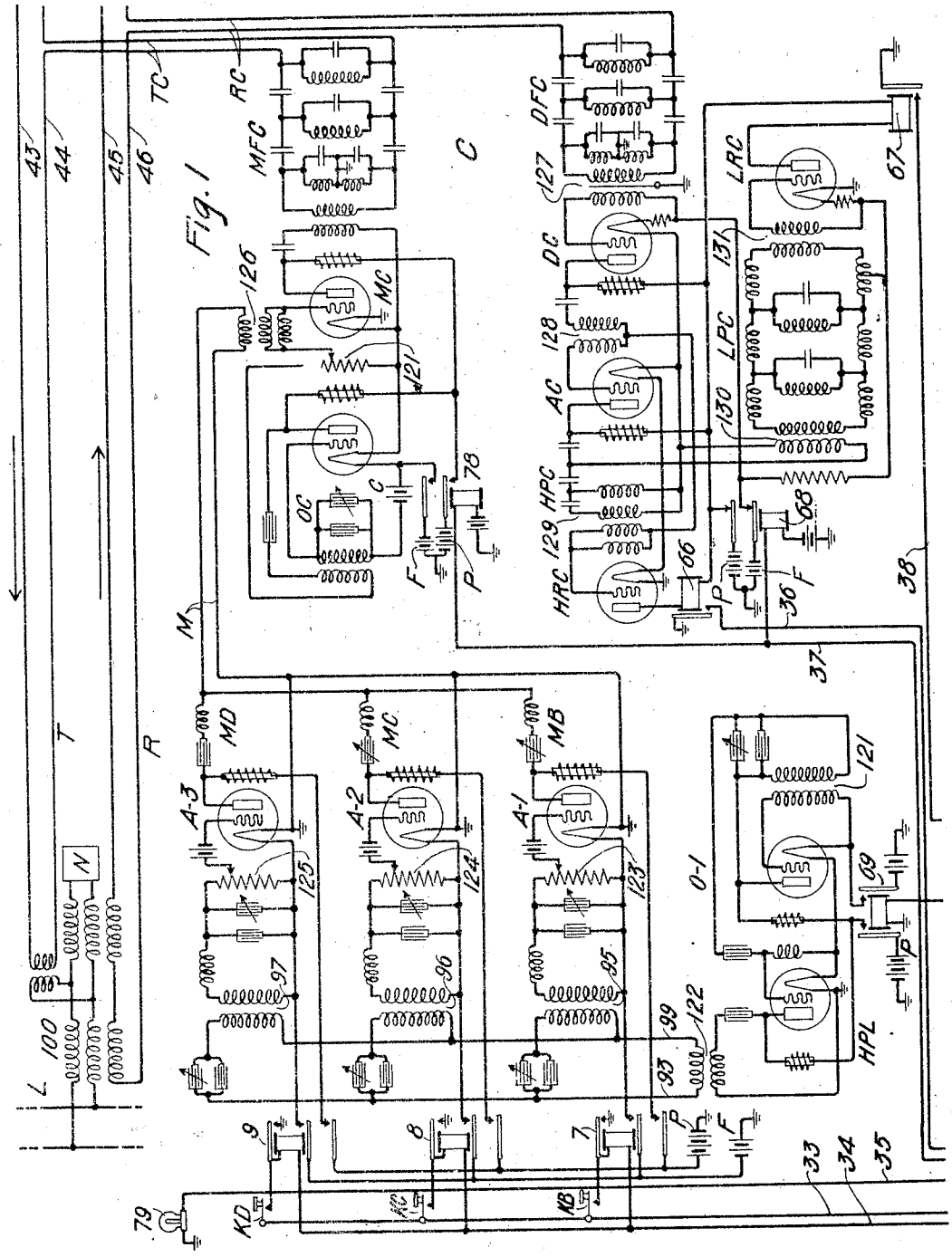
Jan. 5, 1926. 1,568,194

E. H. SMYTHE

CARRIER WAVE TRANSMISSION AND COMMUNICATING SYSTEM

Filed May 5, 1921 4 Sheets-Sheet 1



Inventor:
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CARRIER WAVE TRANSMISSION AND COMMUNICATING SYSTEM

