled to select and energize high frequency signaling apparatus at that station, and circuits for preventing the energization of the particular high frequency apparatus under control of said switch when a wave of the frequency employed by said high frequency apparatus is at the time being used for communication by others of said stations.

101. In a high frequency communicating system, a plurality of stations arranged for intercommunication through the medium of high frequency waves, a switch at each station for automatically selecting for use a high frequency wave and for controlling the energization of high frequency wave apparatus employing the selected high frequency, and means at another of said stations responsive to the transmission of said wave of selected high frequency for giving a busy signal to signify that the selected high frequency has been taken for use by another station.

102. In a two-way radio station, a transmitting antenna and a receiving antenna, separate tuning elements for each antenna, and a controlling member for simultaneously tuning said two antennae.

103. In a two-way radio station, a transmitting antenna, a receiving antenna separated at a distance therefrom and arranged in neutral relation thereto, tuning elements associated with each antenna, and a centrally located controlling member for altering the relations of the tuning elements of both of said antennae to adjust their tuning.

104. In a two-way radio station having separate transmitting and receiving antennae, arranged to employ for any two-way communication, each a different radio frequency tuning, a common controlling device for adjusting the transmitting antenna to one tuning and simultaneously setting the receiving antenna to another tuning.

105. In a signal system, a two-way radio

station having geographically separated radio transmitting and radio receiving apparatus, a two-way telephone line terminal, circuits for associating said terminal with said radio transmitting apparatus and said radio receiving apparatus, and means controlled from said telephone line terminal for tuning both said radio apparatus to desired wave lengths and for rendering said transmitting apparatus active to transmit radio messages by means of waves of the selected transmitting wave lengths.

106. In combination, a two-way carrier telephone channel, a telephone line, means for establishing a two-way talking connection between said channel and said line, a generator for supplying carrier current to said carrier telephone channel, and means actuated in the establishing of a two-way connection for automatically starting said generator into operation and for maintaining said generator in continuous operation dependent upon the continued establishment of said two-way connection.

107. In combination, a carrier telephone transmitting channel, a carrier telephone receiving channel, a telephone line, connection-extending apparatus for operatively connecting said line with both of said channels simultaneously, a source of carrier waves for said carrier transmitting channel, and means dependent upon the operated or non-operated condition of said connection-extending apparatus for rendering said source active or inactive to supply carrier waves.

108. In combination, a calling carrier telephone station and a called carrier telephone station, each provided with connection-extending apparatus, local telephone circuits adapted to be connected with each carrier telephone station, means at one station under control of said connection-extending apparatus for automatically sending out a carrier wave, wave-responsive means at the other station actuated by the wave so sent out and current-responsive means associated with said connection-extending apparatus at said other station and arranged to be actuated by said wave-responsive means.

109. In a carrier telephone system, stations, a carrier telephone channel at a calling station for communicating with a distant station, telephone lines terminating at said calling station, interconnecting apparatus for said channel and said lines, a signal in the calling station, means under control of said apparatus for sending out a carrier wave and for actuating said signal, means also at the distant station for sending out a carrier wave, and means for disabling the signaling circuit in response to receipt of said wave from the distant station.

110. In a carrier telephone system having a calling station and a called station, a two-way carrier telephone channel terminating in

each station, telephone lines and connection-extending apparatus at each station for establishing operative connections between said channel and a line, a signal at the calling station and local circuits for actuating said signal under control of said connection-extending apparatus, means also under the control of said connection-extending apparatus at the calling station for automatically sending out a carrier wave, a relay at the called station responsive to said wave, a current-responsive device associated with the connection-extending apparatus at the called station and actuated by said relay, means controlled by the connection-extending apparatus at said called station for sending out a carrier wave, and a relay at the calling station responsive to said last-mentioned carrier wave, said last relay being arranged to disable said local circuits and said signal.

111. In a carrier telephone system having a transmitting and a receiving high frequency station, and outlying telephone stations accessible from said receiving station, means to establish a communicating connection between said transmitting high frequency station and one of said outlying telephone stations through said receiving high frequency station, means to transmit a carrier wave between said high frequency stations, means to control said wave by speech and to repeat the speech to the connected telephone station, a relay at the receiving high frequency station arranged to be held energized by said carrier wave for the duration of said connection, and means concerned in the establishing, maintaining, and severing of said connection operated by said relay.

112. In a carrier telephone system, means to establish a communicating connection, means to transmit a carrier wave over the established connection, means to control said wave to transmit speech, a relay arranged to be actuated by said carrier wave independently of the transmitted speech variations and means operated by said relay for determining the duration of the establishment of said connection.

