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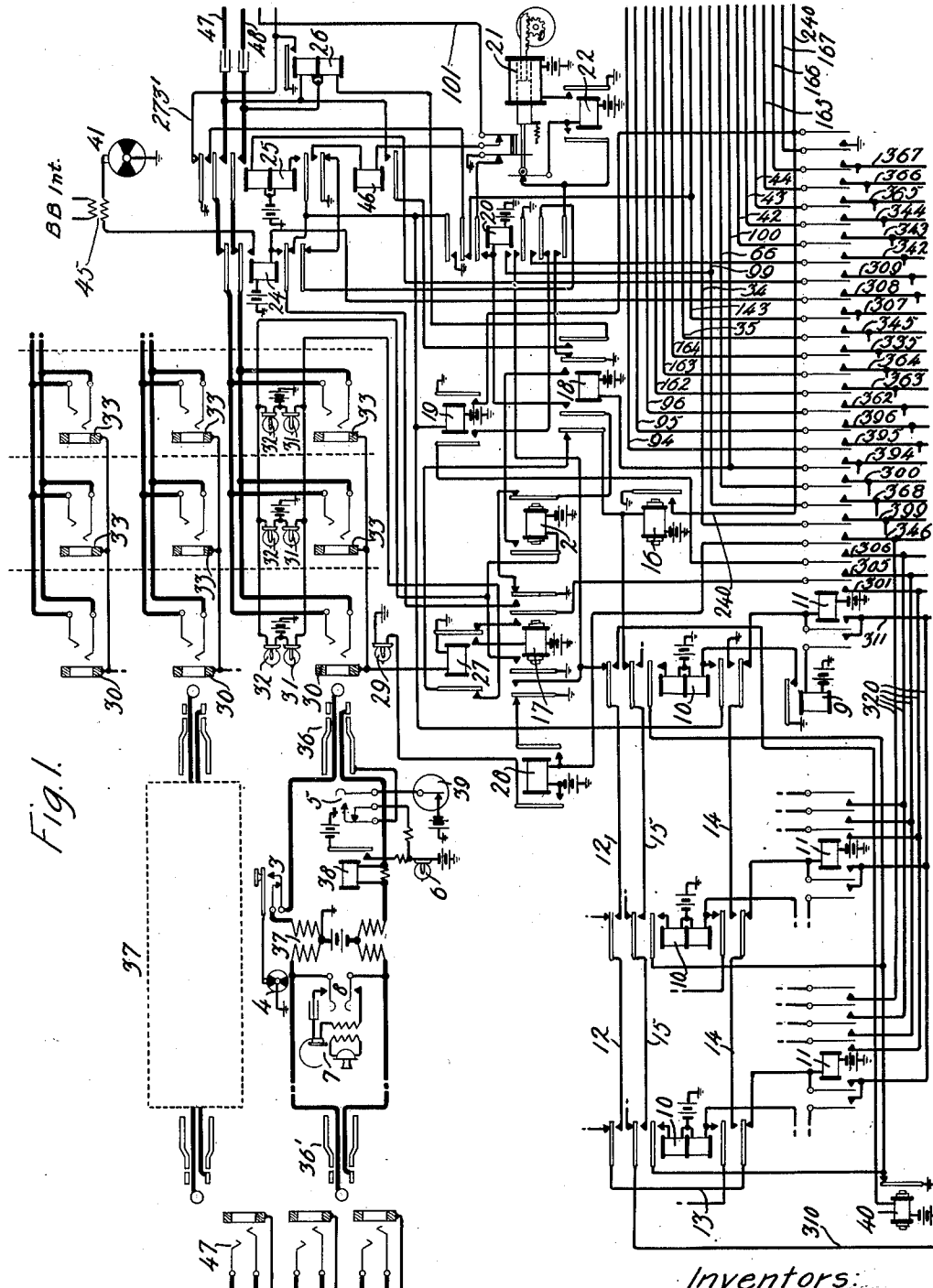
1,572,756

E. H. SMYTHE ET AL

HIGH FREQUENCY WAVE SIGNALING AND COMMUNICATING SYSTEM

Filed May 14, 1921

5 Sheets-Sheet 1



Inventors:
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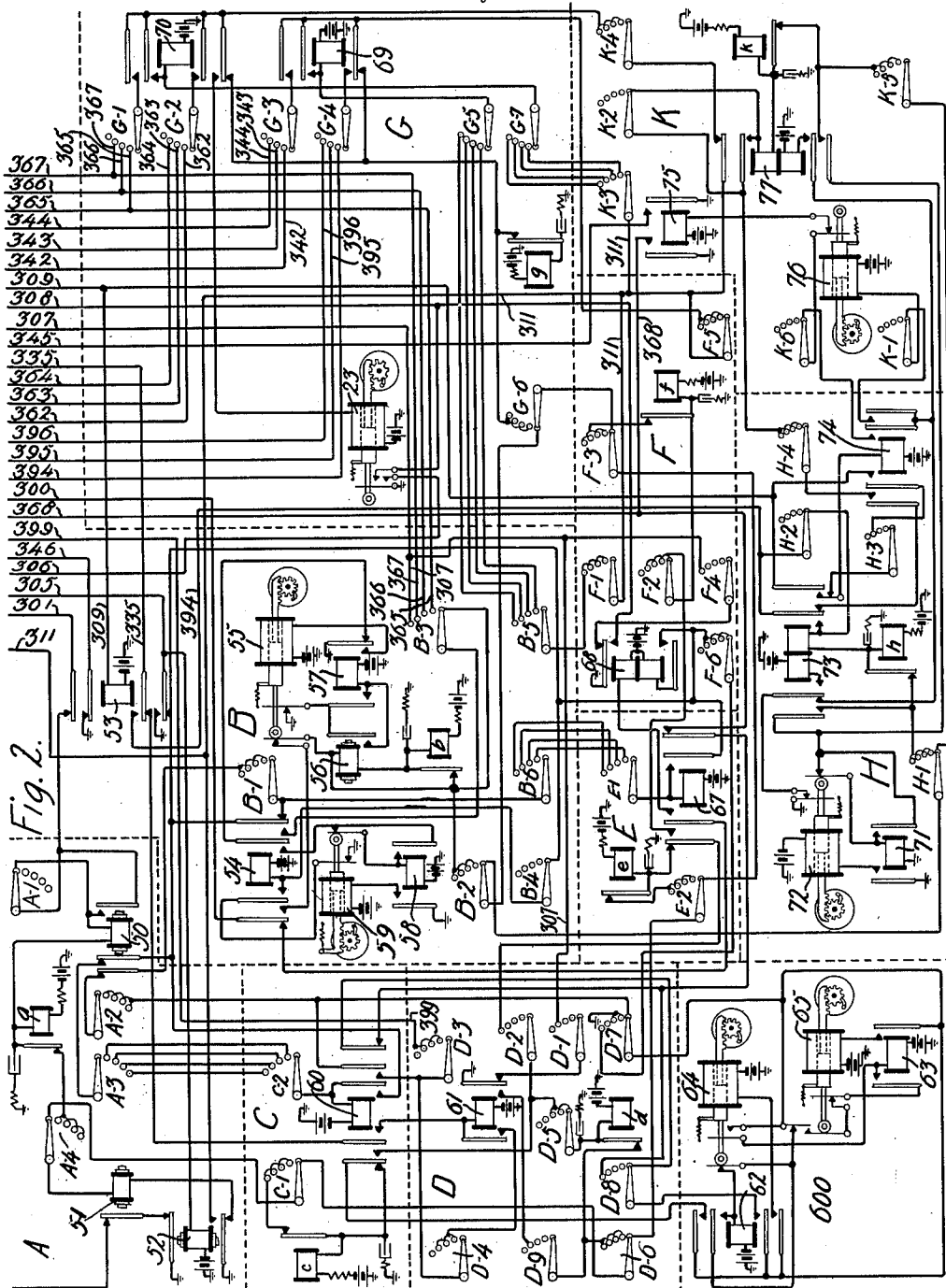
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HIGH FREQUENCY WAVE SIGNALING AND COMMUNICATING SYSTEM

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5 Sheets-Sheet 2



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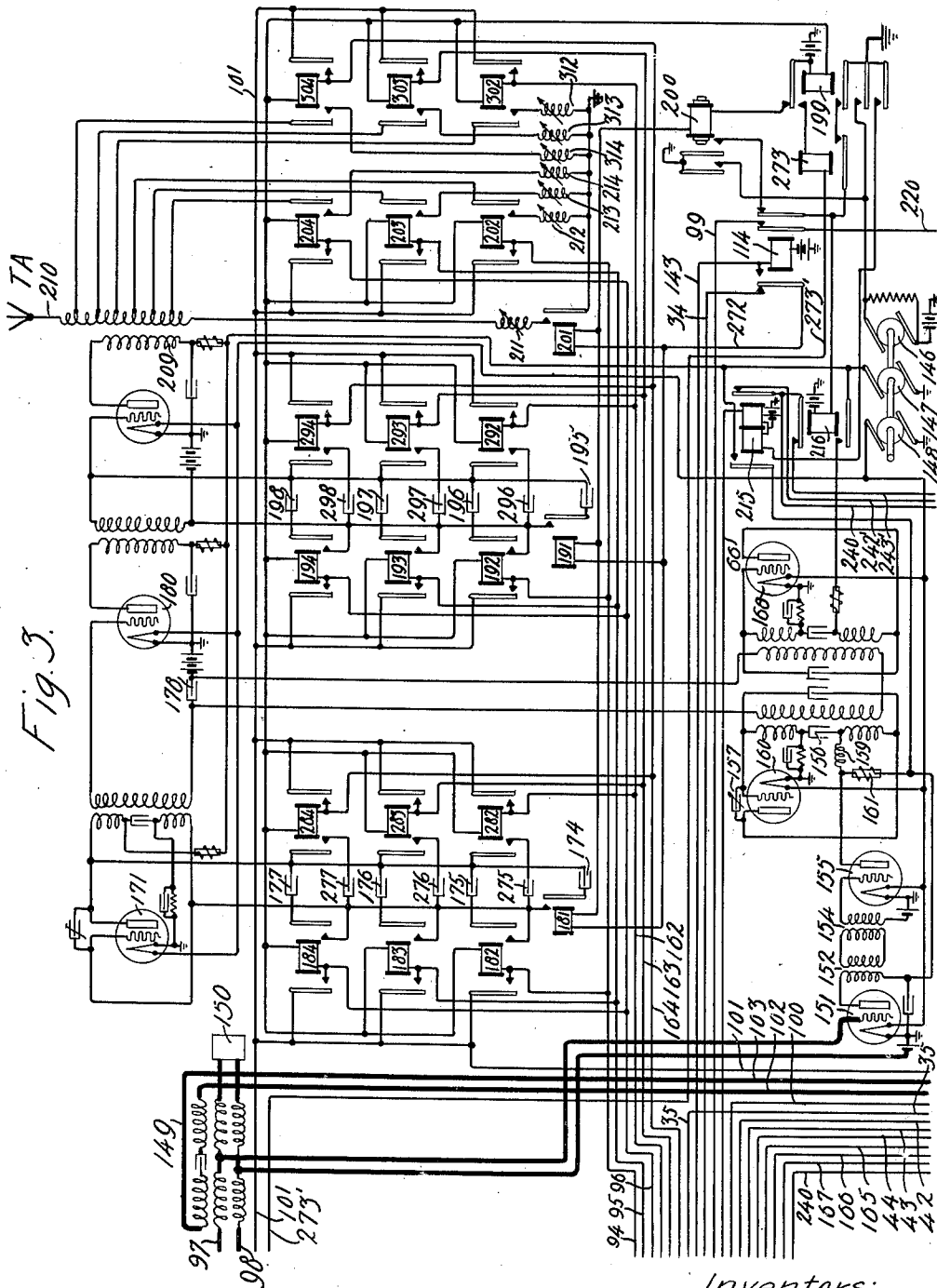
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HIGH FREQUENCY WAVE SIGNALING AND COMMUNICATING SYSTEM

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5 Sheets-Sheet 3



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5 Sheets-Sheet 4

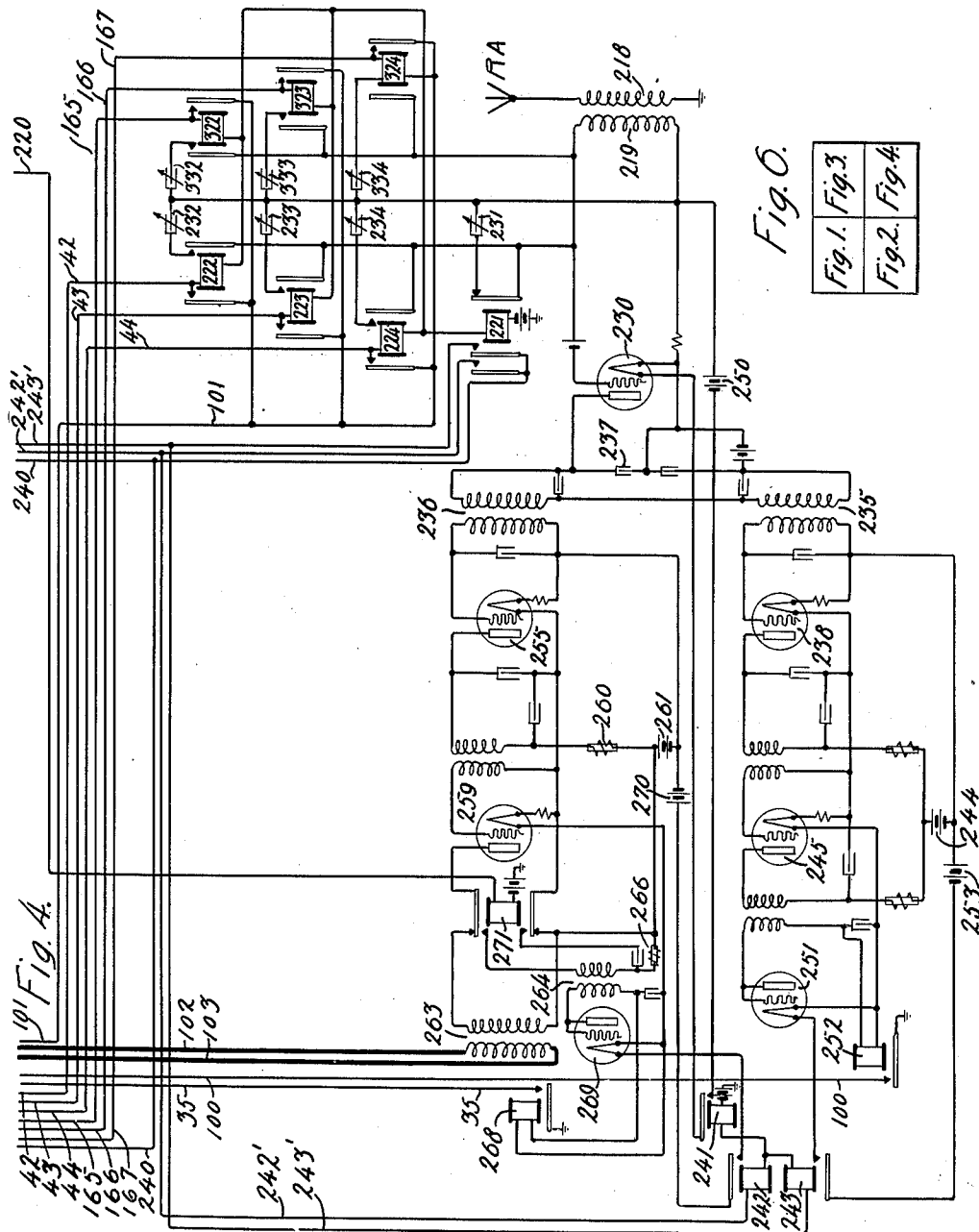


Fig. 0.

Fig. 1. Fig. 3.
Fig. 2. Fig. 4.

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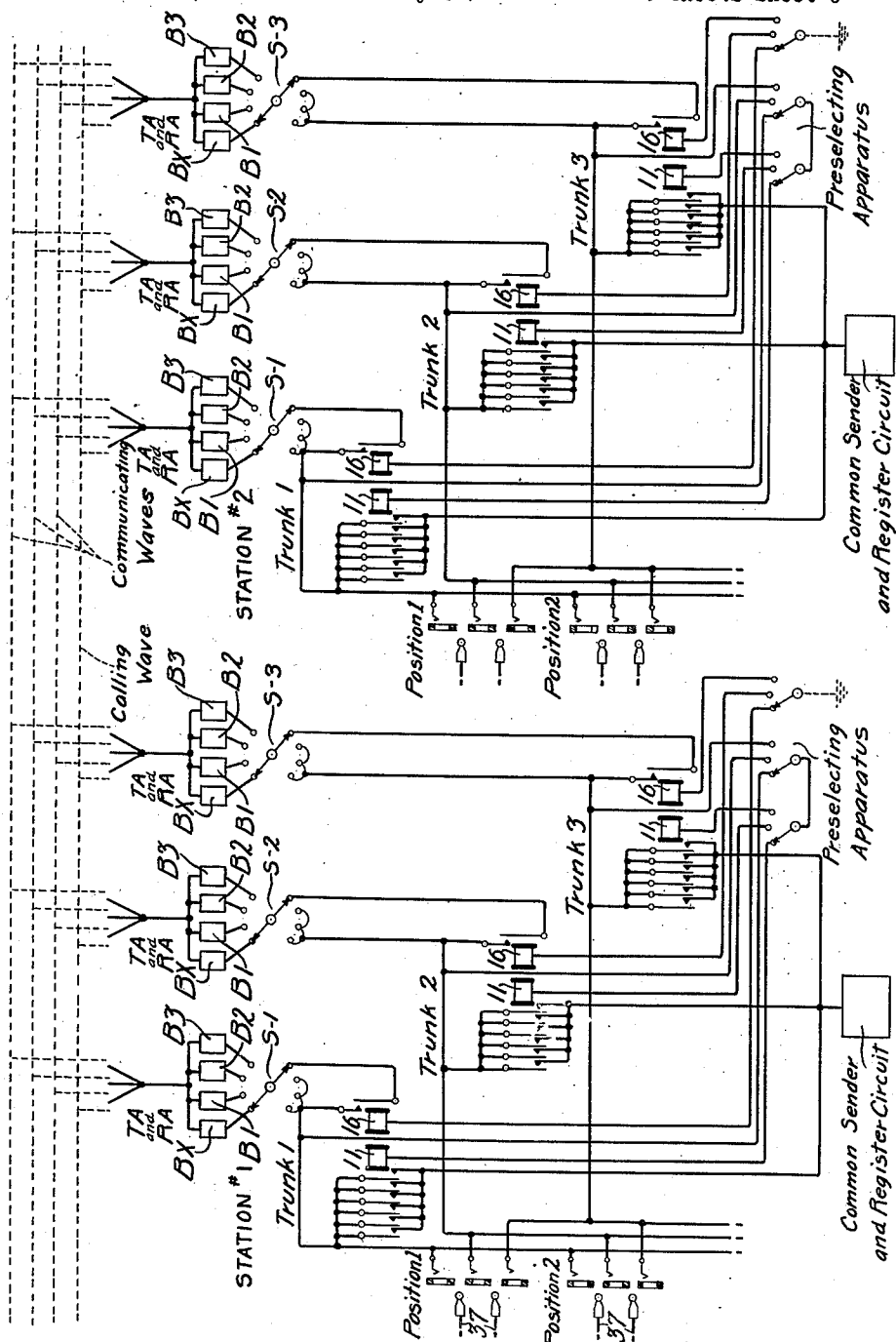
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5 Sheets-Sheet 5

Fig. 5.



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UNITED STATES PATENT OFFICE.