Filed May 5, 1921 4 Sheets-Sheet 2

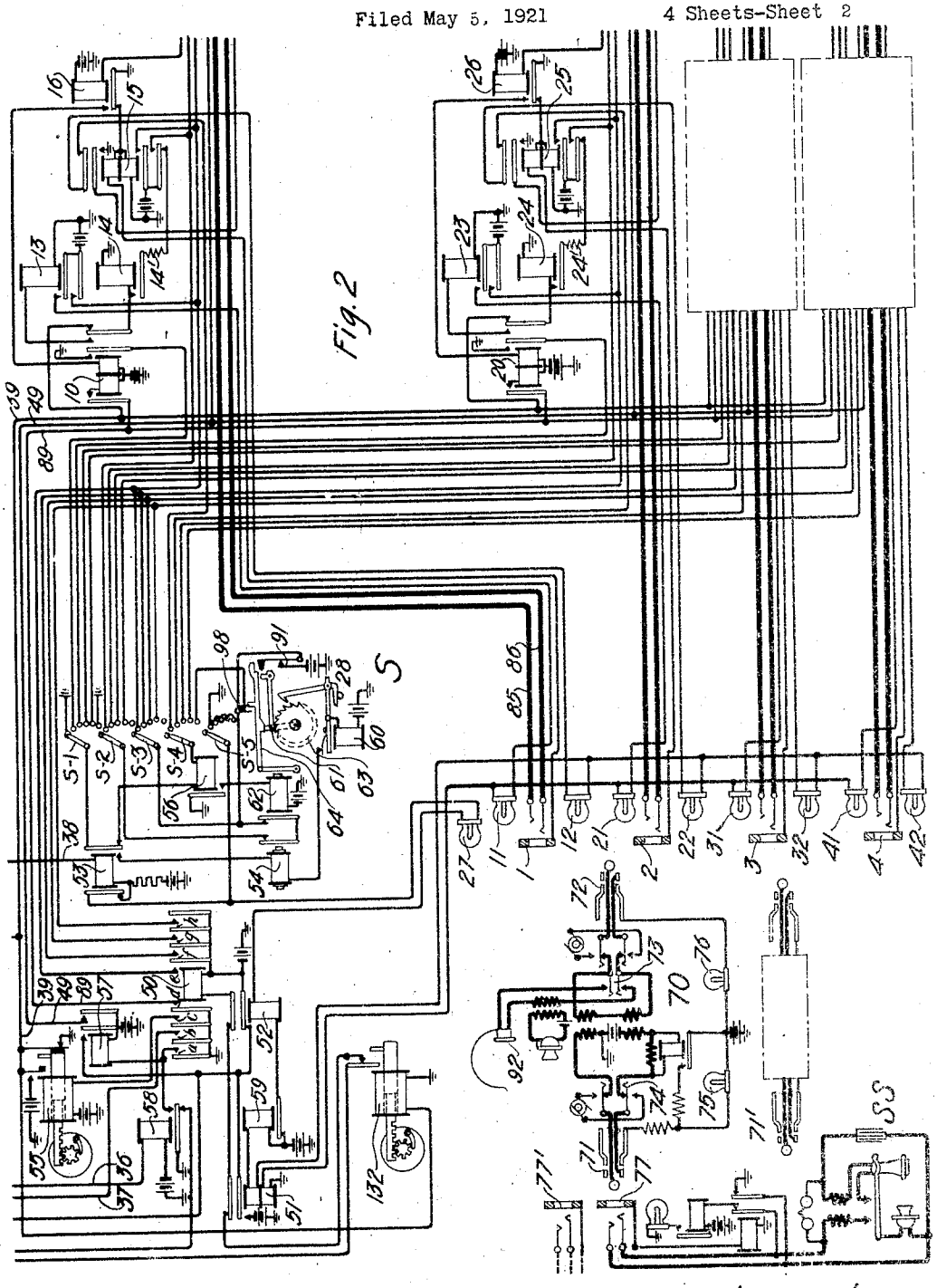


Fig. 2

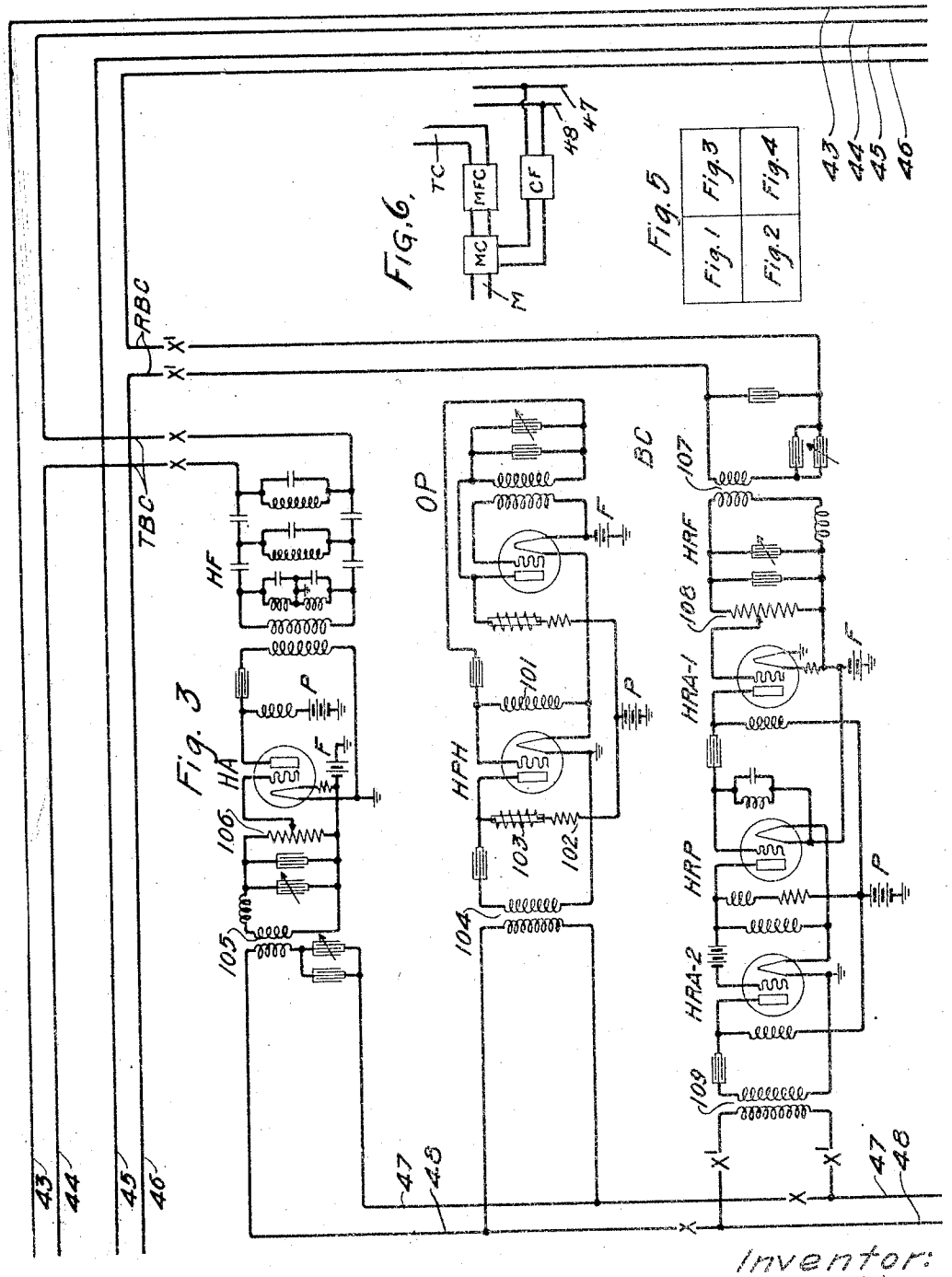
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CARRIER WAVE TRANSMISSION AND COMMUNICATING SYSTEM

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Jan. 5, 1926. 1,568,194

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CARRIER WAVE TRANSMISSION AND COMMUNICATING SYSTEM

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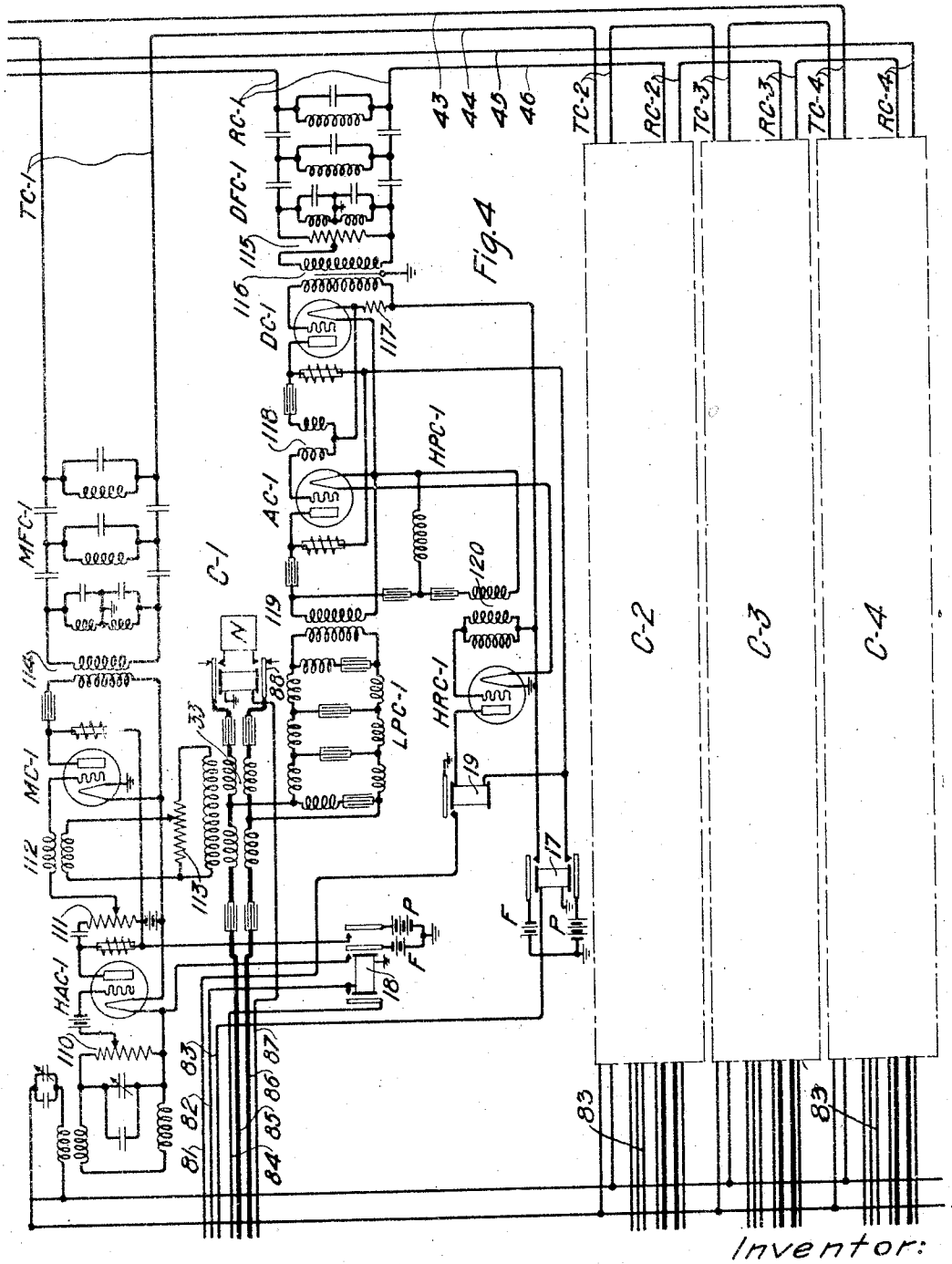