113. In a wave transmission system, means to send out a carrier wave continuously, distantly located signaling apparatus and automatically operating step-by-step apparatus separate from said signaling apparatus, means for utilizing said wave at times under control of an operator to cause actuation of said automatically operating apparatus and means to utilize said wave at other times to transmit signals.

114. In a carrier telephone system, means to impress on the system a carrier wave controlled by speech and another wave controlled in accordance with numerical designations, means for separately receiving said waves and for deriving speech and control

currents respectively from said waves, a switch adapted to be selectively set in accordance with said control currents and a telephone connection including contacts of said switch for transmitting said speech current.

115. In a carrier telephone system, a receiving station, a telephone line, other lines, means to receive a speech-controlled carrier wave from said system and to repeat the speech components into said line, means to receive another wave from said system, and an automatic switch controlled by said last mentioned wave for extending the connection of said telephone line to a selected one of said other lines.

116. In a communicating system means to receive a high-frequency wave, means to derive from said wave a voice-modulated carrier wave and an impulse controlled wave differing in frequency from the other mentioned wave, a circuit for receiving the voice currents, and a switch in said circuit controlled by said impulse-controlled wave.

117. In a communicating system means to transmit waves of different high frequencies and to impress speech on the wave of one frequency and to produce control designations in a wave of another frequency, a circuit at a distant point for receiving the speech and a switch in said circuit actuated under control of said control designations.

118. In a communicating system means to transmit a carrier wave controlled by speech and another wave of a different frequency controlled in accordance with station designations, separate receiving circuits at a distant point of the system and means for separating said waves to said circuits, a connection-extending switch associated with the receiving circuit for said speech-controlled wave, and means for operating said switch in accordance with the station designations of said other wave.

119. In a communicating system, distantly separated high-frequency stations, means at a station for transmitting a carrier wave, means at a distant station operated in response to said wave for sending a return carrier wave to the first station, and means for maintaining the simultaneous transmission of the waves from both stations and for separately and independently controlling each wave in accordance with signals.

120. In a communicating system, a station adapted to transmit carrier waves of different frequencies, distantly-located receivers for separately receiving said waves, sources of carrier waves of different frequencies at said receivers, means controlled by each receiver for operatively associating one of said sources with said receiver to transmit a return carrier wave of a different frequency to said station and means to

maintain simultaneous transmission of the wave sent to any receiving station and the corresponding return wave and to control each wave by signals.

121. In a communicating system having three or more carrier-wave signaling stations, means at a station to transmit a carrier wave to call any other station, the station called being dependent upon the frequency of the carrier wave sent out from the calling station, means at the called station actuated by receipt of said wave for sending out a return carrier wave different in frequency from the received wave and means to maintain simultaneous transmission of the wave sent to any receiving station and the corresponding return wave and to control each wave by signals.

122. In a communicating system having stations, means at a station to call and communicate with another station by means of a carrier wave of a particular frequency, means at said first-mentioned station to call and communicate with a different other station by means of a carrier wave of another particular frequency, and means at each called station actuated in response to the wave from said first mentioned station for sending out each a wave of different frequency to serve as return carrier communicating channels to said first station while continuing to receive and respond to the wave sent out from the first station.

123. In a carrier telephone system, a transmitting carrier channel comprising means to transmit a high frequency wave and to modulate the wave in accordance with speech, a distant telephone station to be communicated with through the medium of said carrier wave channel, a call signal at said station, means to transmit the carrier wave of said channel continuously during the talking period, a relay held energized by said wave, and means controlled by the deenergization of said relay in response to the control of said carrier wave for causing the signal at said distant station to be actuated.

124. In a communicating system, a station adapted to transmit carrier waves of different frequencies, distantly-located receivers for separately receiving said waves, means controlled by each receiver for transmitting a return carrier wave of a different frequency to said station and means to maintain simultaneous transmission of the wave sent to any receiving station and the corresponding return wave and to control each wave by signals.

125. In a radio signaling system, a central station comprising receiving and transmitting circuits adapted for communication with a plurality of stations, switching mechanism associated therewith, said mechanism controlling calling means for selec-

tively calling any distant station and for connecting in the receiving circuit.

126. A signaling system comprising a two-way low frequency communication circuit, a carrier wave circuit comprising a receiving channel conjugately associated with a transmitting channel including a normally inactive source of carrier waves, and means associated with said low frequency circuit for rendering said carrier source active.

127. A carrier telephone system comprising a telephone circuit, a carrier wave circuit comprising a receiving channel in continuously operative condition simultaneously with a transmitting channel, said channels forming together a two-way conversational channel, said transmitting channel including an inactive source of carrier waves, and means responsive to connection of said telephone circuit to said carrier circuit for automatically causing said carrier source to become active.