EDWIN H. SMYTHE, OF EVANSTON, ILLINOIS, AND SAMUEL B. WILLIAMS, JR., OF BROOKLYN, NEW YORK, ASSIGNORS TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

HIGH-FREQUENCY-WAVE SIGNALING AND COMMUNICATING SYSTEM.

Application filed May 14, 1921. Serial No. 469,398.

To all whom it may concern:

Be it known that we, EDWIN H. SMYTHE and SAMUEL B. WILLIAMS, JR., citizens of the United States, residing at Evanston, in the county of Cook and State of Illinois, and at Brooklyn, in the county of Kings and State of New York, respectively, have invented certain new and useful Improvements in High-Frequency-Wave Signaling and Communicating Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to an improved communicating system, and more particularly to a communicating system of the type in which high frequency waves or oscillations, either free or guided, are employed as the medium for conveying between the different stations of the system the energy for controlling the operation of the electric signaling, controlling and communicating apparatus.

Intercommunication between the stations of a high frequency system is effected through the medium of what are commonly known as high frequency channels, each channel consisting of apparatus for transmitting and receiving a wave of a certain frequency as distinguished from the apparatus used in transmitting and receiving a wave of a different frequency; or, in the case of a channel for carrying on conversation or two-way communication between two stations, the channel may comprise the apparatus for transmitting and receiving waves of two different frequencies, one of the waves being used for transmitting in one direction and the other wave for transmitting in the other direction. The characteristics of these channels are such that each is capable of transmitting and receiving only its own particular frequency or set of frequencies, so that simultaneous use of the channels is possible without interference between them. A communicating system employing channels of this type is shown in U. S. Patent No. 1,499,081 issued to E. H. Smythe and S. B. Williams, June 24, 1924. The number of non-interfering channels that may be provided in this class of systems is, however, limited; and it is the particular object of the present invention so to organize a high frequency system that a relatively small num-

ber of non-interfering channels may be used with the highest efficiency in affording controlling and communicating facilities between a number of stations and so that the maximum of flexibility in the matter of the trunking or communicating facilities of the system may be attained.

The present invention contemplates a high frequency system in which intercommunication between the various stations of the system is effected through the medium of a number of such non-interfering high frequency channels, each of which may be available to all of the stations. Each of the stations of the system is so organized that not only may it establish connection with any other station of the system by way of any of the high frequency channels, but it may also utilize simultaneously all of the channels that are not at the time in use for the interconnection of other stations of the system. Furthermore, the system of the invention is so organized that each station has means for keeping at all times in operative relation with one of the channels and available for incoming or outgoing calls one or another of a number of trunks or channel extensions, so that the initiation of a call either from or to the station finds an outlet or inlet for the call at once available; and when one of the trunks or extensions is taken for use, another is automatically preselected and placed in operative relation with the channel for the use of the next call. This calling channel is therefore kept constantly in operative relation with all of the stations of the system, and with an idle or available trunk at each of the stations.

In order to simplify the system, effect economy in the apparatus required, and realize certain advantageous features of operation, the system of the invention is further so organized that only such of the elements of each trunk as are directly involved in the separate connection established over the trunk are individual to the trunk, the other elements that are involved in the receipt of a call, the selection of the particular station called, the selection of a communicating channel and the control of the trunk in the setting up of the connection being common to all of the trunks, and being automatically associated with or attached to each trunk

when their co-operation is required, and thereafter automatically detached and associated with the next trunk to be used.

In addition the system of the invention 5 in the preferred form in which it is disclosed, embodies a number of other features incidental and auxiliary to those mentioned above. The manner in which the above mentioned features, and the features auxiliary or incidental thereto, are realized will 10 be explained in the following description of the preferred form of the invention, and the structures and combinations through which the objects of the invention are attained 15 will be more particularly defined in the appended claims.

The preferred embodiment of the invention is illustrated in the accompanying drawings, in which Figs. 1 to 4, inclusive, 20 show diagrammatically as much of the circuit organization as is necessary to enable the invention and the preferred manner of practicing it to be understood, and in which Fig. 5 is a schematic outline of the general 25 idea or plan of the system. In assembling Figs. 1 to 4 of the drawing to show the circuit organization, they are arranged as indicated in Fig. 6.

Referring first to Fig. 5, this illustrates 30 schematically two of the plurality of stations which may be assumed to be adapted for intercommunication through the medium of the high frequency communicating system of the present invention. These stations 35 are indicated in the present instance as radio stations, that is, stations between which interconnection and intercommunication are established through the medium of 40 unguided high frequency waves transmitted through space. In the specification that follows the high frequency stations may occasionally be referred to as radio stations; but it is to be understood that the use of this 45 term is not intended to limit the invention to exclude a system the stations of which are operatively related through the medium of high frequency waves guided upon conductors, as the stations of the organization 50 disclosed may be of this character. Each high frequency or radio station is represented as being provided with conductive means for establishing connection with any of the 55 local stations that may be assumed to be associated with it, and with radio or high frequency wave means for establishing communication with any of the other radio stations of the system.

The two stations shown in Fig. 5 are indicated station No. 1 and station No. 2, respectively. Each of the stations is indicated 60 as having three trunks, trunk 1, trunk 2 and trunk 3. Each of these trunks is represented as terminating at one end in spring jacks located respectively at position 1 and 65 position 2 of the switchboard, and at the

other end in tuning or channel selecting switches S^1 , S^2 and S^3 , co-operating with radio or high frequency communicating apparatus, which is indicated in the present instance as merely a single antenna designated TA and RA with the associated calling channel BX and communicating channels B^1 , B^2 and B^3 , but which in the present embodiment of the invention stands for 70 separate transmitting and receiving antennæ systems. Each station is assumed to have a number of associated local lines with which the three trunks of the station may be connected through the medium of 75 the connecting circuits 37 shown at the two switchboard positions. 80

The interconnection of the trunks of one station with the trunks of another station is through the medium of three pairs of high frequency communicating waves and a high 85 frequency calling wave, indicated in the present instance by the broken lines designated communicating waves and calling wave, respectively. The ability of each 90 trunk to be brought into operative relation alternatively with the calling wave or any of the pairs of communicating waves is indicated by the antennæ TA and RA being 95 connected through the channels BX, B^1 , B^2 and B^3 with the stationary terminals of the associated tuning switch. In its first or normal position each switch brings its associated trunk into operative relation with the 100 calling wave through the medium of the calling channel BX and the antennæ TA and RA. In each of its other three positions, each switch establishes operative relation with one of the pairs of communicating waves through the medium of the corresponding channel B^1 , B^2 or B^3 . 105

The three trunks of each station are represented as being adapted to be brought into operative relation with the apparatus designated common sender and register circuit through the medium of relays 11, 110 one of which is associated with each of the three trunks. Each trunk is also indicated as having associated with it a relay 16 that is adapted when operated to complete operative connection between the trunk and its 115 particular antennæ TA and RA through the medium of the associated tuning switch and the calling channel BX. The schematic representation is such as to indicate that when the tuning switch is in its normal position to tune the associated antenna to the 120 calling wave, the operative connection between the trunk and the antenna is under the control of the relay 16; while the movement of the switch to tune the antenna to 125 any one of the pairs of communicating waves establishes a direct operative relation between the antenna and the trunk at the lower contacts of the switch. As represented, therefore, when the antennæ asso- 130

ciated with any of the trunks are tuned to one of the pairs of communicating waves, their operative condition is independent of the connection by way of the contacts of the associated relay 16.

Associated with the three trunks at each station is common apparatus for determining which of the trunks shall next be used for incoming or outgoing calls, and which is designated preselecting apparatus. This apparatus is shown in the schematic representation of Fig. 5 as three switch arms, each provided with a contact point for each trunk, the connections extending from the switch arms and their contact points being such that in whichever position the switch is standing the trunk corresponding to that position has control over its multi-contact relay 11, while the associated trunk relay 16 is actuated to make operative the antennae TA and RA of that trunk. Therefore, for each of the three positions that the preselecting apparatus may occupy, a corresponding one of the trunks has its antennae made responsive and operative by way of the calling channel, and the common sender and register circuit placed in readiness to become attached to that trunk when the trunk is energized either through one of its conductive terminals or through its radio or high frequency terminals. When the common sender and register circuit is attached to the particular trunk determined by the position of the preselecting apparatus, it is adapted to control and be controlled by the apparatus of the associated trunk, and to tune the antenna or high frequency terminal of the trunk, through the medium of the corresponding tuning switch to the particular pair of communicating waves that is selected for use.

As has been stated, Fig. 5 is merely an attempt to illustrate schematically the general idea or plan of arrangement of the system, and does not pretend to show anything more than this. Furthermore, the invention contemplates such multiplication of the parts or elements indicated in Fig. 5 as may be desirable in practice. There may be as many stations employed as may be desired. There may also be any desired number of communicating waves or channels for taking care of the traffic between the various high frequency stations of the system; and each station may have as many trunks as there are communicating channels, so that if necessary any one of the stations may utilize all of the channels simultaneously for communication with one or more of the other stations.

Referring now to the preferred circuit organization as illustrated in Figs. 1 to 4 inclusive of the drawing, only as much of the wiring of a single station is shown as is necessary to enable the invention to be understood, it being possible for one skilled in the

art, by mere extension and duplication of the wiring and apparatus illustrated, to organize a system of such capacity as may be desired. As illustrated in the circuit diagram of Figs. 1 to 4 inclusive, the toll station is provided with a plurality of trunks or high frequency channel extensions. The wiring of one of these trunks and the associated high frequency apparatus is shown in detail in Figs. 1, 3 and 4; and two other trunks are indicated by additional relays 10 and 11 and spring jacks 30 and 33 such as those of the trunk that is completely shown. The wiring of the two trunks thus suggested in the diagram may be assumed to be similar to the wiring of the trunk that is shown. Each of the trunks is associated with high frequency terminal apparatus consisting in the present instance of the transmitting antenna TA and the receiving antenna RA with the various elements that constitute and control the associated high frequency channels; and also with certain conductive terminals consisting in the present instance of the answering springjack 30 and two multiple springjacks 33. The multiple springjacks 33 in accordance with the usual practice are located upon different sections of the toll board. Connection with the conductive terminals of the high frequency trunk is made in the present instance through the medium of connecting cord circuits, of which one, designated 37, is shown and another indicated, it being assumed that there are provided as many such connecting circuits as traffic conditions require. Each of the connecting cord circuits 37 is illustrated as being provided with a connecting plug 36 adapted for insertion in the springjacks 30 and 33, a calling key 5, a calling dial 39, a supervisory lamp 6, a supervisory relay 38, an operator's telephone outfit 7, and a listening key 8. The other end of the connecting circuit, which is not shown in detail, is indicated as terminating in a plug 36'; but it may be assumed to be adapted, in any one of the ways well known in the art, for either manual or automatic connection with such other circuits as may require extension to the high frequency trunk. The answering springjack of the trunk has associated with it a line lamp 29, the illumination of which indicates an incoming call over the trunk; and each of the springjacks 30 and 33 has associated with it an assigning lamp 31 for indicating to the operators the availability of the trunk for an outgoing call, and a busy lamp 32 for indicating the condition of use of the trunk.

Each of the stations has a common sender and register circuit which is common to all or a plurality of the trunks of that station, and to the circuits of which any one of the trunks may be temporarily extended through the medium of the contacts of a multi-con-

tact relay 11 individual to the trunk. Which of the trunks of the station shall next be used and brought into operative relation with the common sender and register circuit of Fig. 3, is determined by a control exercised through the medium of a series starting or preselecting circuit including the conductors 12, 15 and 14 that extend between the contacts of the relays 10 of the various trunks; and a relay 40 common to all of the trunks restores the normal condition of the preselecting circuit when all of the trunks in the series have been once used.

The common sender and register circuit of the station, as illustrated in Fig. 2, has associated with it receiving register switch apparatus and transmitting register switch apparatus employed when the trunk to which the common circuit is attached, is being used for calling another radio station, and additional station selecting switch apparatus and receiving register switch apparatus employed when the associated station is being called by some other radio station. The calling receiving register switch apparatus consists of a station receiving register switch A and a carrier wave receiving register switch B, the calling transmitting register switch apparatus consists of a station transmitting register switch C and a carrier wave transmitting register switch E. Each of these transmitting register switches has associated with it a change-over switch, D and F respectively for interposing an interval between the operation of the associated switch and the operation of the next switch or apparatus in the operating sequence. The receiving register apparatus that comes into use when the associated radio station is being called by another radio station comprises a station selecting switch H and a carrier wave receiving register switch K. The common sender and register circuit of each station also has a tuning switch G that operates when the station is the calling station to tune the transmitting antenna and receiving antenna systems of the associated trunk to the pair of carrier waves registered by the carrier wave register switch B; and which operates when the station is the called station to tune the transmitting and receiving antennae systems to the pair of carrier waves indicated by the carrier wave receiving register switch K. All of the switches referred to above are illustrated, in the present instance, as single motion step-by-step switches, the wipers or switch arms of which are advanced step by step by means of an associated stepping magnet, the return of the switch arms to normal being brought about by other energizations of the associated stepping magnet that cause the arms to continue their movement over their rows of contact points until they again rest in their normal position. Such step by step

switches are well known in the art and need not be particularly described.

Associated with the trunks and with the common sender and register circuit in the form in which they are herein disclosed are also a number of plunger relays, as 21, 23, 55, 59, 64, 65, 72 and 76, which are employed to introduce relatively large time intervals into the operation of certain parts of the organization. The plungers of these relays are retarded on their inward movement, and are permitted to move freely on their return movement. They may be of the type disclosed in the application of Samuel B. Williams, Jr., and Walter P. Albert, Ser. No. 146671, filed Feb. 5th, 1917. Two of these slow acting plunger relays or timers 64 and 65 are used, in connection with the associated relays 62 and 63, to constitute an interrupter for producing a slow series of impulses for controlling the apparatus employed in sending out the radio or high frequency signals.

The radio terminals associated with each trunk may consist of two antennae TA and RA. 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, power limiting devices may be used; or the irresponsiveness of the receiving antenna system 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 or high frequency communication between the transmitting antenna TA and the receiving antenna, such as RA, of the distant radio station, is a high frequency carrier wave, the oscillatory current for producing which is generated in the tuned high frequency oscillator 171. The oscillator circuit may be of well known type, comprising a vacuum tube or thermionic oscillator with an oscillation circuit including inductively related inductances in the input and output circuits of the tube. The filament current for this oscillator and for the energization of the other oscillators and for the modulator and power amplifier of the transmitting antenna system is supplied by the filament current generator 148, and the plate current for these devices is supplied by the plate current generator 147. These generators are driven by the motor 146, the current supply for operating which is controlled by the relays 199 and 200.

The carrier wave produced by the high frequency oscillator 171 carries two intermediate frequencies, one of these intermediate frequencies being generated by the oscil-

lator 160 and the other being generated by the oscillator 168. Both of these are vacuum tube oscillators and have oscillation circuits of the same type as the carrier wave frequency oscillator 171 referred to above. The intermediate frequency oscillatory currents generated by the oscillator 160 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 97 and 98 of the trunk and through the four equal windings of the two-way repeating coil 149 into the balancing network 150. The junction points of the two serially included repeating coil windings in each side of the line circuit are connected with the input circuit of a thermionic amplifier 151, and the output circuit of the amplifier is connected by way of the inductive couplings 152 and 154 with the input circuit of the modulator 155.

The operation of the oscillating and modulating circuits herein disclosed, is briefly as follows: The oscillator 160 and modulator 155 are supplied with plate current through the choke coil 161 which has sufficiently large inductance to prevent the passage thereof of current fluctuations of frequencies as high as those used in transmission of speech. The plate current supply circuit for the oscillator 160 contains also a choke coil 159 which transmits voice frequencies but has sufficient inductance to prevent the passage of current fluctuations corresponding to the frequency of oscillator 160. Since the current supplied to the tubes 155 and 160 together in parallel is maintained constant whereas the current through the tube 155 alone is controlled by the impressed voice current, the current through the oscillator 160 is made to vary in a complementary manner, and therefore the amplitude of the wave generated by the oscillator 160 varies in accordance with voice currents received over the line conductors. The frequency of oscillator 160 is controlled by the condenser 157, while the condenser 156, which is too large to have an appreciable effect on the period of the oscillator, serves to prevent short-circuiting of the current supply.

The oscillators 160, 168 and 171 are all connected to and feed into the input circuit of the modulating tube 180. Condenser 178 affords a high frequency by-pass for the radio frequency current from oscillator 171. The output coils of oscillators 160 and 168 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 oscillator.

The action of the modulator 180 is some-

what different from that of 155 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 160 and 168. 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 plate current circuit of the oscillator 160 and modulator 155 is controlled by contacts of a relay 215, so that the intermediate frequency generated by the oscillator 160 may be applied to or withdrawn from the carrier wave to produce signaling impulses. The operation of the other intermediate frequency oscillator 168 is controlled at contacts of the relay 216, and the intermediate frequency that it produces is applied to the carrier wave for the purpose of guarding against the production by any other station of the particular frequency that is being transmitted by the oscillator 171. The intermediate frequency produced by the oscillator 168, therefore may be referred to as the guarding intermediate frequency and that produced by the oscillator 160 as the signaling and talking intermediate frequency. The output circuit of the modulator 180 is inductively coupled with the tuned input circuit of a power amplifier 209 of the thermionic type; and the output circuit of the amplifier is inductively coupled with the tuned transmitting antenna TA of the system. The tuning of the amplifier input circuit and of the transmitting antenna TA, as well as of the oscillating circuit of the carrier wave oscillator 171, is accomplished through the medium of a plurality of branches, each under the control of a relay. In the embodiment of the invention here disclosed, there are seven tuning branches associated with the high frequency oscillator, seven associated with the power amplifier, and seven associated with the transmitting antenna. The seven tuning branches associated with the high frequency oscillator include adjustable condensers 174, 175, 176, 177, 275, 276 and 277, and these branches are respectively controlled by relays 181, 182, 183, 184, 282, 283 and 284. The tuning branches associated with the power amplifier include adjustable condensers 195, 196, 197, 198, 296, 297 and 298, and these branches are respectively controlled by relays 191, 192, 193, 194, 292, 293 and 294. The tuning branches associated with the transmitting antenna include adjustable tuning inductances 211, 212, 213, 214, 312, 313 and 314, and the branches are respectively controlled by relays 201, 202, 203, 204, 302, 303 and 304. For effecting the operation of the relays controlling the tuning branches,

there are seven energizing circuits, and each of these energizing circuits is connected with the windings of three of the controlling relays, one from each of the three tuning groups. The seven energizing paths or conductors are designated 272, 94, 95, 96, 162, 163 and 164, the first of these conductors being connected with the windings of the first relay in each of the three groups in the order in which these relays were mentioned, the second conductor with the winding of the second relay in each group in the order mentioned, and so on. Thus when any one of the energizing paths is closed, the corresponding relay in each of the three tuning groups is operated, and a corresponding tuning branch in each of the three groups is closed.

The capacities and inductances included in the seven branches of each of the three tuning groups are so adjusted that the closure of any one of the seven energizing paths, with the consequent closure of the corresponding tuning branch in each of the three groups, causes the production and application to the transmitting antenna of an oscillation having a frequency differing from the frequency produced when any other one of the seven energizing paths is closed. In the present instance, the frequency of the carrier wave oscillations thus applied to the transmitting antenna may conveniently have the following ratios: 100, 150, 225, 275, 350, 425 and 475, these frequencies being applied by the energization of conductors 272, 94, 95, 96, 162, 163 and 164, respectively.