Fig. 4

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Patented Jan. 5, 1926. 1,568,194

UNITED STATES PATENT OFFICE.

EDWIN H. SMYTHE, OF EVANSTON, ILLINOIS, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

CARRIER-WAVE TRANSMISSION AND COMMUNICATING SYSTEM.

Application filed May 5, 1921. Serial No. 467,043.

To all whom it may concern:

Be it known that I, EDWIN H. SMYTHE, a citizen of the United States, residing at Evanston, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Carrier-Wave Transmission 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 carrier waves or oscillations, either free or guided, are employed as the medium for conveying energy for effecting the operation and control of electric signalling, controlling and communicating apparatus located at separated points in the system.

The invention especially relates to a system in which so-called carrier currents, in the form of high frequency waves guided upon wires, are used as the medium of electrical connection between the electrical devices and apparatuses located at the separated points in the system. These carrier currents are assigned such frequencies that they are non-interfering one with another, so that each carrier serves as a separate and distinct connecting medium superposed upon the line or conductor over which the carrier is transmitted. Each of the carriers is modified or modulated in accordance with the voice currents or other signalling or controlling currents that are to be carried. The carriers thus modulated are transmitted over the toll or long distance line and are passed through individual receiving arrangements, each of which is selective of one carrier frequency to the exclusion of the others, and each of which serves to reproduce from the modulated carrier the voice or signal currents with which the carrier was modulated at the distant station.

The apparatus which is used to transmit and receive by means of any one high frequency wave as distinguished from that which is used for transmitting and receiving by means of a wave of a different frequency, is commonly known as a channel, or a high frequency communication channel.

It is the object of the invention to provide a system in which a frequency selective communication channel associated with a line is made available for use between any two of a number of stations on the line; in which a frequency selective channel when in use is guarded against intrusion; in which any one of a plurality of frequency selective channels is made available for inter-communication between any two of a plurality of stations connected with the line with which the high frequency channels are associated; in which means are provided for enabling any one of the stations simultaneously to employ for use all of the channels, or as many as are not in use for communication between other stations; in which each station has means for applying to the line a plurality of differing frequency waves to each one of which a different distant station of the line is responsive, so that each station may select any other station on the line; in which the selection of a called station by a calling station is accompanied by the production or display of a signal; in which means are provided in the initiation of a call for automatically testing the frequency selective communicating channels and appropriating one that is not in use; in which the automatic channel testing and selecting operation is performed by an automatic switch that may be located at the called station and may be made operative by the selection of that station; in which a special calling high or other frequency channel is employed for effecting the selection of a particular called station by a calling station; in which the selection of the different stations through the medium of the special calling channel is accomplished by the modulation of the carrier frequency of the channel with different lower frequencies to each one of which a different one of the stations is selectively responsive; in which the selection of an idle communicating channel by the automatic testing and selecting switch at the called station is accompanied by the identification of the selected communicating channel at the calling station; in which the completion of connection with the identified channel at the calling station causes the identification of the said channel at the called station; in which the completion of connection with the identified channel at the called station or failure to select a channel causes the restoration of the channel testing and se-

lecting switch; in which a second selection of the called station is prevented until the automatic testing and selecting apparatus of that station is returned to normal; in which all other stations are prevented from using the special calling channel while it is in use by any one of them; in which the calling channel is automatically made available for the use of other stations upon the completion of the station and channel selection or upon failure to select a channel; and in which the condition of use or disuse of a selected communicating channel at each of the two stations that are using it is automatically indicated at the other station.

The foregoing are some of the principal objects that the system of the present invention attains. The foregoing and other features are all included in the present embodiment of the invention, but are capable of separate use where it may be desirable to include only part of the features that are herein disclosed. In addition, the system of the invention in the preferred form in which it is disclosed, embodies a number of other features incidental to those mentioned above, and incidental to its use as part of a comprehensive system providing for inter-communication between toll or other stations. The manner in which the above mentioned objects and features are attained and realized will be explained in the following description of the preferred form of the invention, and the structures and combinations through which the objects are attained 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, arranged as indicated in Fig. 5, show diagrammatically as much of the circuit organization at one toll station of the system as is necessary to enable the invention to be understood, and Fig. 6 shows an alternative detail circuit. It will be understood, without the necessity of full diagrammatic representation, that there are a plurality of stations connected with the toll line L, a total of four such stations being assumed in the following description to be present, and that each of these stations may be in all respects identical in apparatus and circuit arrangement with the particular station illustrated in Figs. 1 to 4; the only differences between the stations being in the use of a harmonic producer at one of the stations and of a harmonic reproducer at each of the other stations, and in the particular calling channel modulating frequencies which each station is adapted to transmit and to which it is adapted to respond, as will be fully explained hereinafter.

Referring now to the preferred circuit organization as illustrated in Figs. 1 to 4 of the drawing, only as much of the wiring at a single one of the stations of the toll line is illustrated as is necessary to enable the invention to be understood; it being possible for one skilled in the art to which this invention pertains, by mere duplication and extension of the wiring and apparatus illustrated, and without the exercise of invention, to organize a system of such capacity as may be desired. As illustrated in the circuit diagram of Figs. 1 to 4, each one of the toll stations or toll points is connected with the toll line L through the medium of a two-way repeating coil or conjugate coil 100, this coil terminating in an artificial line or network N that is constructed and arranged, as is well understood in the art, to balance and match in its characteristics the toll line with which connection is made. Extending from the windings of this two-way repeating coil are two pairs of conductors, T and R, the pair T serving as the transmitting path to the toll line of the locally generated currents, and the pair R serving as the receiving path from the toll line of the currents generated at and transmitted from the other stations of the line. The transmitting and receiving paths each have connection with the local apparatus of the four communicating channels C^1, C^2, C^3 and C^4 and with the local apparatus of the calling channel C. At each of the toll stations there is also a connection of either the transmitting path T or the receiving path R with the base frequency channel BC. The connection of the transmitting path T is with the transmitting branches TC, TBC, TC^1, TC^2, TC^3, and TC^4 of the various channels respectively; and the connection of the receiving path R at each station is with the receiving branches RC, RBC, RC^1, RC^2, RC^3 and RC^4 of the various channels respectively. The transmitting branch apparatus of the base frequency channel BC is provided at only one of the toll stations. At the other three stations the transmitting branch apparatus of this channel is omitted and the apparatus indicated in connection with the receiving branch RBC is provided in its stead. At the station where the transmitting branch apparatus of the base frequency channel BC is provided, the circuit is closed at the points X and is opened at the points X^1. At the other stations where the receiving branch apparatus of the base frequency channel is used, the circuits are closed at the points X^1 and are opened at the points X. Obviously, in each case the opening of the circuits at the points X or X^1, as the case may be, in omitting one or the other of the groups of apparatus, is accompanied by a closing of the transmitting path T at the points X or the receiving path R at the points X^1 to make these paths continuous for the passage of current to and

from the other channel branches associated with these paths.