128. A carrier telephone system comprising a telephone circuit, a carrier wave circuit having a receiving channel and a transmitting channel connected to the same end of said telephone circuit for simultaneous operation, an inactive source of carrier waves included in said transmitting channel, and means associated with said telephone channel for causing said carrier wave source to become active.

129. In a communicating system, the combination with a line, of a plurality of high frequency stations having means for producing and utilizing a plurality of pairs of high frequency waves for communicating between said stations, means controlled over said line for automatically selecting an idle one of said high frequency stations, and means at each of said high frequency stations for automatically selecting for use one of said pairs of high frequency waves.

130. In a communicating system, the combination with a line, of a plurality of high frequency trunks, each trunk having means for producing and utilizing a plurality of high frequency waves, means controlled over said line for automatically selecting an idle one of said high frequency trunks, automatic means for selecting for production and utilization an idle one of said high frequency waves, and means to indicate the selected wave as busy at other trunks of the system.

131. In a signaling system, a line, a plurality of high frequency signaling stations to which said line has access, means at each of said high frequency stations for transmitting and receiving a plurality of high frequency waves for utilization in effecting non-interfering communication with distant similar stations, means controlled over said line for automatically selecting an idle one of said stations, and means for thereafter selecting and appropriating for exclusive

use an available one of said high frequency waves, including means to indicate the selective wave as busy at other stations of the system.

132. In a communicating system, the combination with two high frequency stations, each having communicating apparatus and controlling apparatus, of means at each station for producing and responding to high frequency waves, and automatic switching means for making received waves operative to control alternatively said controlling apparatus and said communicating apparatus.

133. The combination with two high frequency stations each having means for producing and responding to a high frequency wave, of automatic means at each station controlled by said responding means for bringing the producing means of that station into operative relation with the responding means of the other station in turn through the medium of said wave.

134. In a high frequency communicating system, the combination with a plurality of high frequency stations, each provided with high frequency transmitting and receiving means including a transmitting antenna and a receiving antenna separate therefrom, of tuning circuits for each high frequency station controlling the tuning of the high frequency transmitting and receiving means of that station, an electromagnetically operated step-by-step switch for selectively controlling said tuning circuits, an associated station, and means thereat for controlling the operation of said step-by-step switch.

135. In a system of communication including high frequency wave stations each having means for transmitting and receiving a number of high frequency waves, lines each having access to all of said stations, automatic means for selecting an idle station for connection with a calling one of said lines, and means controlled over the two sides of the calling line for selecting for use a wave of a desired high frequency and for operatively associating said calling line with the high frequency apparatus, using said selected high frequency wave whereby signals on the calling line are repeated as variations of the selected high frequency wave.

136. In combination, a high frequency signaling system having a number of stations, each station being capable of communicating through any one of a number of high frequency channels, said channels including provisions for simultaneous and non-interfering transmission and reception from and to said station, means for automatically selecting for use an idle station, and means for automatically selecting a desired high frequency channel of said station.

137. In combination, a high frequency

signaling system having a number of stations, each station being capable of communicating through any one of a number of high frequency channels, a line adapted to be connected to any one of said stations, and means controlled over the two sides of said line for automatically selecting and appropriating for use an idle one of said stations and for automatically connecting said line to a desired channel of said station for communication over said line and through said high frequency channel.

138. A system of communication comprising low frequency lines and a high frequency channel, and means for transmitting impulses over the two sides of a said low frequency line to connect automatically said line with said high frequency channel and for thereafter transmitting signals over said low frequency line and translating said signals into high frequency wave variations for transmission through said high frequency channel.

139. In a system of communication, low frequency lines and a high frequency system, and means for transmitting control currents over the two sides of a low frequency line to select automatically under control of said current an idle station of said high frequency system, and means for automatically selecting a high frequency channel terminating in said station and for connecting said low frequency line to said selected high frequency channel.

140. The combination with a telephone line, of a high frequency station having a source of high frequency waves for transmitting, and means controlled over the two sides of said telephone line for operatively associating the terminals of said line with said source and for thereafter variably controlling the transmission of high frequency waves from said source in accordance with signals on said line.

141. The combination with a telephone line, of a high frequency station, means thereat for generating waves of different high frequencies for transmission, an automatic switching mechanism controllable over said telephone line for selecting any one of a plurality of said wave frequencies to be transmitted and for operatively associating the terminals of the line with said means to control the transmission of the waves of that frequency in accordance with signals on said line, and means at said station operative simultaneously with said wave generating means for receiving high frequency waves from a distance and translating them into signals for transmission over said line.