In the radio receiving part of the system, the receiving antenna RA of each station is connected with the tuned input circuit of the thermionic detector 230 by means of the inductive coupling 218, 219. The output circuit of the detector includes serially the two frequency filters 235 and 236; and also has bridged across the filament and plate circuit a condenser 237 for eliminating the unmodulated carrier frequency. The filter 235 has its constants so adjusted as to pass the guarding intermediate frequency and to suppress the signaling and talking intermediate frequency, and the filter 236 is adjusted to pass the signaling and talking intermediate frequency and to suppress the guarding intermediate frequency. The filter 236 is inductively coupled with the input circuit of the detector 255, and the output circuit of the detector 255 is inductively coupled with the input circuit of the amplifier 259. The output circuit of the amplifier has two branches controlled in switching contacts of the relay 271. The normally closed branch is connected by way of the inductive coupling 263 and conductors 102 and 103 with two windings of the two-way repeating coil 149. The inductive relation of these two windings with the other windings of the re-

peating coil 149 is such that the voice currents flowing in the circuit of this branch are repeated into the trunk talking conductors 97 and 98 connected with the other windings of the repeating coil, but are not repeated into the branch connection of the repeating coil with the transmitting amplifier 151. 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 reacting upon the radio transmitting system of that station and causing similar voice current modulations of the oscillatory currents passing to its transmitting antenna. The other branch of the amplifier output circuit, closed when relay 271 is operated, is connected through the inductive coupling 264 with the rectifier 269, and the circuit of the rectifier includes the winding of relay 268. The relay 268 is adapted to respond to the signaling and talking intermediate frequency of the carrier wave, and to act through the medium of conductor 35 to govern the operation of certain switching mechanism of the associated trunk.

The filter 235, which selects the guarding intermediate frequency of the carrier wave, is connected with the input circuit of the thermionic detector 238, and the output circuit of this detector is inductively coupled with the input circuit of the amplifier 245, the output circuit of which in turn is inductively coupled with the circuit of the rectifier 251. The circuit of the rectifier includes the winding of relay 252, which relay is thus adapted to respond to the guarding intermediate frequency of the carrier wave and to act through the medium of conductor 100 to govern the operation of switching mechanism of the associated trunk.

The tuning of the receiving antenna system of the radio trunk is effected, in the particular embodiment of the invention illustrated, by means of seven branches including the adjustable condensers 231, 232, 233, 234, 332, 333 and 334, respectively. These branches are under the control of relays 221, 222, 223, 224, 322, 323 and 324, respectively. The tuning branch containing the condenser 231 and controlled by relay 221 is normally closed, and the other branches are normally open. The winding of relay 221 is included in a common portion of an energizing circuit having the six branches 42, 43, 44, 165, 166 and 167, and the windings of the other six tuning control relays are included one in each of these six branches. Therefore, when any one of the six branches is closed to operate the included relay and close the corresponding tuning branch, the relay 221 is operated to open the normally closed tuning branch that it controls.

The energization of the transmitting antenna system to effect the application of the carrier wave is under the control of the relays 200 and 199. The relay 200 acts to apply the carrier wave and the guarding intermediate frequency when the first of the seven tuning branches of the transmitting system is closed, and the relay 199 acts to apply the carrier wave and both of its intermediate frequencies when any of the other six tuning branches is closed. The application of the guarding intermediate frequency to the carrier wave is controlled through the medium of the relay 216, and the application of the signaling and talking intermediate frequency is controlled through the medium of the relay 215. Two relays, 242 and 243, respectively, control the energization of the signaling or talking and the guarding intermediate frequency branches of the receiving antenna system; and the relay 241, so connected as to operate when either of the relays 242 and 243 operates, controls the energization of the main or carrier-wave-responsive portion of the receiving antenna system. The relays 242 and 243 are so interrelated with the relays 215 and 216 that the application of either the signaling and talking or the guarding intermediate frequency to the calling carrier wave determined by the first or calling tuning branch of the transmitting antenna system, prevents the energization of the corresponding intermediate frequency branch of the receiving antenna system. When the relay 221 acts to break the normally closed tuning branch of the receiving antenna system upon the closure of one of the other tuning branches, it makes the relays 242 and 243 independent of control by the relays 215 and 216.

As has been stated, the first tuning branch of the receiving antenna system, corresponding to the calling carrier wave, is normally closed, and the first tuning branch of the transmitting antenna system is closed by the completion of a circuit by way of conductor 272 upon the taking of the trunk for use, and at certain other times in the operation of the system, as will subsequently be described. The other six tuning branches of the receiving antenna system and the other six branches of the transmitting antenna system are selectively energized under the control of the tuning selector switch G. When the radio station is calling, one or another of the transmitting system tuning branches 94, 95 and 96, and one or another of the receiving system tuning branches 42, 43 and 44 are energized, depending upon whether the switch G is moved to its first, second or third position from normal. When the radio station is being called, one or another of the transmitting system tuning branches 162, 163 and 164, and one or

another of the receiving system tuning branches 165, 166 and 167 are energized, depending upon the position to which the switch G has been moved. The arrangement is such that when the station is calling and the switch G has been moved to its first position from normal, the transmitting system is tuned, in the present instance, to a wave length of 150 meters and the receiving system is tuned to a wave length of 225 meters; while at the same time a corresponding movement of the tuning selector switch G at the called station to its first position from normal causes the transmitting system of the called station to be tuned to a wave length of 225 meters and the receiving system at that station to be tuned to a wave length of 150 meters. Thus, it will be seen that in this case the receiving system of the called station is tuned to the carrier wave length of 150 meters that the calling station is transmitting, and that the transmitting system of the called station is tuned to a carrier wave length of 225 meters that the receiving system of the calling station is tuned to receive. In like manner when the switches G at the calling and called stations occupy corresponding positions, the transmitting system of each station is tuned to send out a different carrier wave length to which the receiving system of the other station is tuned to respond. This arrangement may be tabulated as follows:

Switch G	Calling station		Called station	
	Transmitting wave length	Receiving wave length	Transmitting wave length	Receiving wave length
	Meters	Meters	Meters	Meters
Position 1.....	150	225	225	150
Position 2.....	275	350	350	275
Position 3.....	425	475	475	425

Additional sets of carrier wave lengths corresponding to additional positions of the switch G may, if desired, be provided by adding other tuning branches to the transmitting and receiving antenna systems of the stations; and these branches may be arranged and controlled similarly to the arrangement and control of the branches that are illustrated. By bringing their switches G into corresponding positions, any calling station and the station that is being called may use for communicating purposes any of these sets of wave lengths. The wave length to which the receiving systems of the waiting or preselected trunks of all of the radio stations are normally tuned may be, for instance, 100 meters and the transmitting systems of the preselected trunks of all of the radio stations are adapted normally to send out this wave. The carrier wave lengths that have been referred to above are merely typical, as any desired combination

of wave lengths may be used, provided only that the frequencies selected are non-interfering.

As has heretofore been stated, the apparatus which is used to transmit and receive by means of any one high frequency wave or pair of waves, as distinguished from that which is used only when a wave or pair of waves, of a different frequency is employed, is commonly known as a high frequency 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.

As has been stated, the system is so arranged that each carrier wave may have applied to it two intermediate radio frequencies, one of which is modulated to carry the speech frequencies and also is applied and withdrawn to convey the signaling and switch controlling impulses, and the other of which is modulated or controlled to guard against simultaneous use by some other station of the carrier wave to which it is applied. These intermediate frequencies may have any desired value above the audio frequency and below the carrier wave frequency range. For example, the talking intermediate frequency may be twenty thousand and the guarding intermediate frequency may be fifty thousand. These two 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 ensured by the non-interfering carrier wave lengths that are employed.

Briefly stated, the operation of the system is as follows: When an operator at one of the toll board positions has occasion to extend a connection through the medium of the radio or high frequency apparatus, she inserts the plug of the connecting cord circuit that is to be used into a multiple spring-jack of one of the trunks, the particular trunk to be used being indicated by the lighted condition of the assigning lamp associated with the springjack of that trunk. The insertion of the plug extinguishes the assigning lamps and lights the busy lamps associated with this trunk at all of the positions. It also attaches the common register and sender apparatus to the trunk that has been taken for use, makes this trunk unavailable for reassignment until all of the trunks of the series have been assigned and used, and energizes the transmitting an-

tenna system associated with this trunk to send out the calling carrier wave with its superposed guarding intermediate frequency. The attaching of the common register and sender apparatus as a result of the insertion of the plug also sets into operation apparatus associated with the common circuit that successively tunes the receiving antenna system of the trunk to the calling station frequency of the various channels or communicating pairs, the testing switch of the common apparatus being automatically stopped when an available channel is found.

When the operator inserts the plug of her connecting cord circuit into the spring-jack of the assigned trunk, she operates the dial associated with the connecting cord circuits to produce impulses in accordance with the number of the distant radio or high frequency station with which connection is desired. These impulses are registered upon a station receiving register switch associated with the common register and sender apparatus. As soon as the channel testing switch and the station receiving register switch have received their registrations, a station transmitting register switch is automatically set into operation to cause impulses of the signaling intermediate frequency corresponding in number to the setting of the station receiving register switch to be sent out from the transmitting antenna system associated with the trunk that has been taken for use.

At each of the distant stations, one of the associated trunks is waiting in its preselected condition with its receiving antenna system energized and sensitive to the calling carrier wave with its guarding and signaling intermediate frequencies. When the insertion of the plug at the calling station causes the sending out of the calling carrier wave with its guarding intermediate frequency, the preselected trunk at each of the distant stations responds and automatically becomes connected with the associated common register and sender circuit, the assigning lamps associated with the preselected trunk at each distant station at the same time being extinguished to prevent these trunks from being used for calls originated at their respective stations. The response of the preselected trunk at each distant station also makes that trunk unavailable for reassignment until the remaining trunks of the associated series have each been used.

When the signaling intermediate frequency impulses controlled by the station transmitting register switch at the calling station are received at the distant stations, they cause the advance of the station selecting switches at the various distant stations to an extent corresponding to the setting of the station transmitting register switch at the calling station. At the conclusion of the

station selecting train of impulses only the apparatus at the particular station that is being called remains responsive to further impulses from the calling station, the apparatus at all of the other stations being held in irresponsive condition until the end of the calling operation. At the particular station called, however, the transmitting antenna system of the trunk is energized for an interval to send out the common calling carrier wave with its signaling intermediate frequency as a return signal. During this same interval, at the end of the station selecting train of impulses, the calling station apparatus operates to render the calling station trunk responsive to the receipt of the return signal.

If the particular station called for any reason has not been selected and the return signal is not received, a busy signal is automatically given the calling station operator, the common sender and register apparatus is disconnected from the trunk, and the connection is released upon the subsequent withdrawal of the calling operator's plug. But if the called station is properly selected and the return signal sent out, the calling station apparatus proceeds with the sending out of the next set of impulses. The number of impulses in this set or train is determined by the setting of the channel receiving register switch, and the impulse train causes a corresponding setting of the channel register switch at the distant selected station, the other distant stations being now irresponsive.

At the end of the channel selecting train of impulses, the transmitting and receiving antennae systems of the calling and called stations are at once automatically tuned to complementary frequencies of the selected communicating pair, and the called station upon becoming tuned sends out a short return signal over its guarding intermediate frequency. If the tuning of the called station has not been properly effected, the failure to receive this return signal at the calling station causes the common sender and register circuit at the calling station to become disconnected from the trunk, and a busy signal to be given the calling operator, who then releases the connection by withdrawing the plug. If the return signal is received at the calling station, the talking conductors of the trunk are extended to the associated high frequency apparatus, and the common sender and register apparatus is released for assignment to another one of the associated trunks.

When the called station has been selected and the high frequency apparatus associated with its assigned or waiting trunk has been tuned to the selected channel or pair of communicating frequencies, a calling lamp associated with the answering spring jack of

the trunk is lighted. This informs the operator of the call; and when the operator inserts a connecting circuit plug into the spring jack of the trunk thus indicated, the line lamp is extinguished, busy lamps associated with the trunk at the various toll board positions are lighted, and the supervisory lamp of the calling operator's connecting circuit is extinguished.

The calling and called operators may then extend the connection to the associated local lines that are to be connected. During the conversation, each operator may signal the distant operator by causing the flashing of the distant supervisory lamp. At the end of the conversation, the withdrawal of the connecting circuit plug by the calling operator restores to normal the transmitting and receiving antennae tuning apparatus at both the calling and the called stations, renders inert the transmitting and receiving antennae systems of the calling station and the transmitting antenna system of the called station, and lights the called station operator's supervisory lamp. The called station operator, upon disconnecting in response to the lighted supervisory lamp, releases the trunk that has been used and renders its receiving antenna system unresponsive.

Before proceeding with a detailed description of the operation of the system, we may briefly consider the normal or waiting condition of the trunks at the various stations as determined by the associated preselecting circuits. At each of the stations, as has been stated in connection with the description of Fig. 5, there are several trunks capable of use as inlets or outlets between the associated station and the other stations of the system. One of these trunks at each station is normally kept in condition to respond to a radio or high frequency call from any other station, and to be used for any outgoing call originated by one of the local operators of the associated station; and this preselected trunk is also in condition to become automatically attached to the common sender and register apparatus upon the receipt of an incoming call or the initiation of an outgoing call. This result is effected by means of a series preselecting circuit extending by way of conductors 12, 14 and 15 and through the contacts of relays 10, one of which relays is associated with each of the trunks. In the initial condition of the preselecting circuit at each station all of the relays 10 are inert; and in this condition the preselected trunk is the one associated with the left-hand relay 10 of the series shown in Fig. 1. When the first trunk is taken for use and is subsequently released from the common sender and register apparatus, the trunk associated with the second or middle relay 10 is automatically pre-

selected and placed in waiting condition; and when this trunk is taken for use and subsequently released from the common apparatus the third trunk, associated with the right-hand relay 10 of the series, is automatically preselected and placed in waiting condition. When the third trunk is taken for use and is released from the common apparatus, the relay 40 operates to release the relays 10 of such of the preceding trunks in the series as may in the meanwhile have become idle as a result of the termination of the communicating connections established over them, thus again placing these trunks in line for preselection or assignment. The preselected or assigned trunk at each station is connected with a normally closed energizing path including resting contacts of the relays 51 and 52 of the common sender and register apparatus, which closed path keeps the relay 16 of the associated trunk operated and the assigning lamps 31 associated with the spring jacks of this trunk lighted. The operated relay 16 holds closed a circuit by way of conductor 240 that keeps the receiving antenna system of the associated trunk energized and responsive to radio or high frequency waves that may be transmitted from the other stations of the system. The condition of preselection also places the multi-contact relay 11 of the preselected trunk under the control of the relays 17 and 20 of the trunk, so that if the relay 17 of this particular trunk is operated as a result of the initiation of a call at the local station, or if the relay 20 is operated as the result of the initiation of a call at one of the distant stations, the multi-contact relay 11 is actuated to connect the circuits of the preselected trunk with the circuits of the common sender and register apparatus. Thus, each of the stations normally has one of its trunks responsive to calls from other stations of the system and normally available for outgoing calls, and in condition to become attached automatically to the common sender and register apparatus upon being taken for use by either an incoming or outgoing call.

In detail, the operation of the system of the invention is as follows: When an operator at one of the positions of the toll board at one station wishes to establish connection with another station through the medium of the high frequency intercommunicating apparatus, she first notes which of the trunks has its assigning lamp 31 lighted, and then inserts plug 36 of the connecting circuit 37 into the multiple spring jack 33 associated with the lighted assigning lamp. The insertion of the plug 36 into the spring-jack 33 closes a circuit that extends from battery through the cord circuit supervisory lamp 6, resting contacts of the calling key 5, registering sleeve contacts of plug 36 and spring jack 33, and winding of relay 27 to ground. This causes the operation of relay 27 and the lighting of supervisory lamp 6, the supervisory relay 38 at the time being inert. When relay 27 operates, it opens the energizing circuit of and extinguishes the assigning lamps 31 associated with this particular trunk at all of the toll board positions. At the same time, a circuit is closed that extends from battery through the winding of slow release relay 17 and right-hand front contact and armature of relay 27 to ground. Relay 17, in operating, closes at its inner left-hand armature and front contact a circuit for causing the illumination of the busy lamps 32 associated with the assigned trunk at each of the toll board positions. The lighting of the lamps 32 serves to warn the operators at the various positions that connection has been established with this particular trunk. At its outer right hand armature and back contact, relay 17 breaks the circuit through the medium of which relay 18 is enabled to energize relay 20 upon the receipt of a call from a distant station, thus immediately rendering this particular trunk unavailable for the receipt of incoming calls. At the same time, relay 17 brings about the energization of relay 2 to break this circuit at another point. At its outer right-hand armature and front contact, relay 17 applies a ground to the conductor subsequently used for holding operated the busy test relay 24, the talking circuit closing relay 25, and the relay 10 of the associated trunk. The application of this ground also energizes relay 19 to operate relay 52, as will be described. At its inner right hand armature and front contact, relay 17 places in readiness the impulse circuit controlled by relay 27; and at its outer left hand armature and front contact relay 17 applies ground to a circuit that extends by way of the outer upper back contact and armature of the associated relay 10, assuming the pre-selected trunk to be the third in the series, conductor 12, outer upper front contacts and armatures of the relays 10 of the other busy or unavailable trunks in series, conductor 13, outer lower armatures and front contacts of the relays 10 of the other busy or unavailable trunks in series by way of conductor 14, outer lower armature and back contact of relay 10 of the preselected trunk, and winding of relay 11 of that trunk to battery. This energizes relay 11 of the trunk, which thereupon closes its plurality of associated contacts, thus extending this particular trunk to the circuits of the common sender and register apparatus. When relay 11 operates it extends the ground that has caused its operation by way of the two left-hand armatures and front contacts of relay 11 to the winding of relay 9; and relay 9 in operating closes a circuit that extends from

battery through the lower winding of relay 10 of the preselected or assigned trunk and the front contact and armature of relay 9 to ground. The resultant operation of relay 10 breaks the initial energizing circuit completed by way of the outer upper and outer lower back contacts and armatures of the relays 10, as previously traced, and extends conductors 12 and 14 to the relay 10 of the next available trunk in the series. If the trunk whose relay 10 has thus been operated as described is the last available trunk of the series, the extension of the series circuit of conductors 12 and 14 causes the operation of the common relay 40 of the series circuit to release for reassignment the trunks that have ceased to be busy, as will hereinafter be described. When relay 10 is operated by the operation of relay 17, as above described, it locks up by way of a circuit that extends from battery through the upper winding and inner upper front contact and armature of relay 10 and the back contact and armature of slow release relay 40 to ground. At the same time, another holding circuit for relay 10 is completed from battery through the lower winding and inner lower front contact and armature of the relay, inner lower back contact and armature of relay 24, and outer right hand front contact and armature of relay 17 to ground.

The operation of relay 10, as has been stated, breaks the initial energizing circuit of the relays 11 and 9. But both of these relays are held energized by way of a circuit that extends through their windings and the left hand armatures and front contacts of relay 11, conductor 311, and lower front contact and armature of relay 52 of the common sender and register circuit to ground, relay 52 having been energized to attract its armatures the instant relay 11 operated, by way of a circuit that extends from battery through the winding of relay 52, conductor 305, contacts of relay 11, left hand armature and front contact of relay 19, middle lower back contact and armature of relay 20, outer lower back contact and armature of relay 24, and outer lower back contact and armature of relay 25 to ground. Relay 19 was operated at the moment the insertion of the plug 36 in the springjack 33 caused the operation of the relays 27 and 17, by way of a circuit that extends from battery through the winding of relay 19, inner lower back contact and armature of relay 24, and outer right hand front contact and armature of relay 17 to ground. Relay 19 also in operating closes at its right hand front contact and armature a branch to ground of the circuit that normally extends from battery through the winding of relay 241, windings of relays 242 and 243 in parallel, conductors 242' and 243', upper armature and back contact of

relay 216 and right hand armature and back contact of relay 215, conductor 240, and front contact and armature of relay 16 to ground. This circuit, through the contacts of relay 19 is closed at the instant the trunk is taken for use by the operator, so that when relay 16 releases upon the operation of relay 10 and opens the normally closed energizing path for relays 241, 242 and 243 by way of the contacts of relay 16, these relays are maintained energized by the above-traced path closed at the right hand front contact and armature of relay 19. Another branch of the energizing circuit of relays 241, 242 and 243 is closed by contacts of the relay 11 when that relay operates; so that these relays are held operated to keep the receiving antenna system of the preselected trunk in responsive condition, subject to the control of relays 215, 216 and 221, from the moment the trunk is preselected for use until the plug 36 is removed from the springjack 33 at the end of the conversation, as will hereinafter be described.