The organization of the transmitting and receiving branches of the various channels will be specifically described hereinafter. As a general description of the organization, it may be said that the transmitting branch TC of the calling channel C is so organized as to apply to the toll line the calling carrier frequency supplied by the oscillator OC and modulated in accordance with one or another of three lower frequencies supplied by way of the associated modulating branches MB, MC and MD. These lower modulating frequencies are supplied from a harmonic producer HPL by a distortion of a base frequency supplied by the oscillator O^1. Each of the modulating branches MB, MC and MD is made operative to apply its particular modulating frequency by the pressing of corresponding keys KB, KC and KD respectively. Each of these keys in being operated causes the application to the calling carrier frequency of the particular modulating frequency adapted to bring about the response of the receiving apparatus of the particular one of the distant toll stations that is being called. The three station selecting keys KB, KC and KD have associated with them a pilot or guard lamp 79 that is illuminated to inform the operator that the selecting apparatus is in use, either locally or at a distant station.

The receiving branch RC of the calling channel is so organized that the unmodulated component of the calling carrier frequency received from the toll line brings about the operation of the relay 66, while the modulated component, if the modulating frequency is that to which this particular station is adapted to respond, brings about the operation of the relay 67. The relay 66 acts through the medium of the relay 58 to render ineffective the station selecting keys KB, KC and KD, and to light the key guard lamp 79 to maintain the existing condition of the communicating channel transmitting apparatus. The relay 67 acts through the medium of the relay 53 to bring about the automatic selection of the called toll station of an idle one of the communicating channels.

The apparatus in the transmitting branch TBC of the base frequency channel BC is so organized as to distort in the harmonic producer HPH a base frequency generated in the oscillator OP. The base frequency and its harmonics are conducted to a distributing circuit comprising the conductors 47, 48, from which the base frequency is separated out and applied to the transmitting path T by way of the branch TBC, while the harmonics are selectively passed to the transmitting apparatus of the communicating channels C^1, C^2, C^3 and C^4 to supply the carrier frequencies for conveying the speech and signalling modulations over the respective channels.

The apparatus in the receiving branch RBC of the base frequency channel BC is so organized that the base frequency received from the particular one of the four toll stations where the base frequency producing apparatus is located, is separated out from the other carrier frequencies passing over the receiving path R, is amplified, passed through a harmonic reproducer HRP, and the harmonics of the base frequency thus produced are supplied to the distributing conductors 47, 48, to supply the carrier frequencies required by the communicating channels C^1, C^2, C^3 and C^4.

The organization of each of the communicating channels C^1, C^2, C^3 and C^4 is such that the voice currents received from the local telephone circuit by way of the talking conductors 85 and 86 are passed through the two-way repeating coil 33, caused to modulate the carrier frequency received from the distributing conductors 47, 48, and the modulated carrier frequency is conducted to the transmitting path T. The organization of each of the communicating channels is also such that the characteristic carrier frequency to which the channel is adapted to respond is separated out from the other frequencies passing over the receiving path R, is detected, and the voice frequency components are conveyed by way of the two-way repeating coil 33 to the local talking conductors 85 and 86, while the carrier frequency components are diverted and caused to operate the relay 19. The relay 19 acts through the medium of the relays 16 and 10 to control the signalling and channel selecting operations. Each communicating channel with its low frequency extension constitutes a trunk for establishing communication with another station.

Each of the communicating channels C^1, C^2, C^3 and C^4 is terminated locally upon spring jacks 1, 2, 3 and 4 respectively. With these four spring jacks are associated the assigning lamps 11, 21, 31 and 41 and the calling lamps 12, 22, 32 and 42, respectively. The function of the assigning lamp is to inform the calling toll operator of the particular channel that has been selected for use; and the function of the calling lamp is to inform the operator at the called toll station of the receipt of a call upon the corresponding channel spring jack. Associated with the channel terminals and their corresponding assigning and calling lamps, there is a call pilot lamp 27 which lights in advance of the lighting of the calling lamp to notify the operator at the called station that a call is about to be received. From the spring jack terminals of the communi-

cating channels the connections are extended to spring jack terminals 77 of local stations SS by means of a plurality of connecting cord circuits 70, of which there may be enough provided to utilize all of the channels simultaneously, or as many of them as are not at the time in use between other stations. Obviously, connection between the communicating channels and the local lines may be effected in any other desired way of the many that are well-known in the art; as for instance, by means of circuits involving the use of automatic switches.

The selection of an available communicating channel, in the particular embodiment of the invention illustrated, is effected by means of an automatic switch S that is set into operation by the energization of the relay 53 under the control of the relay 67 which is responsive to the detected modulating component of the calling carrier frequency. The movement of this switch in its channel testing and selecting operation and the lighting of the lamp signals associated with the channel that is selected for use are under the control of group relays 10, 13, 14, 15 and 16 associated with the channel C^1, and like groups of relays associated with the other communicating channels. Associated with the channel selecting switch S are a stepping magnet 60, a release magnet 62, and the switch controlling relays 54 and 56. The channel selecting switch S with its associated magnets and relays, as well as the relays 50, 51, 52, 55, 57, 58 and 59 that cooperate in the control of the channels, are common to all of the channels of the toll station.

The organization and operation of that part of the system which acts to generate, modulate, transmit, receive and de-modulate or detect the high frequency carrier currents employed in the system is as follows: The frequency of the carrier waves selectively utilized by the communicating channels is determined, in the present embodiment of the invention, by a base or control frequency generated by a thermionic or vacuum tube oscillator OP located at one of the toll stations or at some point upon the toll line. This oscillator may be of any usual and well known type, such as the audion type, with a feed-back connection from its output into its input circuit. The frequency of the oscillatory current produced may be regulated by an adjustable condenser, and may conveniently be, say, five thousand oscillations per second. The oscillator OP supplies substantially sinusoidal oscillations to the input circuit of the harmonic producer HPH. An inductance 101 is bridged across this circuit. The magnitude of the oscillations supplied is such as to overload the thermionic tube HPH; that is, to supply an input wave of greater amplitude than the tube can repeat without distortion. The repeated oscillations in the output circuit of the tube HPH are therefore of non-sinusoidal wave form, which is the equivalent of a base frequency current of sinusoidal form and a series of currents of frequencies which are multiples or harmonics of the base frequency. The plate current supply of the overloaded tube or harmonic producer HPH is through a circuit comprising a resistance 102 and an inductance 103 which constitutes an impedance that is large as compared with the impedance between the plate and filament of the tube. This impedance relationship assists in producing distortion and in stabilizing the output circuit. The output circuit of the harmonic producer HPH is connected with a distributing circuit 47, 48, by means of a transformer 104, and the distributing circuit is thus supplied with both the base and the harmonic frequency oscillations. From the distributing circuit 47, 48, the base and harmonic frequencies are selected by means of tuned circuits leading to the transmitting branches of the various communicating channels and the transmitting branch of the base frequency channel. The inductance of the transformer 105 of the base frequency transmitting branch and the capacities of the variable condenser associated with it are so adjusted that only the base frequency oscillations are selected. Similarly the constants of the transformers and condensers of the other tuned circuits leading from the distributing circuit are so adjusted that each of these tuned circuits selects a different one of the harmonics of the base frequency. The harmonic frequencies selected by the transmitting branches of the communicating channels C^1, C^2, C^3 and C^4 may be ten thousand, fifteen thousand, twenty thousand, and twenty five thousand respectively.