142. In a signaling system, a two-wire line, a plurality of two-way high frequency wave channels, said channels comprising provisions for simultaneous and non-interfering transmission and reception of high

frequency waves including apparatus for generating a plurality of distinctive high frequency waves and controlling each of said waves to transmit signals, a step-by-step switch at a station of said system controlled over the two sides of said line and arranged to select and actuate apparatus individual to one of said channels and employing a particular one of said high frequency waves, and means controlled over said two-wire line for variably transmitting waves from the selected apparatus.

143. In a signaling system, a radio station comprising radio apparatus, a two-wire telephone transmission line associated with said radio station, and selective means controlled over the two sides of said line and operable to connect said radio apparatus to and to disconnect it from a terminal of said transmission line.

144. In a signaling system, a radio station comprising radio apparatus, a two-wire signal transmission line associated with said radio station, a control station associated with said line, and selective means at said radio station controlled over the two sides of said line from said control station to connect said radio apparatus to and disconnect it from a terminal of said line.

145. In a signaling system, a radio station comprising radio apparatus, a plurality of transmission circuits associated with said radio station, and automatic selective means at said radio station controlled by said radio apparatus whereby said radio apparatus can be put into communicative relation with any of said lines.

146. In a signaling system, a radio station comprising radio apparatus, a plurality of two-wire signal transmission circuits, and automatic selective means at said radio station whereby said radio apparatus can be put into communicative relation with one of said transmission circuits, said automatic selective means being controlled over a series circuit including the two wires of any of said transmission circuits.

147. In a signaling system, a radio station comprising radio apparatus, a two-wire signal transmission line associated with said radio station, and means at said radio station controlled over the two sides of said line for changing the operating wave length of said radio apparatus.

148. In a telephone system, a calling subscriber's station, a called subscriber's station, a telephone line connected with at least one of said stations, a source of high frequency carrier current, automatic means operable over a series circuit including the two sides of said telephone line for selectively associating said source of carrier current with said line, and means including said source of carrier current and said telephone line for

transmitting speech between said subscriber's stations.

149. The combination in a telephone system, of a source of high frequency carrier current for the propagation of speech, a telephone transmission line, and automatic switching means controlled over the two sides of said telephone line for operatively associating said source of carrier current with said line.

150. The combination in a telephone system of a plurality of sources of high frequency carrier current for the propagation of speech, a telephone transmission line, and means automatically controlled over the two sides of said telephone transmission line for selectively and operatively associating said sources of carrier current with said line.

151. The combination in a telephone system including a telephone circuit of a two-way carrier wave communication channel including an outgoing and an incoming branch both simultaneously associated in speech-transfer relation with said telephone circuit, a telephone transmission line, and means automatically controlled over said telephone transmission line for connecting said line to said circuit.

152. The combination in a telephone system including a plurality of telephone circuits of a plurality of two-way carrier telephone channels, each including an outgoing and an incoming branch simultaneously associated in speech transfer relation with one of said telephone circuits, a telephone transmission line, and means automatically controlled over said line for operatively associating said line with any one of said circuits.

153. The combination in a telephone system of a high frequency carrier wave channel for the propagation of speech, a telephone transmission line, and means automatically controlled through the medium of said carrier wave channel for operatively associating said carrier wave channel with said line.

154. The combination in a telephone system of a plurality of sources of high frequency carrier current for the propagation of speech, a plurality of telephone transmission lines, and automatic selecting means controlled over the two sides of a telephone transmission line for associating any of said sources of carrier current with the corresponding transmission line in speech transfer relation thereto.

155. In a telephone system, a calling subscriber's station, a called subscriber's station, a telephone line connected with at least one of said stations, a plurality of sources of high frequency carrier current, means automatically controlled over the two sides of said telephone line for selectively associat-

ing said sources of carrier current with said line, and means including said line and a selected one of said sources of carrier current for transmitting speech between said subscribers' stations.

156. In a telephone system, a calling station, a called station, a telephone line connected with at least one of said stations, a high frequency transmitting terminal, a high frequency receiving terminal, means automatically controlled from said calling station for operatively associating with said line said high frequency transmitting terminal and said high frequency receiving terminal in neutral relation with respect to each other, and means including said line and said connected high frequency terminals for carrying on two-way conversation between said stations.