When relay 52 of the common sender and register circuit operates upon the operation of the relay 11 of the preselected trunk, as has been described, it opens at its lower back contact and armature the path that subsequently will be used for the restoration of the switches of the sender and register circuit; and at its upper armature and back contact, it opens the path that extends by way of conductors 310 and 15 and the middle upper armatures and front contacts of the relays 10 of the series circuit and the middle upper armature and back contact of the relay 10 of the first trunk of the series that is available for use to the assigning lamps 31 and the winding of the relay 16 of that trunk. As a result, although the operation of the relay 10 of the trunk that has just been taken for use extends the series circuit to the apparatus of the first trunk that is available, the assigning lamps 31 of that trunk are not lighted, and the relay 16 is not energized to operate the associated relays 241, 242 and 243, (Fig. 4) and render the trunk responsive, until the relay 52 of the common sender and register circuit is released after the common circuit has performed its functions.

The above described series of operations started by the insertion of the plug 36 in the spring jack 33 has caused the preselected trunk to become connected with the common sender and register circuit. The operator may now control the trunk apparatus through the medium of the sender and register apparatus to call the desired high frequency or radio station, the apparatus at the same time proceeding automatically to select for use in communicating a pair of high frequency communicating waves or

channels that is at the time idle and available. The operator controls the station selecting apparatus through the medium of the dial 39 associated with her connecting cord circuit 37. This dial is of the well known type which operates to effect a series of interruptions in the circuit that it controls, the number of interruptions in the series being determined by the degree of angular displacement of the dial by the operator. When the operator has connected the calling dial with the cord circuit by operating the key 5, she moves the dial as far as is necessary to produce the required number of interruptions for selecting the desired station, and then releases it. Upon each interruption of the circuit at the dial contacts, the relay 27 releases its armatures. The duration of each interruption is too short to permit the slow release relay 17 to open the contacts which it controls. Consequently, at each interruption of the circuit at the calling dial 39 a circuit is closed that extends from battery through the winding of the stepping magnet *a* of station register switch A (Fig. 2) winding of the associated slow release relay 50, normal contact and wiper A¹ of register switch A, outer upper back contact and armature of relay 53, conductor 301, contacts of relay 11, inner right hand armature and front contact of relay 17, and right hand back contact and armature of relay 27 to ground. The impulse thus produced causes the register switch A to take one step, thus breaking the initial energizing circuit by way of wiper A¹; but an alternate energizing path has been closed at the right hand front contact and armature of relay 50, and as the relay 50 is slow in releasing, this energizing path through the winding of relay 50 and the winding of the stepping magnet *a* of switch A is maintained during the impulses of the group that are now being transmitted. The register switch A, therefore, takes one step for each of the impulses of the group, and at the end of the impulses line relay 27 remains energized, thus holding open the impulse circuit by way of the winding of the relay 50 and the winding of the associated stepping magnet, thus permitting relay 50 to release. The advance of the switch wipers of the register switch A has caused the wiper A³ to rest upon a contact point corresponding in number to the number of impulses in the transmitted train; and the release of the relay 50 connects switch wiper A³ by way of inner left hand back contact and armature of relay 50, outer lower back contact and armature of relay 53, conductor 305, contacts of relay 11, left hand armature and front contact of relay 19, middle lower back contact and armature of relay 20, outer lower back contact and armature of relay 24, and outer lower back contact and armature of relay 25 to ground. This applies ground to the contact upon which switch arm A³ is resting and identifies that contact.

Concurrently with the registration of the number of the desired toll station upon the register switch A, apparatus associated with the trunk has been operating to send out the common or calling carrier wave, and to select a pair of individual or communicating carrier waves for the subsequent establishment of communicating relation between the calling station and the called station. When relay 11 of the preselected trunk operates upon the insertion of plug 36 into springjack 30, it closes a circuit that extends from battery through the upper armature and back contact of relay 199 (Fig. 3), winding of relay 200, windings of relays 181, 191 and 201 in parallel, left hand armature and back contact of relay 114, conductor 34, contacts of relay 11, conductor 346, and inner upper armature and back contact of relay 53 to ground. Relay 200, in operating, causes the energization of motor generator 146 to cause generators 147 and 148 to generate plate and filament current for the transmitting antenna system; and also causes the energization of relay 216 to render operative the guarding intermediate frequency oscillator of the transmitting antenna system. At the same time, relay 216 in operating opens at its upper armature and back contact the path by way of conductor 243' for energizing relay 243, thus making irresponsive the guarding intermediate frequency branch of the receiving antenna system. Relays 181, 191 and 201 in operating tune the transmitting antenna system to the frequency of the calling carrier wave. Thus, the calling carrier wave with its guarding intermediate frequency is automatically transmitted from the calling station when the preselected trunk is taken for use. The effect of this sending out of the calling wave and its guarding intermediate frequency is to cause the response of the preselected trunk at each of the other toll stations of the system, and the connection of the common sender and register apparatus at each station with the associated preselected trunk in readiness to receive the impulses that are about to be transmitted from the calling station. Also the effect at each of the other stations of the system is to extinguish the assigning lamps 31 associated with the preselected trunk, so that during the transmission of the impulses from the calling station the operators at the other stations know by the absence of any lighted assigning lamp that no call may be initiated by them. The op-

erations by means of which these results are attained will be described in detail hereinafter.

Continuing now with the operations that are taking place at the calling station, when the common sender and register circuit is attached to the preselected trunk through the operation of the relay 11, a circuit is closed that extends from battery through the winding of relay 54 (Fig. 2), switch arm B⁴ and its normal contact, outer lower back contact and armature of relay 53, conductor 305, contacts of relay 11, left hand armature and front contact of relay 19, middle lower back contact and armature of relay 20, outer lower back contact and armature of relay 24, and outer lower back contact and armature of relay 25 to ground. Relay 54 in operating locks up by way of its inner left hand front contact and armature and inner contact of timer 59 to ground. Relay 54 in operating also closes a circuit that extends from battery through the winding of the stepping magnet *b* of switch B, the armature and back contact of this magnet, switch arm B³ and its normal contact, and outer right hand front contact and armature of relay 54 to ground over the circuit previously traced by way of conductor 305. The effect of the closure of this circuit is to cause switch B to take one step, the advance of the switch arms to their first position from normal breaking the energizing circuit of the stepping magnet at the switch B³.

The above described movement of the switch arms of switch B to their first position from normal closes a circuit that extends from battery through the winding of relay 221 (Fig. 4), winding of relay 322, conductor 165, contacts of relay 11, conductor 365, first contact from normal and switch arm B³, and outer right hand front contact and armature of relay 54 to ground by way of conductor 305. Relay 221 in operating opens the condenser branch 231 that normally tunes the receiving antenna circuit to the common carrier wave; and at the same time closes at its inner left hand armature and contact the energizing path for the relay 243 which has heretofore been held open at the upper contacts of the relay 216. Relay 322 in operating closes the condenser branch 332 that tunes the receiving antenna system to one of the carrier wave frequencies of the first individual pair. Relay 322 in operating also at its left hand front contact and armature connects its winding to the holding conductor 101 that is adapted at a later stage of the operation to be connected to ground at the outer lower front contact and armature of relay 25. As a result, therefore, of the first step taken by switch B on the operation of relay 54, the guarding intermediate frequency branch of the receiv-

ing antenna system is energized and the guarding intermediate frequency relay 252 (Fig. 4) is made responsive to the frequency of one of the waves of the first communicating carrier wave pair or channel. As will subsequently be described, when any of the pairs of communicating carrier wave frequencies is in use between two of the radio stations, each of the two stations transmits a different one of the high frequency waves of the pair with the talking or signaling and the guarding intermediate frequencies constantly impressed upon it. Therefore, if the first pair of individual carrier waves is in use when the receiving antenna system of the calling radio station is tuned to either one of the frequencies of this pair, (the tuning in the present instance being to the wave adapted to be transmitted by the calling station), the superposed guarding intermediate frequency is detected, amplified and rectified, and causes the operation of relay 252. When relay 252 operates, it closes a circuit that extends from battery through the winding of the stepping magnet *b* of switch B, armature and back contact of this magnet, outer resting contact of timer 55, outer left hand front contact and armature of relay 54, conductor 300, contacts of relay 11, conductor 100, and front contact and armature of guarding intermediate frequency relay 252 to ground. The stepping magnet *b* of switch B attracts its armature, and in doing so opens the short circuit that normally exists by way of the back contact of the stepping magnet armature around the high resistance winding of slow release relay 56. Relay 56 then operates and closes a circuit for the operation of relay 57 by way of front contact and armature of relay 56 and inner resting contact of timer 55 to ground. Relay 57 in operating locks up by way of its inner left hand front contact and armature, and inner contact of timer 55 to ground; and also, at its outer right hand front contact and armature, closes a circuit for the energization of timer 55. Timer 55 consequently starts the slow inward movement of its plunger, and in doing so opens the outer timer contact, which interrupts the energizing circuit of the stepping magnet of switch B; the circuit of the stepping magnet, however, having already been interrupted in effect by the breaking of the short circuit about the high resistance relay 56. The switch arms of switch B are thus caused to take another step, from their first to their second position from normal. In moving from its first to its second position, switch arm B³ breaks the energizing circuit that had previously existed for the operation of tuning relay 322 (Fig. 4), and closes, by way of conductors 166 and 366, an energizing circuit for the operation of tuning relay 323. As the energizing path for the op-

eration of relay 221 is common to the branches through the various tuning relays, the relay 221 remains energized when the branch through one of the tuning relays is opened and that through another is closed. The release of relay 322 and the operation of relay 323 changes the tuning of the receiving antenna system so that it becomes ir-
 responsive to the calling station transmitting frequency of the first communicating carrier wave pair and becomes responsive to the calling station transmitting frequency of the second communicating carrier wave pair if the second pair of carrier waves is in use, the presence upon the carrier frequency of the superposed guarding intermediate frequency causing the energization of relay 252.

When the timer 55 completes its inward movement, it opens its inner contact. This releases relay 57, which in turn deenergizes and permits the immediate return to normal of timer 55. When the outer contacts are closed upon the return to normal of timer 55, if relay 252 has become energized as a result of the second pair of communicating carrier waves being in use, then a circuit is again completed for the energization of the stepping magnet *b* of switch B by way of the armature and back contact of the magnet, outer contact of timer 55, outer left hand front contact and armature of relay 54, conductor 300, contacts of relay 11, conductor 100 and front contact and armature of relay 252 to ground. This causes another cycle of operations like that previously described, in the course of which switch B advances its wipers to their third contact position from normal, and a test is made to determine the available or unavailable condition of the third pair of communicating carrier waves. If this pair should also be found to be in use, and the relay 252 be consequently again energized, the switch B advances its wipers to their fourth contact position. As a result, a circuit is completed that extends from battery through the winding of relay 24 (Fig. 1), contacts of relay 11, conductor 307, fourth contact and wiper arm B³ of switch B, and outer right hand front contact and armature of relay 54 to ground by way of conductor 305. Relay 24 in operating locks up by way of its inner lower front contact and armature, and outer right front contact and armature of relay 17 to ground. At the same time, relay 24 in operating opens the talking circuit of the trunk, and closes a circuit that extends from battery by way of supervisory relay 38 of the connecting cord circuit, registering ring contacts of the plug 36 and spring-jack 33, inner upper armature and front contact of relay 24, source of busy tone current 45, and busy back interrupter 41 to ground. The closure of this circuit operates supervisory relay 38 to cause the intermittent

flashing of the cord circuit supervisory lamp 6, and to produce a busy tone in any telephone receiver that is at the time associated with the connecting cord circuit. Upon seeing the flashing of the lamp or hearing the busy tone, the operator may withdraw the plug 36 from the spring jack 33, whereupon the apparatus of the trunk that has been taken for use is restored to normal in a manner that will subsequently be described. Also the breaking of the outer lower and inner lower resting contacts of the relay 24 interrupts the circuit that has been maintaining the relay 52 of the common sender and register circuit operated, and that relay in releasing causes the release and restoration of the common sender and register apparatus and the assigning of another preselected trunk for use in a manner which also will be described hereinafter.

For the purpose of the present description, it may be assumed that the first pair of individual communicating carrier wave frequencies is available for use. This being the case, when the switch B advances its arms to their first contact position from normal and tunes the receiving antenna system to one of the first pair of communicating carrier waves, the guarding intermediate frequency relay 252 remains inert. Therefore, no circuit is closed by way of the contacts of this relay for causing the switch B to take another step, and for causing the energization of the relay 56 and consequent energization of the relay 57. At the moment that the relay 54 was first energized, a circuit was closed extending from battery through the winding of relay 58, outer contact of timer 59, inner right front contact and armature of relay 54, and outer right back contact and armature of relay 57 to ground. The operation of relay 58 closes the energizing circuit of the timer 59, and the timer starts the slow inward movement of its plunger, thus breaking the outer resting contact of the timer included in the initial energizing circuit of relay 58. But relay 58 remains energized by way of the locking circuit through its right front contact and armature. As long as the energizing circuit of relay 58 remains closed the inward movement of the plunger of timer 59 continues; and if the relay 57 remains unenergized for a period of time determined by the setting of the timer 59, the timer completes its inward movement and opens its inner contacts, thus releasing relay 54. The interval of time required for the tuning of the receiving antenna system to each pair of the various communicating carrier waves, and for the response to the presence of the tested wave, is less than that required for the timer 59 to complete the inward movement of its plunger; so that each pair of communicating carrier waves that is tested and found

in use causes the operation of relay 57 and the release of relay 58, and consequently of the timer 59, before the timer has moved its plunger far enough to open its inner contacts and release relay 54.

Under the present assumption, that the first pair of communicating carrier waves or channel is found available, is permitted to complete its movement and release relay 54, and that relay in releasing opens, at its outer right hand front contact and armature, the energizing circuit of the receiving antenna tuning branch of the wave frequency under test, thus reestablishing the normal tuning of the receiving system, and at the same time closes a circuit for starting the operation of the impulse mechanism 600 (Fig. 2) to send out station selecting impulses in accordance with the setting of register switch A, and carrier wave or channel impulses in accordance with the setting of register switch B.

Before proceeding with a description of the further operations at the calling station, we may turn to a consideration of the effects produced at the distant stations by the initiation of the call. The normal condition at the various radio stations is one in which one or another of the trunks of each station has been preselected for use, and is standing in readiness to respond to the calling carrier wave with its intermediate guarding frequency sent out when any other station calls. The preselection or assignment of a trunk causes the energization of the relay 16 and the lighting of assigning lamps 31 of that trunk over a circuit closed by way of conductor 15 when relays 51 and 52 fall back upon the release of the common sender and register circuit and the relay 16 in operating closes a circuit that extends from battery through the windings of the relays 241, 242 and 243, (Fig. 4), conductors 242' and 243', resting contacts of relay 215 and 216, conductor 240, and front contact and armature of relay 16 to ground. Therefore, relays 241, 242 and 243 of the preselected trunk at each station are held energized to cause the application of filament current to the thermionic tubes of the receiving antenna system, and thus keep the corresponding trunk in a responsive condition.

Upon the sending out from the calling station of the calling carrier wave with its guarding intermediate frequency, as has been described, the relay 252 (Fig. 4) associated with the preselected trunk at each station responds, and in responding closes a circuit that extends from battery through the winding of relay 18 (Fig. 1), conductor 100, and front contact and armature of relay 252 to ground. When relay 18 operates as a result of the closure of this circuit, it opens at its outer left back contact and ar-

mature the energizing circuit that normally keeps lighted the assigning lamps 31 associated with the preselected trunk at the various positions of the toll board. The extinguishing of the assigning lamps 31 indicates to the operators at the various positions that for the time being there is no trunk available for outgoing connections. The operation of relay 18 also closes a circuit that extends from battery through the winding of relay 20, inner left front contact and armature of relay 18, right back contact and armature of relay 2, and outer right back contact and armature of relay 17 to ground; and relay 20 locks up by way of its inner upper front contact and armature and the inner contact of timer 21 to ground. When relay 20 operates it applies at its outer upper front contact and armature a ground to the holding conductor; and in doing so energizes relay 19. Relay 19, in operating, closes a branch to ground from conductor 240 for keeping energized the relays 241, 242 and 243 (Fig. 4) that maintain the energization of the thermionic tubes of the receiving antenna system. Relay 20 in operating closes a circuit that extends from battery through the winding of the multi-contact relay 11 of the preselected trunk, outer lower back contact and armature of relay 10 of the preselected trunk, thence through conductors 14 and 12 and the closed outer lower and outer upper front contacts and armatures of the relays 10 of the preceding trunks in the series to the outer upper armature and back contact of relay 10 of the preselected trunk, and thence by way of the inner lower front contact and armature of relay 20 to ground. This causes the relay 11 of the preselected trunk to operate and close all of its contacts to attach the common sender and register apparatus. Relay 11 in operating also closes at its left hand armatures and contacts a branch circuit from the operating path for energizing relay 9, and that relay in operating closes an energizing circuit including the lower winding of the associated relay 10. Relay 10, in operating, locks up by way of its upper winding, its inner upper front contact and armature, and the back contact and armature of the common relay 40; and also opens at its outer lower armature and back contact the initial energizing circuit of the relays 11 and 9, these relays thereafter being held energized by a circuit including conductor 311 and the lower front contact and armature of relay 52, as will presently be described.

When relay 20 operates, it also closes a circuit that extends from battery through the winding of relay 53 (Fig. 2), conductor 309, closed contacts of relay 11 of the preselected trunk, middle lower front contact and armature of relay 20, outer lower back contact and armature of relay 24, and outer

lower back contact and armature of relay 25 to ground. Relay 53 in operating closes a circuit that extends from battery through the winding of relay 52 (Fig. 2), and the outer lower armature and front contact of relay 53 to ground. Relay 52 operates and closes a circuit that extends from battery through the windings of the multi-contact relay 11 and the relay 9 in parallel, left armatures and front contacts of relay 11, conductor 311, and lower front contact and armature of relay 52 to ground. The effect of this is to close a locking circuit for the multi-contact relay 11 and the relay 9 which holds these relays operated as long as the relays 52 and 53 remain operated. When relay 10 operates, it opens the energizing circuit of relay 16 and releases that relay to open the associated branch to ground of conductor 240; but as two other branches to ground of this conductor are at the time closed at the extreme right hand contact of relay 11 and the right hand contact of relay 19 respectively, the filament energizing relays 241, 242 and 243 of the receiving antenna system are kept operated.

As described above, the effect of the operation of the guarding intermediate frequency relay 252 of the preselected trunk at each of the various stations in response to the sending out of the calling wave at the calling station is to extinguish the assigning lamps 31 of the associated trunk at the toll operators' positions and operate the associated multi-contact relay 11 to extend the circuits of the preselected trunk to the common sender and register circuit. At the same time relay 20, which operates when relay 18 operates in response to the operation of relay 252, closes a circuit that extends from battery through the winding of relay 271 (Fig. 4), conductor 220, inner right armature and back contact of relay 114, conductor 99 and inner lower front contact and armature of relay 20 to ground. Relay 271 in operating disconnects the talking and signaling intermediate frequency branch of the receiving antenna system from its normal extension to the talking conductors of the trunk, and connects it through the rectifier 269 to the winding of the signaling intermediate frequency relay 268. This relay at each of the distant stations is thereupon in readiness to respond to the signaling intermediate frequency impulses of the calling carrier wave that are about to be sent out from the calling station.