The base frequency oscillation selected from the distributing circuit by the tuned circuit including the transformer 105 passes through a potentiometer 106, from which it is supplied at the desired potential to the input circuit of the amplifier HA. The output circuit of the amplifier HA is inductively coupled with the terminals of a band filter HF through which the amplified base frequency oscillation passes to the transmitting path T. The band filter HF is of the well-known type described in Patent 1,227,113 to Campbell, patented May 22, 1917. The characteristics of this filter, which consists of similar sections having series and shunt capacities and inductances is such that it transmits oscillations of the base frequency with little attenuation, and

effectively diverts from this branch currents of frequencies differing more than a slight amount from the base frequency.

As has been stated, the base frequency oscillator is provided at but one station or point on the toll line. At the other toll stations or points the base or controlling frequency thus supplied to the line passes through the two-way repeating coil 100 of the station into the receiving path R. The receiving branch of the base frequency channel RBC is provided with a transformer 107 with associated condensers to constitute a tuned circuit that acts to divert the base frequency oscillation from the receiving path to the amplifier HRA^1 by way of the potentiometer 108, while permitting the free passage of the other carrier frequencies through the receiving path to their respective channels. The base frequency thus selected is amplified by the amplifier HRA^1, and the amplifier oscillations are impressed upon the input circuit of the thermionic tube HRP. The magnitude of the oscillations are such as to overload this tube, with the result that, as in the case of the tube HPH associated with the base frequency oscillator OP, the repeated oscillations are distorted into a series of currents the frequencies of which are the harmonics of the base frequency current, the tube HRP thus acting as a harmonic regenerator. The base frequency and its harmonics are then amplified by the amplifier HRA^2 and are impressed upon the distributing circuit 47, 48 through the transformer 109. From the distributing circuit the harmonic frequencies of the base or controlling oscillation are selectively supplied to the transmitting branches of the channels C^1, C^2, C^3 and C^4 by way of the tuned circuits previously referred to. Thus at the toll station where the base frequency oscillator OP and the harmonic producer HPH are located the communicating channel carrier frequencies are supplied directly, while at the other stations they are supplied by a harmonic regenerator HRP controlled by the base frequency oscillations transmitted over the toll line. Consequently the corresponding carrier frequency oscillations are identical in frequency at all of the stations of the toll line.

The organization illustrated and described for producing a plurality of harmonic carrier frequencies from a base frequency by distorting that frequency, and for insuring identical frequencies of the carrier oscillations employed at each of the various toll stations by controlling the carrier frequencies at all points from a single base frequency is substantially in accordance with the organization disclosed in United States patent to Kendall No. 1,446,572, February 27, 1923, and British Patent No. 131,426, respectively. The method and organization described above for synchronizing corresponding carrier waves at all stations is the preferred way of securing this result for use in connection with the present invention. But it will be understood that other ways of securing substantially identical frequencies of the carrier waves at the different points at which they are applied may be used.

At each of the communicating channels C^1, C^2, C^3 and C^4 the particular carrier frequency diverted from the distributing circuit 47, 48 by means of the corresponding tuned circuit is applied to the terminals of a potentiometer 110 from which the carrier oscillations at the desired potential are applied to the input circuit of an amplifier HAC^1. The output circuit of the amplifier is connected by way of the potentiometer 111 with the input circuit of a modulator MC^1. The input circuit of the modulator MC^1 also has connection by way of the inductive coupling 112 and the potentiometer 113 with the appropriate winding of the two-way repeating coil 33 in the low frequency or talking circuit. The talking conductors extending to the spring jack terminals of this communicating channel are connected through condensers with the line side of the two-way repeater, and the other side of the repeater is connected through condensers and relay contacts with a balancing network, the characteristics of which are made to match the characteristics of the low frequency lines adopted to be connected with the channel. The voice currents that reach the repeater 33 by way of the conductors 85 and 86 are consequently repeated and impressed at the proper potential upon the input circuit of the modulator MC^1 and are there combined with the carrier frequency derived from the distributing circuit 47, 48 to cause correspondingly modulated current to flow in the output circuit of the modulator. The output circuit of the modulator is connected through an inductive coupling 114 with a band filter MFC^1 of the type disclosed in the Campbell patent previously referred to. The characteristics of this particular form of the Campbell band filter are such that it suppresses any currents of the frequency of the voice currents in the talking conductors of the channel which might be repeated as low frequency currents by the modulator. The corresponding band filter of each of the channels serves to transmit currents of a range of frequencies including the carrier frequency of that channel and frequencies extending up and down from the carrier frequency by an amount depending upon the highest frequency current that it is desired to transmit from the low frequency or talking circuit.

The band filters MFC^1 of the four com-

municating channels, the band filter HF of the base frequency channel BC, and the band filter MFC of the calling frequency channel C are all arranged serially in the transmitting path 43, 44; and the constants of these various filters are so adjusted that each filter passes freely to the transmitting path the carrier frequency from its own channel while at the same time preventing the frequencies supplied through the filters of the other channels from being diverted into its channel. The band filters DFC^1 of the receiving branches of the various communicating channels C^1, C^2, C^3 and C^4, the tuned circuit of the receiving branch RBC of the base frequency channel BC, and the band filter DFC of the receiving branch RC of the calling channel C, are similarly included serially in the receiving path R extending from the two-way repeating coil 100; and the constants of the filters and the tuned circuit are so adjusted that each diverts from the receiving path R into its own channel the particular frequency to which the channel apparatus is adapted to be responsive, while permitting to pass freely through the series circuit the frequencies for which the other channels are adjusted.

The receiving branch of each of the communicating channels is provided with a band filter DFC^1 adjusted, as stated above, to divert into the channel the characteristic frequency band of that channel. The oscillatory current thus diverted is supplied through a potentiometer 115 to the low side of a shielded transformer 116, the high side of which is included in the input circuit of the detector DC^1. The C potential for the grid of this detector tube is derived from the filament battery by including a resistance 117 in the filament current supply circuit beyond the point where the input circuit of the detector is connected with the filament circuit. The output circuit of the detector DC^1 is connected to the input circuit of the amplifier AC^1 through the medium of a transformer 118 which is designed to transmit efficiently the voice frequencies obtained from the demodulation of the modulated carrier wave, as well as the unmodulated carrier component. The output circuit of the amplifier AC^1 is connected to the low pass filter LPC^1, designed to pass the voice frequencies and exclude the carrier frequencies, by way of a transformer 119. The other terminals of the low pass filter are connected to the bridge terminals of the two-way repeating coil 33, where the voice currents are divided between the talking conductors 85 and 86 and the balancing network N in such a way as to have their effects neutralized in the coil of the repeater that is connected with the outgoing transmission branch of the channel. The output circuit of the amplifier AC^1 also has a branch path through a high pass filter HPC^1 which acts to pass the unmodulated carrier wave component and to prevent the passage of the de-modulated voice frequencies. The other terminals of the high pass filter HPC^1 are connected with the low side of a transformer 120, the high side of which is connected in the input circuit of the rectifier tube HRC^1. The output of the rectifier is connected with the winding of a relay 19 which is adjusted to respond and hold its contacts closed as long as the associated communicating channel is receiving the carrier frequency which it is adapted to divert from the receiving path R. The filament and plate energizing currents are supplied to the apparatus of the receiving branch of the channel under the control of a relay 17, and are supplied to the transmitting branch of the channel under the control of a relay 18. The supply circuits are so arranged that the filament and plate current is normally disconnected, and is applied to the receiving and transmitting branch apparatus only when the corresponding relays 17 and 18 are energized.