157. In a telephone system, a calling station, a called station, a line connected with at least one of said stations, a carrier wave transmission terminal, a carrier wave receiving terminal, an impulse sending device at said calling station, means automatically operable under the control of said impulse sending device for extending a two-way signaling path between said stations including said line and said carrier wave transmission and receiving terminal in neutral relation with respect to each other, and means including said carrier wave transmission and receiving terminals and said telephone line for propagating speech between said stations.

158. In a signaling system the combination with a metallic circuit signal transmission line of a source of high frequency waves, means operable in response to the opening and closing of said line circuit for connecting the terminals of said line with said source, means for projecting signals over said line to said high frequency source, and means for modulating the high frequency waves in accordance with said signals.

159. A telephone system comprising telephone exchanges, subscribers' stations, two-wire telephone transmission lines, means at said telephone exchanges for selectively effecting connections between said subscribers' stations through the medium of said transmission lines, said means being controlled over the two-wire circuit of the respective line, a plurality of separated radio stations operatively associated with said telephone exchanges, and means whereby a signal may be propagated through the medium of any of said telephone exchanges, and a plurality of said radio stations conjointly and simultaneously.

160. In a combined wire and radio communication system, a telephone line comprising a conductor and a return path, radio stations, means controlled over said conductor and return path for automatically controlling

a plurality of said radio stations, and means controlled over the same conductor and return path used for controlling said radio stations, for propagating speech through the medium of said line and said plurality of radio stations simultaneously.

161. In a telephone system, distantly separated radio or carrier stations including transmitting and receiving radio or carrier apparatus, a telephone subscriber's station, a telephone switching station, means thereat controlled from said subscriber's station for operatively connecting said subscriber's station with the radio or carrier transmitting and receiving apparatus at one of said radio or carrier stations and for enabling said subscriber to carry on a two-way conversation through the medium of the connected radio or carrier station with the said other radio or carrier station.

162. In a telephone system, distantly separated telephone exchanges, a two-way radio telephone link between said exchanges, outlying subscribers' stations connectible with the respective telephone exchanges, and means whereby a subscriber in one exchange area may call and converse with a subscriber in another exchange area comprising said two-way radio link and switching means controlled by the calling subscriber for automatically connecting his line with said radio link.

163. In a telephone system, a long distance two-way radio trunk terminating in respective telephone central stations, subscribers' stations, means automatically controlled from a subscriber's station for operatively associating his line with a terminal of said radio trunk, and means whereby said subscriber may carry on a two-way conversation over his line and the connected radio trunk with a distant station, the connection of said subscriber's line with said terminal of said radio trunk being maintained continuously for the duration of said conversation.

164. In a telephone system, a long distance two-way high frequency carrier wave trunk, a telephone exchange including an operator's position, a subscriber's line incoming to said position, automatic selective switching means controlled from said operator's position for extending a talking connection from said subscriber's line to a terminal of said carrier wave trunk, and means whereby a two-way conversation may be carried on over said subscriber's line, talking connection and carrier wave trunk with a distant party entirely under the control of the talking parties.

165. A system, according to claim 164, in which said means for carrying on a two-way conversation includes means for connecting said subscriber's line with the transmitting and receiving apparatus of said carrier wave

trunk and for maintaining such connection for the duration of the two-way conversation.

166. A system, according to claim 164, in which said means for carrying on a two-way conversation includes means for connecting said subscriber's line with the transmitting and receiving apparatus of said carrier wave trunk and for maintaining such connection for the duration of the two-way conversation, and in which the means for connecting to the transmitting and receiving apparatus of said carrier wave trunk comprises a hybrid coil in the talking connection, the conjugate limbs of which are connected to said carrier wave transmitting and receiving apparatus, respectively, for the duration of the conversation.

167. In a carrier wave communication system, a plurality of receiving stations each having a normal tuning, a transmitting station equipped with transmitting apparatus, means for tuning and operating said transmitting apparatus with reference to the normal tuning of any of said receiving stations, and an indicator at said transmitting station operable from a receiving station under

control of waves received thereat sent out from said transmitting station for giving different indications dependent on whether the receiving apparatus at said last mentioned receiving station is operating in resonance or out of resonance with the transmitted wave.

168. In a high frequency duplex telephone installation, the combination of a telephone exchange, carrier wave transmitting and receiving stations in connection therewith, a starting relay at the exchange whereby the transmitter is set in action, a control relay controlling the circuit of the starting relay, a holding relay adapted to be energized on the receipt at the receiving station of oscillations from a distant station and controlling the circuit of the control relay, and local means for maintaining said holding relay operated after cessation of the oscillations from the distant station.

In witness whereof, we hereunto subscribe our names this 29th day of March A. D., 1920.

SAMUEL B. WILLIAMS, JR.
LEWIS M. CLEMENT.