Returning now to a consideration of the operations that are taking place at the calling station, when relay 54 releases upon the selection of an idle communicating channel by switch B, a circuit is closed that extends from battery through the winding of relay 62, outer contact of timer 64, outer con-

tact of timer 65, switch arm D' of switch D and its normal contact, off normal contacts and switch arm A² of switch A, outer left hand back contact and armature of relay 50, off-normal contacts and switch arm B¹ of switch B, and outer right hand back contact and armature of relay 54 to ground by way of conductor 305. The fact that this circuit includes the switch arm A² of switch A and back contact of the associated relay 50 prevents the release of the relay 54 from closing the circuit to the impulse apparatus 600 until the station register switch A has taken its registration from the operator's dial 39. Assuming that this has occurred, the closure of the above traced circuit operates relay 62 of the impulse apparatus 600, which relay locks up by way of its inner upper front contact and armature, and also closes at its outer lower armature and front contact a circuit for energizing the timer 64, this circuit being completed to the common operating ground by way of switch arm D' and the path already traced. Timer 64 in operating opens at its outer contact the initial energizing path of relay 62, and at the end of the inward movement of its plunger closes at its inner contact a path to the common operating ground for energizing relay 63. Relay 63 in operating closes at its right hand front contact and armature a circuit to the common operating ground for energizing timer 65, and at the same time locks up to this ground by way of its left hand front contact and armature, inner contact of timer 65 closed the instant the timer starts its inward movement. The inward movement of timer 65 opens at its outer contact the locking circuit of relay 62; and that relay in releasing opens the energizing circuit of and releases timer 64. The inward movement of timer 65 continues until its plunger engages and opens the inner timer contacts and the opening of these contacts releases relay 63, thus releasing and permitting the return of timer 65. The return of timer 65 to normal reestablishes the original circuit condition of the impulse apparatus 600, whereupon the cycle of operation is again performed in the manner described, and continues to be repeated as long as the operating ground is kept connected with the impulse apparatus circuit.

The operation of the impulse apparatus 600, as described, causes a series of slowly recurring energizations and deenergizations of the relay 62, which have the effect of causing the application of a series of signaling intermediate frequency impulses to the calling carrier wave that is being sent out from the calling radio station, and of causing a step by step advance of a series of switches C, D, E and F that co-operate with

the register switches A and B in controlling the transmission of the groups of radio impulses.

Upon the first energization of the relay 62 of the impulse apparatus 600, a circuit is completed that extends from battery through the stepping magnet *c* of switch C, outer left hand back contact and armature of relay 60, outer upper front contact and armature of relay 62, and thence to ground by way of the previously traced operating path closed upon the release of relay 54. This energizes the stepping magnet of switch C; but the advance of the switch arms does not occur until the energizing circuit of the stepping magnet is broken.

Simultaneously with the closure of the stepping circuit for the switch C, the impulse relay 62 closes another circuit that extends from battery through the right-hand winding of relay 215 (Fig. 3), conductor 66, contacts of relay 11, conductor 368, outer right hand back contact and armature of relay 67, outer right-hand back contact and armature of relay 60, normal contact and switch arm D^s, and thence by way of inner lower front contact and armature of relay 62 to the operating ground of the impulse apparatus 600. As a result of the closure of the above traced circuit the relay 215 is energized to apply the signaling intermediate frequency to the calling carrier wave, and at the same time to open the energizing path of the relay 242 (Fig. 4), thus rendering the signaling intermediate frequency branch of the receiving antenna system insensitive to the signaling intermediate frequency applied by the relay 215. The result, therefore, is that as the relay 62 of the impulse apparatus operates, a series of signaling intermediate frequency impulses are set out from the calling station, and at the termination of each impulse the station selecting switch C takes one step.

When the advance of the switch arms of switch C brings them to the point where the arm C² engages the contact corresponding to the contact upon which the arm A³ of the station register switch has been left resting a circuit is completed that extends from battery through the winding of relay 60, switch arms C² and A³ and the contacts upon which they are resting, inner left-hand back contact and armature of relay 50, outer lower back contact and armature of relay 53, and thence to ground by way of conductor 305. Consequently, the instant the identified contact is engaged by switch arm C², the relay 60 is operated to break, at its outer left-hand armature and back contact, the energizing circuit of the stepping magnet *c* and bring the switch to rest. When the relay 60 operates, it locks up to the holding conductor 305 by way of its inner right-hand armature and front contact, at its

outer right-hand armature and back contact it breaks the circuit over which the impulses for energizing the signaling intermediate frequency relay 215 are transmitted, at its inner left-hand armature and front contact it brings the relay 61 under the control of the signaling intermediate frequency relay 268 (Fig. 4), and at its outer left-hand armature and front contact it extends the impulse circuit controlled at the outer upper armature and front contact of relay 62 to the stepping magnet *d* of the switch D.

Before describing the function of the switch D, the energizing circuit for which is closed by the operation of the relay 60 at the end of the station selecting impulse train, we may turn to a consideration of the effect of the receipt of the station selecting impulses at the other stations of the system. At each of the other stations, as has been described, the preselected trunk has responded to the guarding intermediate frequency sent out when the calling station calls, has extinguished its associated assigning lamps 31, has become connected to the common sender and register circuit of the associated station, and has placed its signaling intermediate frequency relay 268 in condition to respond to the signaling intermediate frequency impulses. Consequently upon the receipt of the first impulse of the station selecting train the relay 268 at each of the distant stations closes a circuit that extends from battery through the winding of stepping magnet *h* of switch H (Fig. 2), right-hand winding of relay 73, normal contact and switch arm H², inner lower front contact and armature of relay 53, conductor 335, contacts of relay 11, conductor 35, and front contact and armature of relay 268 to ground. As a result of the closure of this circuit, the stepping magnet of switch H and the associated relay 73 are both energized. Relay 73 in operating closes an alternative energizing path from the above traced circuit by way of its inner right-hand armature and front contact, over which path the relay 73 and the stepping magnet *h* are controlled after the initial energizing circuit is opened at switch arm H² and its normal contact. Relay 73 also closes a locking circuit for itself that extends from battery by way of the left-hand winding and inner left-hand front contact and armature of relay 73, and the inner contact of timer 72 to ground. Relay 73 in operating also closes a circuit that extends from battery through the winding of relay 74, outer right-hand switch spring and armature of relay 73, conductor 309, contacts of relay 11, middle lower front contact and armature of relay 20, outer lower back contact and armature of relay 24, and outer lower back contact and armature of relay 25 to ground.

As the impulses of intermediate signaling frequency are sent out from the calling station the intermediate signaling relays 268 associated with the receiving antenna systems of the preselected trunks at all of the other stations are caused alternately to attract and release their armatures, and consequently to cause the attraction and retraction of the armatures of the stepping magnets *h* of the switches *H*. As the stepping magnet of the switch *H* at each of the stations releases its armature at the end of each impulse, it causes the associated switch arms to be advanced one step, and at the same time, closes a circuit that extends from battery through the winding of the stepping magnet *h*, the armature and back contact of the magnet, outer left-hand front contact and armature of relay 73, outer contact of timer 72, and winding of high resistance relay 71 to ground. While the stepping magnet *h* is deenergized the above circuit is completed to actuate relay 71 without permitting enough current to flow to operate the stepping magnet. The actuation of relay 71 causes that relay to close a locking circuit for itself at its right-hand front contact and armature; and at its left-hand armature and front contact relay 71 closes a circuit for energizing timer 72 and causing the inward movement of its plunger. But the operating time of the timer 72 is such that while the intermediate signaling impulses are being received, the stepping magnet *h* of switch *H* does not permit its armature to remain retracted long enough to allow the timer to complete the inward movement of its plunger.

Each received impulse of the intermediate signaling frequency of the station selecting train causes the switch arms of the switch *H* to advance one step. At the end of the impulse train the stepping magnets of the switches *H* at the various stations retracted long enough to permit their associated timers 72 to cause the interruption of the associated inner contacts. This causes the opening of the locking circuit by way of the left-hand winding and left-hand front contact and armature of relay 73. Relay 73 in releasing breaks the circuit by way of conductor 309 which during the energization of relay 73 has been holding relay 74 energized. But as the outer right-hand switch spring of the relay 73 breaks its contact with the outer right-hand armature, it engages a contact connected with the switch arm *H*³. As a result of the received impulses, the switch arms *H*³ at all of the stations have been correspondingly advanced and are each resting on the particular contact corresponding to the number of impulses in the train. At each of the various stations a different one of the contacts of the arm *H*³ is connected with the inner left-

hand front contact of the associated relay 74. In the case of the particular station illustrated in the drawing, the fourth contact point from normal of the switch arm *H*³ is thus connected. Therefore, if there have been four impulses of the signaling intermediate frequency in the station selecting train to cause the switch arm *H*³ to be left resting upon its fourth contact point at the termination of the impulse train, the release of relay 73 closes a branch by way of switch arm *H*³ and its fourth contact point and inner left-hand front contact and armature of relay 74 to conductor 309 in place of the branch that is opened when relay 73 releases; so that the relay 74 is held energized upon the release of relay 73 if impulses have been received corresponding in number with the contact point that is connected with the left-hand front contact of relay 74. But if the received impulses have been such as to leave switch arm *H*³ resting upon some other of its contact points, then the release of relay 73 is accompanied by the release of relay 74 to render inoperative the circuits subsequently involved in establishing connection between the calling station and the selected station.

Assuming that it is station No. 4 that is being called, and that consequently the impulses have been such as to advance the switch arm *H*³ to its fourth contact point, relay 74 remains up when relay 73 releases, and a circuit is closed that extends from battery through the winding of relay 75, inner contact of timer 76, switch arm *K*⁶, inner right-hand front contact and armature of relay 74, inner left-hand back contact and armature of relay 73, and inner contact of timer 72 to ground. Relay 75 in operating closes circuits for applying to the transmitting antenna system of the preselected trunk at the station the calling carrier wave with its signaling intermediate frequency. One of these circuits extends from battery through the winding of relay 114 (Fig. 3), conductor 143, contacts of relay 11, conductor 345, and right-hand front contact and armature of relay 75 to ground. Relay 114 in operating closes a circuit that extends from battery through the upper armature and back contact of relay 199, winding of relay 200, the windings of relays 181, 191 and 201 in parallel, left-hand armature and front contact of relay 114, and thence to ground by way of conductors 143 and 345 and the right-hand front contact and armature of relay 75. The closure of this circuit causes relays 181, 191 and 201 to operate to effect the tuning of the transmitting antenna system to the frequency of the calling carrier wave, and causes relay 200 to operate to start the motor generator 146 to generate current for energizing the plate and filament circuits of the transmit-

ting antenna system. Relay 200, however, is prevented in operating from energizing relay 216 to energize the guarding intermediate frequency oscillator, the energizing circuit of the relay 216 being open at the outer right-hand back contact and armature of relay 114. When relay 114 operates, it breaks at its inner right-hand back contact and armature the energizing circuit of the relay 271, so that the latter relay is released to render temporarily inoperative the signaling intermediate frequency relay 268 of the receiving antenna system. The operation of relay 75 also closes a circuit that extends from battery through the right-hand winding of relay 215, conductor 66, contacts of relay 11, conductor 368, and left hand front contact and armature of relay 75 to ground. Relay 215 in operating applies plate current for the energization of the signaling intermediate frequency oscillator, and releases relay 242 to render irresponsible the signaling intermediate frequency branch of the receiving antenna system.

The duration of the application of the calling carrier wave with its signaling intermediate frequency to the transmitting antenna system of the preselected trunk at the selected station is determined by the timer 76, the energizing circuit for which is completed at the same time that the energizing circuit of the relay 75 is closed. The energizing circuit of timer 76 extends from battery through the magnet of the timer, switch arm K^1 and its normal contact, outer right-hand front contact and armature of relay 74, inner left-hand back contact and armature of relay 73, and inner contact of timer 72 to ground. Upon the expiration of the interval measured by the timer 76, the plunger of the timer opens the associated inner contact, thus breaking the energizing circuit of relay 75 and causing the withdrawal of the calling carrier wave with its signaling intermediate frequency. At the same time, relay 271 (Fig. 4) is again operated, by the release of the relay 114, and again operatively connects the signaling intermediate frequency relay 268 with the receiving antenna system, in readiness to respond to further impulses from the calling station.

Returning now to the actions that are taking place at the calling station, the operation of the relay 60 at the end of the station selecting train of impulses has closed a circuit that extends from battery through the winding of the stepping magnet d of switch D, switch arm D^5 and its normal contact, outer left-hand front contact and armature of relay 60, and outer upper front contact and armature of relay 62 of the impulse apparatus 600 to the operating ground of the impulse apparatus over the path previ-

ously traced. Consequently, upon the termination of the next succeeding impulse of the apparatus 600 the switch arms of the switch D are advanced one step to their first contact position from normal. In moving to its first contact point from normal the switch arm D^7 closes a direct path to ground for continuing the operation of the impulse apparatus; and inasmuch as the second contact point from normal of the switch arm D^7 is also connected directly to ground, the impulse apparatus 600 continues to operate until it has caused the switch arms of switch D to advance to their third contact positions, at which time the operating ground at switch arm D^7 is broken and the impulse apparatus 600 temporarily comes to rest. The operating path for the stepping magnet d of switch D is also broken at the third contact position of switch arm D^5 when the switch D has taken three steps.

The time interval from the operation of relay 60 to the taking of the first step by switch D at the calling station substantially corresponds to the time interval that elapses at the called station between the receipt of the last impulse of the station selecting train and the operation of the relay 75 to apply the signaling intermediate frequency as a return signal. From the moment switch D at the calling station takes its first step until it comes to rest with its switch arms in their third contact position, a circuit is closed that extends from battery through the winding of relay 271 (Fig. 4), conductor 220, inner right-hand armature and back contact of relay 114, conductor 99, contacts of relay 11, conductor 399, switch arm D^3 and the contact which it is engaging, middle right-hand front contact and armature of relay 60, off-normal contacts and switch arm A^2 , outer left-hand back contact and armature of relay 50, off-normal contacts and switch arm B^1 , outer right-hand back contact and armature of relay 54, outer lower back contact and armature of relay 53, and to ground by way of the holding conductor 305. Relay 271 is thus operated to switch the talking and signaling intermediate frequency branch of the receiving antenna system of the calling station to the rectifier 269 to render the associated relay 268 responsive to the return signal when it is sent out from the called station.

If the return signal is received, the consequent operation of the relay 268 closes a circuit that extends from battery through the winding of the relay 61 (Fig. 2), inner left-hand front contact and armature of relay 60, inner lower back contact and armature of relay 53, conductor 335, contacts of relay 11, conductor 35, and front contact and armature of relay 268 to ground. This causes the operation of relay 61, which locks up by way of a circuit that extends through

the left-hand armature and front contact of relay 61, off-normal contacts and switch arm D⁴, middle right-hand front contact and armature of relay 60, off-normal contacts and switch arm A², outer left-hand back contact and armature of relay 50, off-normal contacts and switch arm B¹, outer right-hand back contact and armature of relay 54, outer lower back contact and armature of relay 53, and to ground by way of the holding conductor 305. The receipt of the return signal, therefore, causes relay 61 to remain operated until the switch D has moved its switch arms beyond their third contact positions and broken the above-traced locking circuit.

We will assume in the first place that for some reason the called station is not selected, and therefore that no return signal is sent back to the calling station during the interval while the switch D is moving its switch arms to their third contact positions. When the third contact position is reached a circuit is closed that extends from battery through a winding of relay 24 (Fig. 1), contacts of relay 11, conductor 307, third contact and switch arm D¹ and right-hand back contact and armature of relay 61 to ground, this relay being inert as a result of the non-receipt of the return signal. The closure of this circuit causes the operation of the relay 24 to apply busy tone to the talking circuit of the trunk, and to cause the flashing of the operator's cord circuit supervisory lamp 6, as has previously been described in connection with the operation of the switch B. Relay 24 in operating also brings about the deenergization of the relay 52 of the common sender and register circuit to disconnect the common circuit from the trunk circuit and restore its apparatus to normal, in a manner which will be described hereinafter.

We will now assume that the selection of the called station has been properly made, and that consequently the return signal is received before the switch arms of switch D have arrived at their third contact position. In this case when the switch arms reach their third position from normal, the circuit traced above for operating the busy tone applying relay 24 is open at the right-hand armature and back contact of relay 61; that relay having been actuated by the return signal. Instead a circuit is closed that extends from battery through the winding of the stepping magnet *d* of switch D, switch arm D² and its third contact point, and right-hand front contact and armature of relay 61 to ground. As a result switch D is caused to take another step, thus bringing its switch arms to their fourth contact position. This unlocks relay 61 through the opening of its locking circuit at switch arm D⁴, releases relay 271 (Fig.

4) through the opening of its energizing circuit at switch arm D³, and again supplies an operating ground for the impulse apparatus 600 by way of switch arm D⁷ and its fourth contact point, switch arm F⁶ and its normal contact, outer lower back contact and armature of relay 53, and to ground by way of the holding conductor 305. At the same time, the impulse conductor controlled at the outer upper armature and front contact of relay 62 of the impulse apparatus is extended by way of outer left-hand armature and front contact of relay 60, switch arm D² and its fourth contact point, and outer left-hand armature and back contact of relay 67 to the stepping magnet *e* of the transmitting channel register switch E.

The impulses produced by the impulse apparatus 600 are now effective to cause a step-by-step advance of the switch E, and at the same time to cause the sending out of corresponding impulses of the signaling intermediate frequency. The circuit for causing the application of the signaling intermediate frequency impulses extends from battery through the right-hand winding of relay 215 (Fig. 3), conductor 66, contacts of relay 11, conductor 368, outer right-hand back contact and armature of relay 67, fourth contact point and switch arm D⁸, inner lower front contact and armature of relay 62, and thence to ground by way of the operating ground path of the impulse apparatus 600. Each of the channel selecting impulses of the signaling intermediate frequency is accompanied by a one step advance of the switch arms of the switch E. When this advance brings the switch arm E¹ into engagement with a contact point corresponding to the contact point which the arm B⁶ of the receiving channel register switch B is identifying, a circuit is closed that extends from battery through the winding of relay 67, switch arms E¹ and B⁶ and the corresponding contact points with which they are in engagement, outer right hand back contact and armature of relay 54, outer lower back contact and armature of relay 53, and thence to ground by way of the holding conductor 305. Relay 67 in operating locks up by way of its inner right hand front contact and armature, outer lower back contact and armature of relay 53, and to ground by way of the holding conductor 305. At its outer right hand armature and back contact relay 67 interrupts the energizing circuit of the signaling intermediate frequency relay 215, so that that relay ceases to be under the control of the impulse apparatus 600. At its inner left hand front contact and armature, relay 67 closes a path that puts relay 68 under the control of the relay 252 in the guarding intermediate frequency branch of

the receiving antenna system. At its outer left hand armature and contacts, relay 67 in operating disconnects the impulse conductor from the stepping magnet *e* of switch E and extends it by way of switch arm F² to the stepping magnet *f* of switch F.