As has previously been stated, the receiving path R of each toll station is arranged to receive a calling carrier frequency by way of the transmitting branch TC of the calling channel C, the calling carrier being modulated by lower frequencies in accordance with which of the modulating branches MB, MC and MD is made operative. In accordance with the present embodiment of the invention, the calling carrier frequency is supplied by an oscillator OC, the output circuit of which is connected by way of potentiometer 121 with the input circuit of the modulator MC. The calling carrier may be of any suitable frequency that differs selectively from the frequencies that are used by the base channel BC and the four communicating channels C^1, C^2, C^3 and C^4. If the base channel frequency is five thousand and the four communicating channel frequencies are ten thousand, fifteen thousand, twenty thousand and twenty-five thousand respectively, as has been assumed, the frequency to which the calling channel is adjusted may be thirty thousand. The calling channel frequency is illustrated as being supplied to the modulator MC by a separate oscillator OC; but obviously, if desired, the calling carrier frequency of thirty thousand may be one of the harmonics of the base frequency oscillator OP, and may be supplied to the modulator MC by a correspondingly tuned branch of the distributing circuit 47, 48. This alternative arrangement is diagrammatically indicated in Fig. 6 where the tuned circuit or filter CF is selective of the calling channel frequency and serves to derive the harmonic of this frequency from the distributing circuit 47, 48 and to apply it to

the modulator MC. The rest of the circuit is as shown in Figs. 1 and 3, the oscillator OC being, of course, omitted when the arrangement of Fig. 6 is used.

The modulation of the calling carrier wave is effected by lower frequency currents produced by the oscillator O^1 and the harmonic producer HPL. The oscillator O^1 as in the case of oscillators OP and OC is of the well-known type having a feed-back connection from its output circuit to its input circuit by way of the inductive coupling 121. The output circuit of the oscillator O^1 is connected with the input circuit of the harmonic producer tube HPL. The magnitude of the oscillations supplied is such as to overload the tube HPL, thus causing the tube to distort the sinusoidal wave of the oscillator O^1 and produce in its output circuit non-sinusoidal currents that are the equivalent of the base frequency current of the oscillator together with the harmonics of the base frequency. This series of currents is supplied by way of transformer 122 to the distributing conductors 93, 99. The various frequencies that are thus supplied to the distributing circuit are selectively diverted by way of a plurality of tuned circuits, including the transformers 95, 96 and 97 and their associated variable condensers, to the potentiometers 123, 124 and 125, respectively, of the modulating circuits MB, MC and MD. From the potentiometers the oscillations of the selected frequencies are conducted to the input circuits of the amplifiers A^1, A^2 and A^3. The output circuits of these amplifiers are connected in tuned branches of the modulating circuit M, the tuning of the branches being such as to permit the passage to the modulating circuit of the frequency of the corresponding modulating branch and to exclude from the branch in question the frequencies of the other modulating branches that feed into the modulating circuit M. The modulating circuit M is connected with terminals of a transformer 126, the other terminals of which are connected with the input circuit of the modulator MC.

The modulating branches MB, MC and MD are normally inoperative and are made operative under the control of the associated relays 7, 8 and 9 respectively, these relays acting when operated to apply current from the filament and plate batteries F and P to energize the apparatus of the corresponding branches. The relays 7, 8 and 9 in turn are controlled respectively by the keys KB, KC and KD, which are the station selecting keys of the organization. The oscillator O^1 and harmonic producer HPL are also normally inert, and are energized through the energization of relay 69, which operates to connect the filament and plate batteries to the circuit.

The oscillator O^1 may be arranged to produce oscillations of any suitable frequency as, for instance, 200 cycles. As a result of the action of the harmonic producer HPL there is transmitted to the distributing circuit 93, 99 the base frequency 200 of the modulator O^1 together with the harmonic frequencies thereof. If three modulating paths MB, MC and MD are employed, these paths have their constants adjusted to divert from the distributing circuit, amplify and pass to the modulating circuit M the three harmonic frequencies 400, 600 and 800. If additional modulating branches are to be used, they may be adjusted to employ the base frequency 200 and other higher harmonic frequencies.

As will subsequently be explained, each of the toll stations is adapted to have the receiving branch of its calling channel selectively responsive to a particular one of these lower modulating frequencies; so that the transmitting branch of the calling channel at each station is arranged to transmit the calling carrier frequency and as many lower frequency modulations thereof as there are distant toll stations to be selectively controlled or signalled. The transmitting branch of the calling channel at each toll station is of course arranged to modulate the calling channel frequency only with the lower frequencies to which the distant toll stations are responsive, and not with the lower frequency to which the particular toll station itself is responsive. Thus the particular station illustrated in the drawing is assumed to be responsive to the 200 modulating frequency, and consequently the modulating branches are so arranged as not to apply the 200 frequency to the modulating path M, but to apply the three harmonic frequencies 400, 600 and 800. At the toll station responsive to the 400 frequency the modulating branches are arranged to employ the 200, 600 and 800 frequencies; and similarly at the other stations the particular modulating frequency to which that station is adapted to respond is not arranged to be applied to the transmitting branch.

At each of the toll stations there is a connection from the receiving path R by way of a band filter DFC and a shielded transformer 127 to the input circuit of a detector DC. The band filter DFC is designed to divert into the receiving branch of the calling channel C the band of frequencies including the calling channel frequency, in this instance assumed to be thirty thousand, and its modulations extending up and down from this frequency through a range determined by the modulating frequencies derived from the modulating path M. The output circuit of the detector DC is connected through a transformer 128 with the input circuit of an amplifier AC. The out-

put circuit of the amplifier is connected through the high pass filter HPC and the transformer 129 with the input circuit of the rectifier tube HRC. The output circuit of the rectified tube includes the winding of the relay 66, which is thus adapted to respond to the presence in the circuit of the unmodulated component of the calling channel carrier wave. The output circuit of the amplifier AC also has connection through the medium of the transformer 130 with a low pass filter LPC. This filter is designed to pass to the input circuit of the rectifying tube LRC, through the medium of the transformer 131, the particular modulating frequency of the calling carrier wave to which this toll station is responsive, and to exclude the other modulating lower frequencies to which the other toll stations respond, the demodulation of the modulated calling carrier wave into its carrier and modulating components being effected in the detector DC. The ouput circuit of the rectifying tube LRC is connected with the winding of the relay 67, which relay therefore responds only when the calling carrier wave is modulated with the particular frequency to which the associated station is adapted to respond. At other stations there will be substituted for the low-pass filter LPC a band filter designed to pass the particular modulating frequency to which that station is intended to respond and to exclude other frequencies. Thus, for example, the station which is intended to be called by means of the frequency sent out through the channel A^2, namely 600 cycles will be designed to pass 600 cycle current freely and exclude currents of 400 and 800 cycles or any other currents of frequencies differing materially from 600 cycles.

In outline the operation of the system is as follows:

When it is desired to establish communicating relation between any two of the toll stations connected with the line, the operator at the calling station presses the particular station selecting key at her position that corresponds to the station that is being called. She first, however, observes the key guard or pilot lamp. If this is lighted she knows that the calling channel is in use, and waits until the going out of the lamp shows that the calling channel is available. If she should fail to observe the lamp or should disregard it, the pressing of the station selecting key would nevertheless be ineffective until the calling channel was released by the station using it.

Assuming that the calling channel is free, the pressing of the station selecting key causes the energization of the calling channel, and the application to it of the calling carrier frequency modulated by the particular lower frequency corresponding to the key pressed and to which the called station is responsive. At the same time the pressing of the station selecting key at the calling station effects the maintaining of the communicating channels at the calling station in the condition of use or disuse in which they happen to be at the instant the key was pressed, and also prepares apparatus associated with the then idle channels at the calling station for the receipt of a return signal from the called station for identifying the communicating channel that the testing apparatus at the called station is about to select. The application of the modulated calling carrier frequency by the pressing of the selecting key at the calling station causes the lighting of the key guard or pilot lamp at all of the stations, the calling and called stations included, and makes the calling channel at all of the stations temporarily unavailable for use for any other call. The application of the calling carrier frequency also maintains the communicating channels at all the stations in the condition of use or disuse in which they happen to be at the moment the calling station selecting key was pressed.

The response of the called station to the modulating frequency of the calling carrier wave lights a calling pilot lamp to notify the called station operator that a call is coming, and sets into operation the automatic selecting switch, which thereupon successively tests the various communicating channels. In making its test this switch in engaging the terminals of each communicating channel renders the receiving branch of that channel responsive to the presence on the line of the particular carrier frequency which the communicating channel under test is adapted to use, providing the receiving branch is not already responsive on account of the channel being in use locally. If the response of the receiving branch shows the channel to be in use, the testing switch advances to the terminals of the next channel, and stops upon the terminals of the first communicating channel that is not in use, at the same time causing the application to the line of the characteristic carrier frequency of the selected channel. To the application of this characteristic frequency the previously set or prepared apparatus of the corresponding communicating channel at the calling station responds, and causes the lighting of the assigning lamp associated with the corresponding spring jack terminal of this channel at the calling station. Coincidentally with the lighting of the assigning lamp the modulated calling carrier frequency is withdrawn at the calling station, thus making the calling channel available for use at other stations of the toll line. But at the calling and called stations the key guard lamp remains lighted and the

calling channel controlling keys and circuits are held ineffective for a further period of time.

The lighting of the assigning lamp notifies the operator at the calling station of the channel that has been selected, and when she establishes connection with the selected channel by plugging into its associated spring jack, the transmitting branch of the selected channel is energized and the characteristic carrier frequency is applied at the calling station. To the application of the carrier frequency at the calling station the receiving apparatus of the selected channel at the called station responds and causes the lighting of the corresponding calling lamp associated with the spring jack terminal of the selected channel at the called station. At the same time the carrier frequency is withdrawn from the transmitting branch of the selected channel at the called station, thus causing the supervisory lamp in the calling operator's cord circuit to light to indicate to that operator that the operator at the called station has been signalled but has not yet responded. When the operator at the called station responds by plugging into the spring jack of the selected channel indicated by the lighted calling lamp, the calling lamp and the calling pilot lamp at the called station and the supervisory lamp associated with the operator's connecting cord circuit at the calling station are extinguished, and at the same time the channel selecting switch at the called station is released and returned to normal. When the connecting circuit plugs are inserted in the spring jacks of the selected channel at the calling and called stations, the key or guard pilot lamps at the respective stations are extinguished and the calling channel controlling circuits at these stations are again made available for use. The extension of the selected channel to local lines at the calling and called stations is effected through the medium of the connecting cord circuits at these stations, and the withdrawal of the connecting circuit plug from the channel spring jack at either toll station causes the lighting of the corresponding supervisory lamp in the cord circuit at the other station. If the channel selecting switch at the called station fails to select a channel, the calling carrier frequency is automatically withdrawn at the calling station, and the channel selecting switch at the called station is automatically released.

The operation of the system of the invention will now be described in detail. When an operator at one of the toll points or stations has occasion to utilize the toll line for establishing connection with another toll station, she first presses the particular one of the three keys KB, KC or KD corresponding to the distant station that is to be called. If it is assumed that the distant station through which the connection is to be established is the station D, then the operator momentarily depresses the key KD. On the assumption that no other toll station is at the time calling, this closes a circuit that extends from battery through the winding of relay 50, upper armature and back contact of relay 52, upper armature and back contact of relay 51, inner contacts of timer 132, conductor 34, winding of relay 9, momentarily closed contacts of key KD, conductor 33, and back contact and armature of relay 58 to ground. The effect of the closure of this circuit is to energize relay 9, which thereupon locks up to ground by way of its upper armature and front contact. If it had happened that at the time the key was pressed some other call over the toll line was in the process of being made, the circuit traced above would have been held open at the included contacts of relay 58, relay 51 or relay 52, as will hereinafter be described. But under the present assumption that the calling circuit is free for use, the circuit traced above is closed, the relay 9 is locked up, as described, and the relay 50 is also operated.

The relay 50 in operating closes at its contacts *a* an energizing circuit for relay 57; and that relay in operating closes at its inner front contact and armature an energizing circuit for the key pilot lamp 79. The illumination of this lamp persists until the apparatus at the called toll station has selected a channel for use and identified the selected channel by causing the lighting of the associated assigning lamp at the calling toll board, as will be described. Relay 57 in operating also closes a circuit that extends from battery through the outer armature and front contact of relay 57, conductor 49, and thence to ground by way of the conductor 84 and the left-hand locking contact and winding of any of the relays 18 associated with a channel that is at the time in use at the calling toll station. This is for the purpose of preventing any alteration in the condition of use of a channel during the testing operation that is about to take place.

Relay 50 in operating also, at its contact *b*, applies ground to conductor 37 that has parallel branches from battery extending through the windings of relay 68 and 78. Relay 68 in operating breaks the normal connection of the plate battery P and the filament battery F with the energizing circuits of the receiving branch RC of the calling channel C. The effect of this is to make the receiving branch of the calling toll station irresponsive to the calling carrier frequency and the particular superposed modulating frequency to which the calling toll station is normally responsive, and thus

to prevent any possible operation of the associated relays 66 and 67 while this particular toll station is calling. At the same time the relay 78 in operating connects the associated filament battery F and plates battery P with the transmitting branch TC of the calling channel C. The closure of the filament and plate battery circuits makes operative the oscillator OC and the modulator MC of the transmitting branch TC, and as a result the calling carrier frequency is applied to the toll line.