As the operating ground for the impulse apparatus 600 is still applied by way of switch arms D⁷ and F⁶, the apparatus continues to send out impulses. These impulses, however, are ineffective to cause the transmission of corresponding signaling intermediate frequency impulses, as the path from the impulse relay 62 to the signaling intermediate frequency relay 215 is interrupted at contacts of relay 67. The impulses of apparatus 600 now serve merely to cause the advance of switch F to exercise a timing function in the control of the circuits. At the first step taken by switch F, ground from conductor 311 is applied by way of switch arm F¹ to switch arm B⁵ to identify the contact upon which arm B⁵ of the receiving channel register switch B is resting. At the same time a circuit is closed that extends from battery through the winding of stepping magnet *g* of tuning switch G, armature and back contact of this magnet, lower back contact and armature of relay 69, off-normal contacts and switch arm F⁵, and to ground by way of conductor 311 and lower front contact and armature of relay 52. Upon the closure of this circuit, the stepping magnet *g* under the control of its own interrupting contacts effects a rapid step-by-step advance of the switch arms of the switch G. When arm G⁵ engages the contact point which is identified by switch arm B⁵ of the receiving channel register switch B, a circuit is closed that extends from battery through the winding of relay 69, switch arms G⁵ and B⁵ with the corresponding contacts upon which they are resting, off-normal contacts and switch arm F¹, and conductor 311 to ground at the lower contact of relay 52. Relay 69 in operating opens the energizing circuit of stepping magnet *g*, thus stopping the advance of the switch, closes a locking circuit for itself by way of its inner upper front contact and armature, off-normal contacts and switch arm F⁵, and conductor 311 to ground, and extends this same ground connection to the switch arms G³ and G⁴ and the contacts upon which the advance of the switch has stopped them.

When the switch arms G³ and G⁴ have been thus advanced to the position corresponding to that occupied by arm B⁵ of the channel register switch B, and relay 69 has been operated, a circuit is closed that extends from battery through the winding of relay 199 (Fig. 3), thence in parallel through the windings of the three relays 182, 192 and 202 (it having been assumed that the first of the three communicating channels or pairs

of waves has been found available), conductor 94, contacts of relay 11, conductor 394, first contact and switch arm G⁴, and to ground by way of the lower front contact and armature of relay 69 and the path already traced. The operation of the three relays 182, 192 and 202 tunes the transmitting antenna system of the calling station to the proper one of the carrier wave frequencies of the pair that has been selected; and the operation of relay 199 included in the common part of the energizing circuit opens the energizing path by way of relay 200 which up to this moment has kept relays 181, 191 and 201 operated, and thus breaks the paths that have held the transmitting antenna system tuned to the common or calling carrier wave frequency. The release of relay 200 breaks the branch of the energizing circuit of the motor 146 that drives the plate and filament current generators, and the branch of the energizing circuit of the relay 216 which applies the guarding intermediate frequency to the carrier wave; but at the same time other branches are closed by the operation of relay 199, so that this apparatus remains energized. Relay 199 also closes a circuit by way of the left hand winding of relay 215, thus operating that relay to apply the signaling and talking intermediate frequency. The result, therefore, of the movement of arm G⁴ of tuning switch G and the operation of relay 69 is to withdraw the calling carrier wave and to substitute for it one of the individual carrier waves of the selected pair with its superposed guarding and signaling or talking intermediate frequencies. The relay 200 included in the energizing path for tuning the transmitting system to the calling carrier wave is so constructed and adjusted that it holds closed the energizing circuits controlled at its contacts for a sufficiently long period after the deenergization of relay 200 so that the relay 199 may have time to operate and maintain the closure of these circuits.

When the tuning selector switch G operates as described above to withdraw the common carrier wave and apply one of the individual carrier waves of the selected pair or channel to the transmitting antenna system, it also operates to alter the tuning of the receiving antenna system from that of the calling carrier wave to that of the other individual carrier wave frequency of the selected pair that is now about to be sent out from the transmitting antenna system of the called station. When switch G moves its arms to the contact point identified by switch arm B⁵ of switch B and relay 69 operates, a circuit is closed that extends from battery through the winding of relay 221, winding of relay 222, conductor 342, contacts of relay 11, conductor 342, first contact and switch arm G³, outer upper front

contact and armature of relay 69, and to ground over the path previously traced. Relay 221 in operating opens the tuning branch of the receiving antenna system that is closed through condenser 231; and relay 222 in operating closes its associated tuning branch including condenser 232. The receiving antenna system of the calling station is thus made irresponsive to the calling carrier wave, and is placed in condition to respond to the particular individual carrier wave frequency that is about to be sent out by the transmitting system of the called station in consequence of its being tuned to the selected channel, as will be described. Relay 221 in operating also short circuits and renders ineffective the contacts of relays 215 and 216 which normally act to open the circuits of conductors 242' and 243' when the relays 215 and 216 are operated. This is in order that relays 242 and 243 may keep the talking and guarding intermediate frequency branches of the receiving antenna system operative while the corresponding branches of the transmitting antenna system are energized by the relays 215 and 216 as long as the radio apparatus of the trunk is tuned to any of the individual communicating channels.

In the meantime the channel selecting impulses sent out from the calling station, as described, under the control of the channel transmitting register switch E, have been acting to bring about a similar tuning of the transmitting and receiving antennae systems at the called station to the selected individual or communicating pair of carrier wave frequencies. It will be remembered that following the receipt of the station selecting impulses at the called station, the relay 75 is operated for an interval determined by the timer 76 to send out the return signal; and that following the transmission of this return signal, the relay 75 is released to place the receiving antenna system and the relay 268 of the called station in readiness to respond to the channel selecting impulses from the calling station.

When the relay 268 operates in response to the first of the channel selecting impulses, it closes a circuit that extends from battery through the winding of the stepping magnet *k* of switch K, upper winding of relay 77, normal contact and switch arm K², off-normal contacts and switch arm H⁴, outer left hand front contact and armature of relay 74, inner right hand back contact and armature of relay 73, inner lower front contact and armature of relay 53, conductor 335, contacts of relay 11, conductor 35, and front contact and armature of relay 268 to ground. Relay 77 in operating closes at its inner upper armature and front contact, a path for the stepping impulses in shunt of the switch arm K² and its normal contact,

and closes at its inner lower front contact and armature a locking circuit for the relay 77 by way of its lower winding, inner left hand back contact and armature of relay 73, and inner contacts of timer 72. At the end of the first channel selection impulse the release of relay 268 opens the stepping circuit and the resultant release of the stepping magnet *k* of switch K causes the associated switch arms to take a step in advance. When the stepping magnet *k* of switch K releases it closes a circuit that extends from battery through the stepping magnet winding and its armature and back contact, outer lower front contact and armature of relay 77, outer contact of timer 72, and winding of high resistance relay 71 to ground. The operative relationship between the stepping magnet and relay 71 is such that the closure of this circuit causes relay 71 to operate without operating the stepping magnet of switch K. When relay 71 operates it closes an energizing circuit for itself in shunt of the outer contact of timer 72, and also closes the timer energizing circuit. The intervals between succeeding impulses of the channel selection train are insufficient to permit the completion of the inward movement of the plunger of timer 72; but the protracted deenergization of the stepping magnet of switch K at the end of the impulse train allows the energizing circuit of relay 71 to remain closed and bring about the complete operation of the timer 72. This opens at the inner contact of the locking circuit by way of the lower winding of relay 77 and releases that relay. As a result the stepping circuit is opened and the switch arms of switch K are brought to rest upon contacts corresponding in number to the number of impulses in the channel selection train, the switch arm K³ occupying a position corresponding to the position occupied by the switch arms B⁶ and E¹ at the calling station.

Upon the release of relay 77 a circuit is closed that extends from battery through the winding of the stepping magnet *g* of tuning switch G, armature and back contact of this magnet, outer lower back contact and armature of relay 70, off-normal contacts and switch arm K⁴, outer upper back contact and armature of relay 77, conductor 311, and lower front contact and armature of relay 52 to ground. As a result the stepping magnet *g* operates under the control of its interrupting contacts to advance the switch arms of the switch G. When the switch arm G⁷ engages the contact corresponding to the contact identified by the arm K³ of switch K, a circuit is completed that extends from battery through the winding of relay 70, switch arms G⁷ and K³ and the contacts upon which they

are resting, and thence by way of conductor 311 to ground at the lower front contact and armature of relay 52. The relay 70 upon operating is held operated by a locking circuit extending to the holding conductor 311 by way of the inner upper front contact and armature of relay 70, off-normal contacts and switch arm K^4 , and outer upper back contact and armature of relay 77. Relay 70 in operating opens at its outer lower armature and back contact the circuit of the stepping magnet, thus bringing the switch arms to rest upon contacts corresponding with the identified contact of switch K. At the outer lower armature and front contact of relay 70 a circuit is closed for energizing timer 23; and the timer, at the end of the interval for which it is set, closes a circuit that extends from battery through the upper winding of relay 25 (Fig. 1), contacts of relay 11, conductor 308, and inner contacts of timer 23 to ground. The closure of this circuit operates relay 25 to extend the circuit of the talking conductors of the trunk, and to effect other changes that will be described hereinafter. When the relay 25 is operated it is locked up by way of its lower winding, its inner lower front contact and armature and the outer upper armature and front contact of relay 20 to ground. At the same time a circuit is closed that extends from battery through the winding of relay 28, contacts of relay 11, conductor 306 and inner contacts of timer 23 to ground. Relay 28 locks up by way of its right hand front contact and armature, and outer left hand back contact and armature of relay 17 to ground, and at its left hand front contact and armature relay 28 closes a circuit for lighting line lamp 29 of the associated trunk.

The stopping of the switch arms G^1 and G^2 upon their associated contacts corresponding to the identified contact of switch K, and the operation of the relay 70, closes circuits for tuning the transmitting and receiving antennae systems of the called station trunk to the complementary frequencies of the pair selected by the calling station. If, as has been assumed, it is the first pair in order of the communicating waves that has been selected, the switch arms G^1 and G^2 are resting upon their first contact points from normal. The tuning circuit of the transmitting antenna system thus completed extends from battery through the winding of relay 199 (Fig. 3), the windings of relays 282, 292 and 302 in multiple, conductor 162, contacts of relay 11, conductor 362, first contact point and switch arm G^2 , inner lower front contact and armature of relay 70, contacts of switch arm K^4 , and thence to the holding conductor 311 by way of the outer upper back contact and armature of

relay 77. The operation of the three relays 282, 292 and 302 tunes the transmitting antenna system of the called station to the frequency to which the receiving antenna system of the calling station is responsive. At the same time relay 199 in operating breaks the path by way of the winding of relay 200 over which the calling frequency tuning relays 181, 191 and 201 are adapted to be energized, thus preventing these relays from acting to tune the transmitting antenna system to the calling frequency while it is tuned to an individual transmitting frequency. Relay 199 also operates the motor generator 146 to generate plate and filament current for the transmitting system, and operates the relays 215 and 216 to cause the energization of the talking or signaling intermediate frequency and the guarding intermediate frequency oscillators. The closure of the energizing circuit of relay 216 is subject to the control of relay 273, which latter relay is operated over a path extending from battery by way of upper armature and front contact of relay 199, winding of relay 273, conductor 273', and outer upper back contact and armature of relay 25 to ground. As relay 199 operates to close the circuit of relay 273 immediately upon the operation of relay 70 upon the completion of the tuning selection, while relay 25 does not operate to open the circuit of relay 273 until the expiration of the interval measured by timer 23, relay 216 at this time is energized to apply the guarding intermediate frequency only during the period measured by the operation of the timer. This brief application of the guarding intermediate frequency constitutes a return signal, the object of which will be explained hereinafter.

The circuit for tuning the receiving antenna system to the other frequency of the selected communicating pair, on the assumption that the first pair or channel has been selected, extends from battery through the winding of relay 221 (Fig. 4), relay 322, conductor 163, contacts of relay 11, conductor 365, first contact point from normal and switch arm G^1 , outer upper front contact and armature of relay 70, contacts of switch arm K^4 , and outer upper back contact and armature of relay 77 to ground by way of the holding conductor 311. Relay 322 in operating tunes the receiving antenna system of the called station to the frequency of the selected pair that the transmitting antenna system of the calling station is adapted to send out. Relay 221 in operating breaks at its right hand back contact and armature the branch that normally keeps the receiving antenna system tuned to the calling carrier frequency, and at its left hand front contacts and armatures connects con-

ductors 242' and 243' directly to conductor 240, thus rendering relays 242 and 243 independent of control by relays 215 and 216.

When relay 25 (Fig. 1) operates as a result of the operation of timer 23 upon the energization of relay 70 associated with switch G, a circuit is closed that extends from battery through the winding of relay 114, conductor 143, middle upper front contact and armature of relay 20, and outer upper front contact and armature of relay 25 to ground. The resultant operation of relay 114 opens the circuit that has heretofore been closed from battery through the winding of relay 271, conductor 220, inner right hand armature and back contact of relay 114, conductor 99, and inner lower front contact and armature of relay 20 to ground. The consequent release of relay 271 disconnects the talking and signaling intermediate frequency branch of the receiving antenna system from the rectifier and relay 268, and reestablishes the normal connection of this branch with the talking conductors of the trunk.

The paths of the tuning relays of the transmitting and receiving antennae systems traced above are the initial energizing paths. Each of the operated tuning relays 282, 292 and 302 of the transmitting system and 322 of the receiving system also has a locking circuit closed at its right hand front contact and armature to the conductor 101, which conductor is connected to ground at the outer lower front contact and armature of relay 25 (Fig. 1) when that relay is operated. Consequently the tuning of the transmitting and receiving systems of the called station is maintained after the initial energizing circuits of the tuning relays are opened by the release of relay 11, which is brought about in the manner that will now be described.

When relay 25 at the called station operates as a result of the stopping of tuning switch G upon the identified contacts and the operation of relay 70 and timer 23, it breaks at its outer lower armature and back contact the circuit that has previously existed by way of outer lower armature and back contact of relay 24, middle lower armature and front contact of relay 20, contacts of relay 11 and conductor 309 for the energization of relay 53. Relay 53 in releasing breaks at its outer lower front contact and armature the energizing circuit of relay 52; and relay 52 in releasing opens at its lower front contact and armature the holding conductor 311, thus releasing relay 70 to withdraw ground from the arms of tuning switch G, and closes at its lower back contact and armature a circuit for bringing about the restoration of the switches of the common sender and register circuit that have been moved from normal by the receipt and registration

of the call. The circuit closed at the lower armature and back contact of relay 52 extends from ground through said relay contacts, the winding of slow release relay 51, switch arm A⁴ and its normal contact, switch arm C¹ and its normal contact, switch arm D⁶ and its normal contact, switch arm E² and its normal contact, switch arm F³ and its normal contact, and switch arm G⁶ and its off normal contacts to battery by way of the stepping magnet *g* of switch G and its interrupting contacts. The stepping magnet of switch G is thereupon operated to step the associated switch arms around to normal. The restoring circuit is then extended by way of switch arm G⁶ and its normal contact, switch arm B² and its normal contact, and switch arm H¹ and its off-normal contacts to the stepping magnet *h* of switch H. When the stepping magnet *h* has operated to step the associated switch arms around to normal, the restoring circuit is further extended by way of switch arm H¹ and its normal contact and switch arm K⁵ and its off normal contacts to the stepping magnet *k* of switch K. Upon the return of the switch arms of switch K to normal the stepping circuit is opened.

As long as the various switches are being restored to normal, the slow release relay 51 included in the stepping circuit holds its armature attracted. When the last switch in the series has been restored and the stepping circuit is opened, the relay 51 releases its armature and closes a circuit that extends from ground through the upper armature and back contact of relay 52, armature and back contact of relay 51, conductor 310, middle upper armature and front contact of each of the relays 10 that are in operated condition, as a result of being associated with trunks that are in use or have not been restored to availability, thence by way of the middle upper armature and back contact of the relay 10 of the first trunk that is available, to two parallel branches to battery, one of which branches includes the winding of relay 16, and the other of which branches extends by way of the outer left hand armature and back contact of relay 18, left hand armature and back contact of relay 27 and the multiple assigning lamps 31 of the associated trunk. As a result, the release of relay 52 of the common sender and register circuit and the release of relay 51 upon the restoration of the switches to normal lights the assigning lamps at the various positions associated with the next trunk in order that is available for use. At the same time relay 16 closes a circuit that extends from battery through the windings of relays 241, 242 and 243 of the trunk thus designated or pre-selected for use, conductors 240, 242' and 243', and front contact and armature of relay 16 to ground; and relays 241.

242 and 243 in operating energize the filaments of the thermionic tubes of the receiving antenna system of this trunk and thus makes the receiving system responsive to the common calling carrier wave.

When the holding relay 52 of the common sender and register circuit at the called station is deenergized, as a result of the operation of the relay 25 of the called station trunk when it is taken for use, it interrupts the energizing path by way of conductor 311 over which the relay 11 has been held operated to keep the common sender and register circuit connected with this trunk. Consequently the trunk that has been taken for use at the called station is immediately released from the common sender and register circuit, and is thereafter under the control of its own individual apparatus. At the same time relay 9 associated with the relay 11 is released and opens the branch of the holding circuit of relay 10 that includes the lower winding of that relay. But relay 10 continues energized through the medium of two paths to ground, one of which includes the lower winding of relay 10, the inner lower front contact and armature of that relay, and the outer upper armature and front contact of relay 20; and the other of which includes the upper winding and the inner upper front contact and armature of relay 10 and the back contact of the common relay 40. Another path to ground is also provided while the relay 17 is energized by the presence of a connecting circuit plug in one of the trunk spring jacks, this path including the lower winding of relay 10, inner lower front contact and armature of that relay, inner lower back contact and armature of relay 24, and outer right hand front contact and armature of relay 17. Therefore, the relay 10 of the appropriated trunk remains energized until relay 20 is released and plug 36 is withdrawn at the end of the conversation and thereafter until the relay 40 is operated.

The operation of relay 40 occurs when the last trunk of the series has been associated with the common sender and register apparatus and consequently after all of the trunks of the series have been in use. Under these circumstances the relays 10 of all of the trunks are in their operated condition, each relay being actuated when its associated trunk is taken for use, and thereafter being held energized under the control of its locking windings. Consequently when the relay 10 of the last trunk of the series is operated a circuit is closed that extends from battery through the winding of relay 40, conductors 12, 13 and 14 and the closed outer upper and outer lower front contacts and armatures of the trunk relays 10 in series to ground at the end of the series. Relay 40 in operating interrupts the locking circuits of

all of the relays 10 completed by way of their upper windings and inner upper front contacts and armatures. If any of the trunks is in use at the time the relay 40 operates, the relay 10 of that trunk is held operated by way of its lower winding and one or more of the energizing paths controlled at the contacts of the associated relays 9, 17 and 20. But if the trunk is not in use at the time, the maintained energization of the associated relay 10 is under the sole control of the relay 40, and when the relay 40 operates, the relays 10 of such idle trunks are released and the associated trunks are again placed under the control of the preselecting or signing circuit.

It will be remembered that when the calling station initiates the call and sends out the calling carrier wave with its guarding intermediate frequency, all the stations respond and connect the preselected trunk of each to the common sender and register apparatus in readiness to receive the station selecting impulses. The station selecting switches H of the non-selected stations are left advanced upon the termination of the station selecting impulses and the release of relays 73 and 74. The apparatus at each of the non-selected stations thereafter is maintained in the condition it occupied at the termination of the station selecting impulses, until the end of the calling stage of the operation and the simultaneous shifting of the calling and called stations from the calling to the selected communicating frequencies. When this shift occurs, the non-selected stations remain tuned to the calling frequency, and consequently upon the withdrawal of the calling frequency by the shift of the calling station, the guard relay 252 (Fig. 4) at each of the non-selected stations is released. This causes the release of relay 18, which relay in releasing causes the operation of the timer 21 and the release of the relay 20 in a manner that will be described more in detail in connection with the disconnect operation at the end of the conversation.

When relay 20 releases it breaks at its middle lower armature and front contact the circuit by way of conductor 309 that has been holding relay 53 of the common sender and register apparatus energized. Thereafter, the restoration to normal of the common sender and register apparatus is substantially the same as that already described, and which takes place when relay 53 is released by the breaking of its energizing circuit in contacts of relay 25 upon the completion of the tuning operation at the calling and called station. When the restoration of the station selecting switch H at the non-selected station is completed, which switch is the only one that has been displaced from normal at each such station, relay 51 of the common sender and register

apparatus releases and closes the circuit by way of conductor 310 which operates relay 16 of the next trunk in the series to energize and make responsive its receiving antenna system. The closure of the circuit by way of conductor 310 also lights the assigning lamps 31 of the trunk that has been made responsive, so as to furnish an indication to the operator that this trunk is now available for use. The release of relay 53 upon the withdrawal of the calling frequency also operates to release relays 11 and 9 of the non-selected station trunk that has responded to the call, with the result that this trunk is disconnected from the common sender and register apparatus. At the same time the release of relays 11 and 19, both consequent upon the release of relays 18 and 20, breaks the circuit to ground over the conductor 240 that has been holding the receiving antenna system of the associated trunk in its responsive condition. Consequently, the particular trunk that has responded to the call at the non-selected station is rendered unresponsive upon the withdrawal of the calling frequency, and is thereafter held unresponsive under the control of the common relay 40 until the end of the series of trunks is reached and the relay 40 operated to release the relays 10 of such of the trunks as are not at the time in use.

Having described the manner in which the receipt of the channel selecting impulses has tuned the transmitting and receiving antennae systems of the called station to the selected pair of communicating waves, has disconnected the common sender and register apparatus from the trunk and restored the apparatus to normal, and has preselected and energized another trunk and designated it for use, we may now return to a consideration of the further actions that are taking place at the calling station. The last stage of the calling station operation that was described was the automatic tuning of the calling station trunk to the selected pair of communicating carrier waves when the switch F had taken its first step from normal. The first step of the switch F at the calling station and the accompanying tuning of the radio apparatus at that station is substantially coincident with the automatic tuning of the radio apparatus at the called station upon the release of relay 77 associated with the channel receiving register switch K. Therefore, if the operations at both stations have proceeded in a normal manner, the receiving antenna system of each station has become tuned to the wave frequency of the transmitting antenna system of the other station when the switch F at the calling station has moved beyond its first contact position from normal. As soon as the transmitting and receiving antennae systems of

both stations have been brought into operative relation by being tuned to the selected channel, relay 252 at the calling station is energized by the guarding intermediate frequency applied as a return signal to the transmitted wave of the selected pair at the called station during the interval measured by the timer 23. Relay 252 in operating closes a circuit that extends from battery through the upper winding of the relay 68 (Fig. 2), inner right hand front contact and armature of relay 67, outer left hand back contact and armature of relay 54, conductor 300, contacts of relay 11, conductor 100, and front contact and armature of relay 252 to ground. If for any reason the proper tuning of the two stations to the selected channel has not been effected and operative relation has not been established, then the guarding intermediate frequency relay 252 of the calling station does not respond and relay 68 remains unenergized. Assuming that this latter is the case, when the advance of the switch arms of switch F under the control of the impulse apparatus 600 has brought them to their fourth contact positions from normal, a circuit is closed that extends from battery through the winding of relay 24 (Fig. 1), contacts of relay 11, conductor 307, fourth contact point and switch arm F, and upper back contact and armature of relay 68 to ground, the relay 68 remaining inert as a result of the failure of relay 252 to be energized. The closure of this circuit operates relay 24 to apply the busy tone, cause the flashing of the operator's supervisory lamp 6, and release the common sender and register circuit from the trunk, in a manner previously described. But if the tuning of the two stations has been properly effected, and the return signal is received before the switch F has advanced its arms to the fourth contact position where the circuit for operating relay 24 is completed, relay 68 has operated, has become locked up to the holding conductor by way of its lower winding and lower armature and front contact, and has closed a circuit that extends from battery through the upper winding of relay 25, contacts of relay 11, conductor 308, and upper front contact and armature of relay 68 to ground. When relay 25 operates it is locked up by way of its lower winding, its inner lower front contact and armature, inner lower back contact and armature of relay 24, and outer right hand front contact and armature of relay 17 to ground. At its outer upper armature and front contact the relay 25 closes a circuit by way of middle upper armature and front contact of relay 20 and conductor 143 for energizing relay 114, thus guarding relay 271 against the possibility of being energized during the conversation to break the talking circuit of the receiving

antenna system. At its middle and inner upper armatures and front contacts the relay 25 completes the talking circuit of the trunk. At its outer lower armature and front contact relay 25 connects conductor 101 to ground for the purpose of holding locked up whichever ones of the transmitting and receiving antennae systems' tuning relays have been operated in the tuning process. The adjustment of the apparatus is such that the holding circuit by way of conductor 101 is closed before the initial energizing circuits of the tuning relays by way of the contacts of relay 11 are opened in the release of the common sender and register apparatus that is about to occur. At its outer lower armature and back contact relay 25 in operating breaks the circuit that heretofore has existed by way of resting contacts of relays 24 and 20 and front contacts of relays 19 and 11 for holding energized the relay 52 of the common sender and register circuit. The release of relay 11 opens the locking circuits of relays 67 and 60, and these relays are deenergized. Upon the opening of its energizing circuit relay 52 releases, and in doing so opens the circuit of the holding conductor 311, thus releasing relays 9, 11 and 69; closes the switch restoring circuit by way of slow acting relay 51, thus successively stepping around to their normal positions the switch arms of switches A, C, D, E, F, G and B, in the order named, and also cooperates with the relay 51, upon the release of that relay, to close the circuit by way of conductors 310 and 15 and the contacts of the relays 10 of the various trunks for preselecting the next trunk in the series that is in condition to be made available for use; this preselection being accomplished by the energization of the corresponding relay 16 to make the receiving antenna system of the trunk responsive, and by the lighting of the assigning lamps 31 of the trunk. The above mentioned results that follow the completion of the tuning operation, the receipt of the return signal, and the actuation of relay 25 at the calling station are the same or similar to those that have been described as occurring at the completion of the tuning operation at the called station, and it is believed will be understood without further explanation. As a result of all of the operations described in the foregoing, the transmitting and receiving antennae systems of the calling and called stations are now tuned to complementary frequencies of the particular pair or communicating channel that was found available and selected for use; and the preselected trunk at each station, having made use of the common sender and register circuit in the station selecting and channel selecting or tuning operations, has now released the common circuit, the common circuit upon

its release having thereupon automatically become operatively associated with the trunk that is next in order to be taken for use.

Communicating relation having thus been established between the two stations over the selected communicating channel, it now remains for the operators to be informed that the circuits are in readiness for communication. As previously described, when the timer 23 at the called station operates as a result of the operation of the associated relay 69 to energize relay 25 and thus close the talking conductors and release the common sender and register apparatus, it also energizes relay 28 to light the line lamp 29 associated with the preselected trunk. When the answering operator at the called station sees the lighted line lamp 29, she inserts the plug 36 of a pair of connecting cords 37 into the answering spring jack 30 corresponding to the lighted lamp. This closes a circuit by way of the sleeve conductors of the connecting cord circuit and trunk circuit for operating the relay 27 of the trunk. Supervisory lamp 6 of the called station cord circuit is not lighted, because the supervisory relay 38 is operated to shunt out the lamp by way of the low resistance winding of relay 26 bridged across the talking conductors of the trunk, the circuit of the low resistance winding being closed at the outer right hand contacts of relay 18, which relay is operated through the medium of relay 25 because of the guarding intermediate frequency that is at the time being received from the calling station. The guarding intermediate frequency is applied at the calling station because the relay 26 at that station is energized immediately upon the operation of relay 25 by means of the current that flows from the calling station cord circuit through the high resistance winding of relay 26, the low resistance winding at the time being open at the outer right hand contacts of relay 18 of the calling station.

Relay 27 of the called station, in operating as a result of the insertion of plug 36 into springjack 30, operates relay 17, and relay 17 in operating breaks at its outer left hand back contact and armature the locking circuit of relay 28, thus releasing that relay and extinguishing line lamp 29. At its inner left hand armature and front contact relay 17 closes a circuit that causes the lighting of the busy lamps 32 associated with the trunk at the various positions, and at its outer right hand armature and front contact relay 17 closes an additional path to ground for maintaining the energization of relays 25, 19 and 10.

It will be remembered that in the interval between the tuning in of the transmitting and receiving antennae systems at the called station and the operation of the relay 25 under the control of the timer 23, a circuit

was closed for energizing relay 273 (Fig. 3) for applying the guarding intermediate frequency to the carrier wave sent out from the called station to constitute a return signal to the calling station. The energizing circuit of the relay 273 is broken at the outer upper back contact and armature of the relay 25 upon the operation of that relay, and the guarding intermediate frequency is withdrawn. But when the operator at the called station plugs into the answering jack 30 in answering the call, the cord circuit battery applied to the talking conductors by this operation energizes relay 26 of the trunk by way of its high resistance winding, and relay 26 in operating again applies ground to conductor 273', and causes the re-energization of relay 273, thus causing the guarding intermediate frequency again to be applied to the carrier wave of the called station transmitting antenna system.

The guarding intermediate frequency which is now thus steadily applied at the called station causes the response of relay 252 (Fig. 4) at the calling station; and that relay in operating closes a circuit that extends from battery through the winding of relay 18 (Fig. 1), conductor 100, and front contact and armature of relay 252 to ground. When relay 18 operates it closes at its outer right hand front contact and armature the circuit of the low resistance winding of relay 26 bridged across the talking conductors of the trunk; and this sufficiently increases the current flow in the talking conductors of the cord circuit to bring about the operation of the supervisory relay 38. This relay thereupon closes the shunt about supervisory lamp 6, and the going out of that lamp indicates to the calling station operator that the called station operator has answered the call and is in readiness for conversation.

The operators at the calling and called stations may now operate their listening keys 8 to bring their respective telephone sets 7 into connection with the associated connecting cord circuits; and when they have done this they may converse with each other, the conversation being effected through the medium of the conductive connections of the connecting cord circuits with the respective radio trunks, and the radio or high frequency 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. If the connection is to be extended to local stations that may be assumed to be associated with the toll stations, this may be done through the medium of the connecting cord circuits 37 in any of the ways, either manual or machine switching, that are well known in the art, and which therefore need not be specifically shown or described.

During the continuance of the connection, the guarding intermediate signaling frequency applied at each station maintains energized the relay 18 at the other station. The operated condition of the relay 18 at the calling station does not cause the operation of the associated relay 20, for the reason that before the normal break in the energizing circuit of the relay 20 at the inner left hand armature and front contact of relay 18 is closed by the operation of that relay, this energizing circuit has been opened at the outer right hand back contact and armature of relay 17 which was operated when the calling operator inserted the plug 36 into the spring jack 33. The relay 18 at the calling station, however, under the control of the guarding intermediate frequency applied at the called station, controls at its outer right hand armature and front contact the bridge of the trunk talking conductors by way of the low resistance winding of relay 26; and the relay 18 at the called station in like manner operates under the control of the guarding intermediate frequency applied at the calling station to control at its outer right hand contacts a similar low resistance bridge of the talking conductors at the called station. Therefore, the operator at each station by temporarily causing the withdrawal of the guarding intermediate frequency applied at that station is enabled to interrupt the low resistance bridge of the talking conductors by way of the low resistance winding of relay 26 at the other station, and by doing so to cause the deenergization of the cord circuit supervisory relay 38 at the other station and the lighting of the supervisory lamp 6. The operator does this by pressing the cord circuit key 3, which substitutes an intermittent ground connection by way of the interrupter 4 for the steady ground connection by way of the repeating coil winding. During each interruption of the path to ground effected in the operation of the interrupter 4, the relay 26 of the trunk is deenergized and releases its armature; and this breaks the energizing circuit of relay 273 by way of conductor 273', the other branch of the energizing circuit being at the time open at the outer upper back contact and armature of relay 25. Consequently relay 273 is intermittently released, thus causing an intermittent deenergization of relay 216, and a corresponding series of interruptions of the guarding intermediate frequency applied to the carrier wave. This in turn causes corresponding deenergizations of the relay 18 at the distant end, which causes the flashing of the supervisory lamp 6 of the distant operator's connecting cord circuit. The duration of the interruptions of the guarding intermediate frequency determined by the operation of the interrupter 4 is so adjusted that

the relay 18 at the called station, when the calling station is doing the signaling, is not deenergized for a sufficient length of time to permit the timer 21 to bring about the release of the associated relay 20, which release is effected in a manner that will subsequently be described.

The control of the disconnect is assigned to the calling station operator. When the signal associated with the local station end of the connecting cord circuit indicates that the conversation is completed, the calling station operator withdraws plug 36 from the spring jack 33 in which it has been inserted. This act releases relay 27, which in turn releases relay 17. Relay 17 in releasing breaks the energizing circuit of and extinguishes the busy lamps 32. It also, at its outer right-hand front contact and armature, breaks the circuit that up to this moment has maintained the energization of the relays 25, 19 and 10. Relay 25 in releasing releases the tuning relays 282, 292 and 302 that have been held operated to tune the transmitting antenna system to the appropriate frequency of the selected pair, and deenergizes the energizing circuits of the motor generator 146, the signaling frequency relay 215, and the guarding frequency relay 216 at contacts of relay 199. The relay 19 in releasing releases relays 241, 242 and 243 to deenergize and render unresponsive the receiving antenna system of the associated trunk, the other two branches of the energizing circuit of these relays by way of a front contact of relay 11 and a front contact of relay 16 being open at the time. The breaking of the holding circuit of relay 10 by way of the lower winding of that relay leaves the maintained energization of the relay 10 subject to the control of the common relay 40 in readiness again to be placed in line for assignment or pre-selection when the relay 40 operates.

When relay 17 releases upon the withdrawal of the calling operator's plug, it grounds at the outer right-hand armature and back contact of relay 17 the conductor over which relay 18 normally acts to effect the energization of relay 20. As relay 18 may remain energized for a moment after relays 25 and 19 are released to break the antennæ tuning and energizing circuits, the operation of relay 20 at this time is prevented by slow release relay 2, which locks up by way of the inner right hand front contact and armature of relay 18, and does not release to close the break in the energizing circuit of relay 20 until relay 18 has been released and has thus opened the energizing circuit at another point.

As a result of the above described operations, the trunk at the calling station is returned to its normal position, its transmit-

ting antenna system being rendered inert and its receiving antenna system unresponsive. Upon the discontinuance of the transmitted carrier wave at the calling station, the relay 252 at the called station is released and releases the associated relay 18. Relay 18 in releasing opens at its outer right-hand front contact and armature the bridge of the trunk talking conductors by way of the low resistance winding of relay 26. It also closes a circuit that extends from battery through the winding of relay 22, outer contacts of timer 21, outer lower armature and front contact of relay 20, and inner right-hand back contact and armature of relay 18 to ground. Relay 22 closes a locking circuit for itself by way of its left-hand front contact and armature; and also closes at its right-hand front contact and armature an energizing circuit for timer 21. The timer 21 thereupon starts the inward movement of its plunger, breaking the initial energizing circuit of relay 22 at the outset of the movement, and breaking the locking circuit of relay 20 and the locking circuit of the antennæ tuning relays by way of conductor 101 at the completion of the movement. The release of the tuning relays is accompanied by the release of relay 199 and the consequent withdrawal of the carrier wave with its two intermediate frequencies. When relay 20 releases it opens at its middle upper front contact and armature the path by way of conductor 143 over which relay 114 has been kept energized, thus preventing the release of relay 199 from completing a circuit by way of relay 200 for sending out the calling carrier wave. Relay 20 in releasing also opens at its outer upper front contact and armature one of the holding paths to ground that has been maintaining the energization of the relays 25, 19 and 10. But these relays are not released at this time, for the reason that the other holding path to ground by way of the outer right-hand front contact and armature of relay 17 is still completed on account of the called station operator's plug 36 still being in the answering jack 30. The holding of the trunk is therefore now under the sole control of the called station operator's plug 36.

As previously stated, when relay 18 at the called station was released as a result of the withdrawal of the carrier wave at the calling station, it opened the talking conductor bridge by way of the low resistance winding of relay 26. Also, upon the expiration of the interval measured by the timer 21, the interruption of holding conductor 101 introduces another break into the talking conductor bridge at the contacts of relay 46, this break thereafter holding the bridge open independent of further control by relay 18. The effect of this is to cause the release of supervisory relay 38 of the

called station operator's connecting cord circuit; and that relay in releasing causes the lighting of the supervisory lamp 6. In response to this disconnect signal, the called station operator withdraws the plug 36, whereupon relays 27 and 17 release. Relay 17 in releasing now breaks the remaining holding path of the relays 25, 19 and 10, and these relays in releasing release the trunk and put it in condition for reassignment.

It will be understood that by the use of a wire or conductive connection between the various stations for guiding the high frequency waves or oscillations between these stations, in place of the unguided transmission of the waves or oscillations through space, as herein disclosed, the present system may be employed as a system of wire communication. Since the apparatus at the various stations would be of the same general character, whether the system were a high frequency wire system or a radio system, the claims 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, telegraph currents or other signaling currents, are sometimes referred to as low frequencies to distinguish them from the high or carrier frequencies.

In order fully to disclose the present invention in its preferred form it has been convenient to make use of certain features in connection with the production and propagation of high frequency waves that are the subject of copending applications of various inventors, assigned to the assignee of the present application. Such features are disclosed and claimed in the application of Ralph V. L. Hartley, Serial No. 225,808, filed March 30, 1918; and in the applications of Raymond A. Heising, Serial No. 81,980, filed March 3, 1916, and Serial No. 131,868, filed November 17, 1916. Other features incorporated in the present disclosure are disclosed and claimed in the application of

Samuel B. Williams, Jr., and Lewis M. Clement, Serial No. 370,476, filed April 1, 1920; the application of Edwin H. Smythe and Samuel B. Williams, Jr., Serial No. 379,105, filed May 5, 1920; and in the application of Edwin H. Smythe, Serial No. 467,043, filed May 5, 1921. These features, as has been stated, are disclosed and claimed in the above mentioned applications, and no claim is made to them in the present application.

What is claimed is:

1. In a high frequency communicating system having a plurality of stations, the combination with a plurality of trunks at each station means for transmitting and receiving high frequency signals associated therewith, and means for preselecting an idle one of said trunks at each station for use in establishing communicating relation with another station through the associated high frequency signaling means.

2. In a high frequency communicating system having a plurality of stations and high frequency communicating means at each station, the combination with a plurality of trunks at each station, means for preselecting an idle one of said trunks for use in establishing communicating relation with another station, and means for placing said trunk under the control of received high frequency oscillations during its period of preselection.

3. In a high frequency communicating system having a plurality of stations, the combination with a plurality of high frequency channels, of trunks at each of said stations adapted for operative relation between stations through the medium of said channels, and automatic preselecting means for selecting and energizing a particular one of said trunks to render the same responsive to received high frequency signals from another of said stations.

4. In a high frequency communicating system, the combination with a plurality of stations and a plurality of high frequency communicating channels all of which are available for use at each of said stations, of as many trunks at each station as there are channels, and means at each station for automatically preselecting one or another of said trunks to be used for establishing communication with another station through the medium of one or another of said communicating channels.

5. In a high frequency communicating system, the combination with a station having a plurality of trunks and associated high frequency apparatus, of means at said station for originating an outgoing call, a distant station and means thereat for originating a call incoming to said first-mentioned station over said high frequency apparatus, said trunks being normally unre-

sponsive to said calls, and apparatus for automatically selecting a particular one of said trunks and rendering the same responsive to said outgoing and incoming calls.

5 6. In a high frequency communicating system, the combination with a station having a plurality of trunks and associated high frequency apparatus, of automatic preselecting mechanism for rendering operative a particular one of said trunks, and a distant station having means for producing high frequency oscillations for controlling said automatic preselecting mechanism through the medium of the trunk that said mechanism has rendered operative.

7. In a high frequency communicating system, the combination with a station having a plurality of trunks and associated apparatus responsive to high frequency oscillations, of automatic preselecting mechanism adapted to select for use an idle one of said trunks, a distant station having means for producing high frequency oscillations for controlling said selected trunk, and means under the control of said distant station for operating said preselecting mechanism to select for use another one of said trunks.

8. In a high frequency communicating system, the combination with a station having a plurality of trunks and associated high frequency apparatus, of switching mechanism common to said trunks, selecting mechanism for selecting and rendering operative an idle one of said trunks and placing said switching mechanism in operative relation therewith, a distant station having means for producing high frequency oscillations for controlling said common switching mechanism through the medium of the selected trunk, and means controlled by said switching mechanism for controlling said selecting mechanism to select and render operative another of said trunks.

9. In a high frequency communicating system, the combination with a station having a plurality of trunks and associated high frequency apparatus, of switching mechanism common to said trunks, means for operatively associating said switching mechanism with a particular one of said trunks, a distant station having means for producing high frequency oscillations, and means under the control of said high frequency oscillations for causing said switching mechanism to become disassociated from the trunk with which it has been in operative relation and to become associated with another of said trunks.

10. In a high frequency communicating system having a plurality of stations, the combination with means providing a high frequency calling channel and a plurality of high frequency communicating channels available for use at each station, of a plurality of trunks at each station, switching

mechanism common to the trunks of each station, preselecting mechanism at each station for bringing said switching mechanism into operative relation with an idle one of said trunks and rendering said trunk responsive to oscillations received over said calling channel, means at a distant one of said stations for producing calling oscillations to control said switching mechanism over the preselected trunk with which it is in operative relation, and means under the control of said calling oscillations for disconnecting said switching mechanism from the preselected trunk and causing the preselection of another trunk.

11. In a high frequency communicating system having a plurality of stations, the combination with a plurality of trunks at each of said stations, adapted for operative relation between said stations through the medium of high frequency channels, of automatic means at each station for preselecting and designating one of said trunks for use, and means for employing said trunk for establishing communicating relation between stations through the medium of a similarly preselected and designated trunk at another station.

12. In a high frequency communicating system having a plurality of stations, the combination with a plurality of trunks and associated high frequency apparatus at each station for intercommunication between stations, automatic preselecting means at each station for selecting for use one of the associated trunks, means for indicating the trunk that has been preselected, and means made operative in the initiation of a call at any of said stations for rendering inoperative said preselection indicating means at all of said stations.

13. In a high frequency communicating system having a plurality of stations, the combination with a plurality of trunks and associated high frequency apparatus at each station for intercommunication between stations, of means at each station for preselecting an idle one of said trunks, means for indicating the preselected trunk, and means made operative in the initiation of a call at any of said stations for withdrawing the preselection indication at the other stations.

14. In a high frequency communicating system having a plurality of stations, the combination with a plurality of trunks and associated high frequency apparatus at each station for intercommunication between stations, of means at each station for preselecting for use and designating an idle one of said trunks, and means made operative in the initiation of a call for withdrawing the designation of said preselected trunks at the various stations.

15. In a high frequency communicating system having a plurality of stations, the

combination with a plurality of trunks and associated high frequency apparatus at each station for intercommunication between stations, of means at each station for preselecting and designating for use an idle one of the associated trunks and associated high frequency apparatus, and means made operative as a result of the initiation of a call for preselecting and designating for use another of said trunks at each of said stations.

16. In a high frequency communicating system having a plurality of stations, the combination with means for providing a plurality of high frequency channels available for use at each of said stations, of a plurality of trunks at each station, each trunk having means for utilizing for communication any available one of said high frequency channels, and means at each station for automatically preselecting for use one or another of the associated trunks.

17. In a high frequency communicating system having a plurality of stations, the combination with means for establishing a high frequency calling channel and a high frequency communicating channel available for use at each of said stations, of a plurality of trunks at each station adapted to be connected to either of said channels, preselecting means at each station for keeping one or another of the associated trunks responsive to oscillations received over said calling channel, means controlled by said received oscillations for connecting said preselected trunk to said communicating channel, and means made operative upon the connecting of the preselected trunk to the communicating channel to cause said preselecting apparatus to preselect another of said trunks.

18. In a high frequency communicating system, the combination with a station having a plurality of trunks and communicating apparatus adapted for connection with any of said trunks, of means for establishing a high frequency calling channel and a plurality of high frequency communicating channels, automatic preselecting means for placing a particular one of said trunks under the control of oscillations received over said calling channel and for making said trunk available for connection with said communicating apparatus, and automatic testing means associated with said trunk for selecting an idle communicating channel over which the connection of said preselected trunk may be extended.

19. In a high frequency communicating system having a plurality of stations and communicating apparatus at each station, the combination with means for establishing a plurality of high frequency communicating channels available for use at each of said stations, a plurality of trunks at each station, each trunk being adapted to link said

communicating apparatus of the associated station with one of said communicating channels, automatic preselecting means for determining the trunk with which said communicating apparatus is to be connected, and automatic testing means for selecting an idle communicating channel through which the connection of said trunk may be extended.

20. In a high frequency communicating system having a plurality of stations, the combination with means for establishing a high frequency calling channel and a plurality of high frequency communicating channels available for use at each of said stations, of a plurality of trunks at each station, each trunk being provided with means for connecting it to any one of said channels, means for placing a particular one of said trunks in operative relation with said calling channel, switching mechanism associated with said trunk, means at a distant station for transmitting calling oscillations through said channel for controlling said switching mechanism to connect the associated trunk to one of said communicating channels, and means made operative upon the connecting of said trunk to one of said communicating channels for bringing another of said trunks into operative relation with said calling channel.

21. In a high frequency communicating system having a plurality of stations, the combination with means for establishing a high frequency calling channel and a plurality of high frequency communicating channels available for use at each of said stations, of a plurality of trunks at each station, each trunk having conductive terminals and being provided with means for connecting it to any of said channels, switching mechanism common to said trunks, means made operative upon establishing connection with one of said trunks at a conductive terminal thereof for operatively associating said switching mechanism with said trunk, means for controlling the connection of said trunk with any desired one of said channels through the medium of said switching mechanism, and means made operative upon the connection of said trunk to one of said communicating channels for disconnecting said switching mechanism from said trunk.

22. In a high frequency communicating system, the combination with a station having a plurality of trunks and associated high frequency apparatus, of selecting means adapted to select a particular one of said trunks and render it responsive to high frequency oscillations, selective switching mechanism associated with the selected trunk, and a distant station having means for producing high frequency oscillations for selectively controlling said selective switching mechanism.

23. In a high frequency communicating system having a plurality of stations, the combination with a plurality of high frequency channels, of trunks at each station adapted for operative relation between stations through the medium of said channels, station selecting mechanism common to said trunks, preselecting mechanism for placing said station selecting mechanism in operative relation with an idle one of said trunks, and means at each station for producing high frequency oscillations for selectively controlling said station selecting mechanisms of the distant stations by way of their associated preselected trunks to select any desired one of said stations.

24. In a high frequency communicating system, the combination with a plurality of stations and a plurality of high frequency channels each of which is available for use at each of said stations, of a plurality of trunks at each station associated with said channels, means for selecting an idle one of said trunks responsive and controlling apparatus common to the trunks of each station, and automatic selecting mechanism for operatively associating said common responsive and controlling apparatus with the selected trunk.

25. In a high frequency communicating system, the combination with a station having a plurality of trunks and associated high frequency communicating apparatus, of switching mechanism common to said trunks, preselecting means for placing said switching mechanism in operative relation with any desired one of said trunks, and a distant station having means for producing high frequency controlling waves to which said switching mechanism is responsive.

26. In a high frequency communicating system having a plurality of stations and high frequency communicating apparatus at each station, the combination with a plurality of trunks at each station, of switching mechanism at each station common to the associated trunks, means made operative in making connection with one of said trunks for attaching said common switching mechanism thereto, and means operated during the attachment of said common switching mechanism to a trunk for rendering the same responsive to received high frequency oscillations.

27. In a high frequency communicating system having a plurality of stations and high frequency communicating apparatus at each station, the combination with a plurality of trunks at each station, of common switching mechanism associated with the trunks of each station, means for rendering one of said trunks responsive to high frequency oscillations received from a distant station, and means for automatically attaching said common switching mechanism to

said trunk upon the receipt of said high frequency oscillations.

28. In a high frequency communicating system, the combination with a station having a plurality of trunks and associated high frequency communicating apparatus, of call receiving mechanism common to said trunks, automatic pre-selecting means adapted to keep said call receiving mechanism in operative relation with one or another of said trunks, and a distant station having means for producing high frequency calling waves to which said call receiving mechanism is responsive.

29. In a high frequency communicating system having a plurality of stations, the combination with a plurality of trunks and associated high frequency apparatus at each station, common call receiving apparatus at each station adapted to cooperate with the associated trunks, means at each station for initiating a call for another station over said high frequency apparatus, and means made operative at all of the other stations upon the initiation of the call for attaching said common call receiving apparatus to an idle one of said associated trunks.

30. In a high frequency communicating system having a calling station and a called station, the combination with a plurality of trunks and associated high frequency apparatus at each station for inter-communication between stations, of automatic preselecting means for selecting and rendering responsive to high frequency oscillations an idle one of said trunks at each station, means made operative in establishing connection between said stations over said preselected trunks at each station for preselecting another trunk at each station, and means made operative during the continuance of said connection for maintaining responsive said first-mentioned trunk at each station.

31. In a high frequency communicating system having a calling station and a called station, the combination with a plurality of trunks and associated high frequency apparatus at each of said stations for intercommunication between stations, of automatic preselecting means at each station for selecting and rendering responsive to high frequency oscillations an idle one of the associated trunks, a connection switch associated with each trunk operated in establishing connection with the preselected trunk, means made operative in the establishment of connection between said stations over said preselected trunks for preselecting another trunk at each of said stations, and means controlled by each of said connection switches during the continuance of said connection for keeping the associated trunk responsive to high frequency oscillations.

32. In a high frequency communicating system having a plurality of stations, the

combination with a plurality of trunks at each station, and means for establishing a plurality of high frequency channels available to each of said trunks, of means operative upon the taking for use of a trunk at a calling station to select a channel and to transmit calling oscillations over the selected channel.

33. In a high frequency communicating system having a plurality of stations, the combination with a plurality of trunks at each station, and means for establishing a plurality of high frequency channels available to each of said trunks, of means operative upon the taking for use of a trunk at a calling station to select a channel and to transmit calling oscillations over the selected channel, and means to maintain one trunk only at each of the remaining stations in condition to respond to said calling oscillations.

34. In a carrier wave communication system, a plurality of stations having a plurality of trunks, in combination with means for automatically tuning a trunk at a called station to one of a plurality of frequencies upon the initiation of a call and to a frequency other than one of said plurality of frequencies upon the answering of a call.

35. In a carrier wave transmission system, a plurality of stations, each of which has a plurality of trunks, each trunk including transmitting and receiving means, and means at any station for indicating the availability of a trunk for use in combination with means for testing for and selecting an idle carrier frequency and means for tuning the transmitting means of said trunk to the idle frequency.

36. In a carrier wave transmission system, a plurality of stations, each of which has a plurality of trunks, each trunk including transmitting and receiving means, and means at any station for indicating the availability of a trunk for use in combination with means for testing for and selecting an idle carrier frequency and means for tuning the receiving means of said trunk to the idle frequency.

37. In a radio station, a plurality of trunk extensions each terminating in antenna array suitable for two-way communication, means for indicating an idle condition of a particular trunk, means for selecting the idle trunk for use, and means responsive to the presence of electromagnetic waves having certain predetermined characteristics in the ether, surrounding said antenna array for determining the tuning of said antenna array.

38. In a radio system, a station having a plurality of high frequency trunks and means for maintaining in a condition unresponsive to incoming high frequency call

signals all of said trunks except those trunks in use and one idle trunk.

39. In a radio system, a receiving station having a plurality of antennae, a distant transmitting station having a plurality of antennae, and means automatically operable by the initiation of a call from said transmitting station to said receiving station to automatically tune selected ones of said antennae to frequencies appropriate for communication between said stations.

40. A radio station comprising a plurality of antennae, means for tuning each of said antennae to any selected one of several different frequencies, and means responsive to the transmission of waves of the frequency to which one of said antennae is tuned to prevent any other of said antennae being tuned to that frequency.

41. A radio station comprising a plurality of antennae, means for tuning each of said antennae to any selected one of several different frequencies, a distant station, and means responsive to the transmission from said distant station of waves of the frequency to which one of said antennae is tuned to prevent any other of said antennae being tuned to that frequency.

42. A high frequency communication system having a plurality of stations, a plurality of trunks at each station, means whereby a plurality of said trunks at one station may be simultaneously utilized to communicate with other stations, and means for automatically tuning said trunks to selected frequencies not in use at any other of said stations.

43. The method of maintaining a radio station provided with a plurality of equivalent trunks for interchangeable connection with a plurality of substations in responsive condition to a calling wave which comprises automatically causing the preselection and visual identification of a trunk at the station upon and as a result of the utilization of another trunk for communication with any other station.

44. In a radio communication system having a plurality of trunks at a calling station, high frequency channels and a mechanical step-by-step testing device, the method of establishing communication without interfering with existing communications comprising selecting a trunk, connecting a testing device thereto, testing for and selecting an idle channel and tuning the selected trunk to a frequency identifying the channel selected as being idle.

45. A high frequency signaling system comprising a plurality of stations, a plurality of trunks at each station, high frequency signaling apparatus associated therewith, means for preselecting an idle trunk at each station and conditioning the associated sig-

nalizing apparatus for operation, and means controlled through the preselected trunk at each station for causing the selection of a station to the exclusion of other stations.

5 46. A high frequency signaling system comprising a plurality of stations, a plurality of trunks and associated high frequency signaling apparatus at each station, means for preselecting an idle trunk at each station and conditioning the associated signaling apparatus for operation, and means common to the trunks at a station controlled through the preselected trunk for causing the selection of a station to the exclusion of other stations.

15 47. In a high frequency system, a plurality of stations, a plurality of trunks at each station, high frequency transmitting and receiving apparatus associated with the trunks, means for preselecting an idle trunk at each station and conditioning the associated receiving apparatus for operation, and means controlled through the conditioned receiving apparatus and preselected trunk for causing the selection of the station to the exclusion of other stations.

20 48. In a high frequency signaling apparatus, a plurality of stations with a plurality of trunks at each station, high frequency transmitting and receiving apparatus for generating and modulating and for receiving and demodulating a plurality of carrier waves of different frequencies, means at each station for preselecting an idle trunk and conditioning the receiving and demodulating apparatus for response to one of said carrier frequencies, and station selecting means at each station controlled through said conditioned receiving apparatus.

30 49. In a high frequency signaling system, a plurality of stations, a plurality of trunks at each station for interchangeable use in selectively signaling and establishing communication between said stations, a station selector at each station, means for preselecting an idle trunk at each station and controlling the station selector thereover.

45 50. In a high frequency signaling system, a plurality of stations, a plurality of high frequency signaling equipments at each station, each adjustable to provide communication with similarly adjusted equipment at other stations, a plurality of different signaling channels, means for preselecting an idle equipment at a station, and conditioning it for use with the preselected equipment at other stations.

50 51. In a selective signaling system, a plurality of stations, a plurality of high frequency signaling equipments at each station, each capable for use in establishing communications over a plurality of carrier waves of different frequencies, means at each station for preselecting an idle equipment and adjusting it for response to one of said

carrier waves, and means at each station controlled with said preselected equipment for selectively signaling said station.

52. In a selective signaling system, a plurality of stations, a plurality of high frequency signaling equipments at each station, each capable for use in establishing communication over a plurality of carrier waves of different frequencies, means at each station for preselecting an idle equipment and adjusting it for response to one of said carrier waves, and means controlled through said equipment for adjusting the signaling to the signaled station equipment for communication over a different carrier wave.

53. In a radio signaling system comprising a transmitting and a receiving station, the method of indicating a suitable condition for reception at the receiver, which consists in receiving continuously waves which are emitted continuously from the transmitter and in visually indicating at the receiver and transmitter the receipt at the receiver of such waves.

54. In a radio signaling system, a radiating station, means for transmitting carrier waves therefrom continuously, a receiving station, and means thereat for continuously receiving said transmitted waves and indicating means responsive to said received waves whereby suitable conditions for reception are visually indicated at the receiving station and at the radiating station.

55. In a radio signaling system, a radiating station, means for transmitting carrier waves therefrom continuously, means for impressing thereon the message to be transmitted, a receiving station, and means thereat for detecting the message to be transmitted, and supplemental means responsive to the carrier wave to indicate suitable conditions for reception of the message impulses at the receiving station and at the radiating station.

56. In a radio signaling system, a radiating station, means for transmitting carrier waves therefrom continuously, means for impressing thereon the message to be transmitted, a receiving station and means thereat for detecting the message to be transmitted, supplemental means responsive to the carrier wave to indicate suitable conditions for reception of the message impulses at the receiving station and at the radiating station, and a calling device at the transmitting station adapted to send impulses on the carrier wave to call the receiving station.

57. In a radio signaling system, a radiating station, means for transmitting carrier waves therefrom continuously, means for impressing thereon the message to be transmitted, a receiving station and means thereat for detecting the message to be transmitted, and supplemental means responsive to the carrier wave to indicate suitable con-

ditions for reception of the message impulses.

58. In a radio signaling system, a radiating station, means for transmitting carrier waves therefrom continuously, means for impressing thereon the message to be transmitted, a receiving station and means thereat for detecting the message to be transmitted, supplemental means responsive to the carrier wave to indicate suitable conditions for reception of the message impulses, and a calling device at the transmitting station adapted to send impulses on the carrier wave to call the receiving station.

59. In a radio signaling system, a radiating station, means for transmitting carrier waves therefrom continuously, means for impressing thereon the message to be transmitted, a receiving station and means thereat for detecting the message to be transmitted, supplemental means responsive to the carrier wave to indicate suitable conditions for reception of the message impulses, and a call responsive device at the receiving station controlled thereby.

60. In a radio signaling system, a radiating station, means for transmitting carrier waves continuously, means for impressing thereon the message to be transmitted, a plurality of receiving stations, each adapted to be continuously responsive to said transmitted waves, means at each receiving station to indicate its condition of receptiveness, and a selective calling mechanism asso-

ciated with the transmitter for calling certain receiving stations.

61. In a radio signaling system, a radiating station, means for transmitting carrier waves continuously, means for impressing thereon the message to be transmitted, a plurality of receiving stations, each adapted to be continuously responsive to said transmitted waves, means at each receiving station to indicate its condition of receptiveness, a selective calling mechanism associated with the transmitter for calling certain receiving stations, and a selective responsive device at the receiving station responsive to certain signals only.

62. In a radio signaling system, a radiating station, means for transmitting carrier waves continuously, means for impressing thereon the message to be transmitted, a plurality of receiving stations, each adapted to be continuously responsive to said transmitted waves, means at each receiving station for receiving a transmitted message and other means to indicate its condition of receptiveness, and a selective calling mechanism associated with the transmitter for calling certain receiving stations.

In witness whereof, I hereunto subscribe my name this 2nd day of May A. D., 1921.

EDWIN H. SMYTHE.

In witness whereof, I hereunto subscribe my name this 12th day of May A. D., 1921.

SAMUEL B. WILLIAMS, JR.