The modulating frequency determined by the pressing of the key KD is not immediately applied to the calling carrier wave, but awaits the operation of the timer or slow-acting relay 55. The energizing circuit of this relay is closed at contacts *c* upon the operation of the relay 50; and when, an interval after the operation of the relay 50 determined by the time required for timer 55 to draw in its plunger, the inner contacts of timer 55 are closed, the energizing circuit is completed for the operation of the relay 69. This relay in operating connects the associated filament and plate batteries with the circuits of the oscillator O^1 and the harmonic producer HPL, which thereupon operate to generate the pre-determined base modulating frequency and its harmonics. These modulating frequencies, as has been described, are selectively separated out by the different appropriately tuned circuits and are applied by way of the associated inductive couplings 95, 96 and 97 to the modulating branches MB, MC and MD of the transmitting branch TC of the calling channel C. The only one of the modulating branches that is at the time energized is, under the present assumption, the branch MD corresponding with the key KD that has been pressed. Therefore the modulating frequency which this branch is adapted to transmit is applied to the input circuit of the modulator MC associated with the calling channel oscillator OC. As a result the calling carrier wave that is applied to the toll line is modulated by the particular harmonic frequency of the oscillator O^1 that is adapted to be transmitted through the modulating branch MD. The effect of the application to the toll line of the calling carrier wave carrying this particular frequency modulation will be described in detail hereinafter.

When relay 50 operates as a result of pressing one of the station selecting keys, it applies battery at its contacts *e*, *f*, *g* and *h* to branches 83 extending to ground through the windings of each of the relays 17 of the four communicating channels. The relays 17 of all of the communicating channels are thus held operated during the period of energization of the relay 50, and act to energize the receiving branches RC^1, RC^2, RC^3 and RC^4 of the associated channels, and thus to make the associated relay 19 of each of these channels responsive to the presence upon the toll line of the carrier frequency which the corresponding channel is adapted to employ. Each relay 19 associated with a channel that is in use at any point therefore responds and closes, by way of conductor 81, an energizing circuit for the relays 16, 26, etc., of the corresponding channels; and the relays 16, 26, etc., in operating close energizing circuits for the associated relays 10, 20, etc., that extend from battery by way of the right-hand windings of these relays. At the same time that the relay 50 causes the energization of the relays 17 of all the channels to cause the response of the relays 10, 20, etc., of the channels that are in use, it also applies at its contact *d* a ground to conductor 89 which has branches to the left-hand armatures of the relays 10, 20, etc., of the various channels. This causes a locking circuit to be completed from battery through the left-hand winding of such of the relays 10, 20, etc., as may have become energized as a result of being associated with the channels that are in use, so that these relays are prevented from changing their operated condition during the succeeding test and assignment of a selected channel.

An interval after the operation and locking up of the relays 10, 20, etc., associated with busy channels, the timer 55 completes the inward movement of its plunger and applies battery to the conductor 39. This conductor has branches to the outer right-hand back contact of each of the relays 10, 20, etc., and the corresponding outer right-hand armature of these relays are connected to ground by way of the windings of associated relays 14, 24, etc. As a result, any of the relays 14, 24, etc., which is associated with a relay 10, 20, etc., that has not been operated, has its energizing circuit closed as soon as the timer 55 closes its inner contact; and such of the relays 14, 24, etc., that are thus energized are locked up by way of the associated front contact and armature, resistances 14^1, 24^1, etc., and outer lower back contact and armature of associated relays 15, 25, etc., to battery. The channels which at the time are idle and available for selection are thus marked or identified by the fact that their associated relays 14, 24, etc., are operated and locked up; the energizing circuits of the corresponding relays associated with the busy channels being held open at this time by the energized condition of the associated relays 10, 20, etc.

Turning now to the operations that take place at the toll points or stations other than the one which is calling, the application of the calling frequency by the oscillator OC of calling branch C upon the pressing of key KD, causes the response of the relays 66 as-

sociated with the receiving branches RC of the calling channels C at all of the other toll stations of the line. Each of the relays 66 in operating closes the circuit that extends from battery through the winding of relay 58, conductor 36, and front contact and armature of relay 66 to ground. Relay 58 in operating opens at its back contact and armature the path by way of conductor 33 over which the initial energization of the modulating branch relays 7, 8 and 9 is effected, so that the station selecting keys KB, KC and KD are deprived of control over these relays and over the associated relay 50 in the path common to the branches through relays 7, 8 and 9. At the same time relay 58 in operating closes at its armature and front contact the energizing circuit of relay 57. Relay 57 in operating applies battery to conductor 35 to illuminate the key pilot lamp 79. Consequently the instant one of the station selecting keys is pressed at any of the toll points, the station selecting keys at all of the other toll points are made ineffective, and the associated key pilot lamp 79 is lighted to warn the operators at these various other points that the calling apparatus is unavailable for their own use. Each of the relays 57 at these other toll points in operating also applies battery to conductor 49, which conductor, as hereinbefore described, has branches 84 to locking contacts of each of the relays 18 of all of the channels C^1, C^2, C^3 and C^4 of the associated station. Therefore the pressing of any of the station selecting keys at a calling toll station has the effect of causing the continued energization during the calling operation of all of the relays 18 associated with channels that are in use at each of the other toll stations. The result is to keep all of the channels in the condition of use that they were in at the instant the station selecting key at the calling station was pressed, and to maintain them in this condition until the end of the channel selecting and assigning operation.

As has previously been described, the timer 55 at the calling station operates upon the completion of the inward movement of its plunger to energize relay 69 and thus energize the oscillator O^1 and the harmonic producer HPL to generate the base and harmonic frequencies, one of which, in the present instance that controlled by the relay 9, is applied to modulate the calling carrier wave. At the particular toll station that is being called the modulating frequency is separated out and passes by way of the filter LPC tuned to this particular frequency to the associated rectifier LRC, and is there rectified to cause the response of the associated relay 67. The filters LPC at the other toll stations on the line are tuned to prevent the passage of this particular frequency, and therefore their relays 67 are not operated. At the toll station that is being called, the relay 67 in operating acts through the medium of relay 53 to close a circuit that extends from battery through the winding of stepping magnet 60 of channel selecting switch S, armature and back contact of this magnet, winding of slow-release relay 54, right-hand front contact and armature of relay 53, and switch arm S^1 and its normal or resting contact to ground. Magnet 60 in operating interrupts at its armature and back contact this energizing circuit, and the armature of magnet 60 in falling back acts through the medium of the stepping pawl 28 and ratchet wheel 63 to cause all of the switch arms to take one step. As soon as the switch arms are thus moved off of normal, a circuit is closed that extends from battery through the back contact and armature of relay 59, winding of relay 52, call pilot lamp 27 and switch arm S^5 to ground. The resultant operation of relay 52 closes a circuit to battery in parallel with that by way of the inner right-hand front contact and armature of relay 57 for maintaining during the operation of switch S the illumination of the selecting key pilot lamp 79; disconnects the energizing winding of relay 50 from conductor 34 to keep the station selecting keys KB, KC and KD from exercising control over the relays 50, 7, 8 and 9 of the calling circuit as long as the switch S is off of normal; and the closure of the circuit through the calling pilot lamp 27 lights that lamp to indicate to the operator at the called toll station that a call for her station is coming.

Upon the first step taken by switch S, a circuit is closed that extends from battery through normally closed contacts 91 associated with the holding pawl of the switch S, switch arm S^3, conductor 83, and winding of relay 17 of the first channel C^1 to ground. If the first communicating channel C^1 happens to be in use locally at the time, the relay 17 is already energized by a branch energizing circuit closed by the insertion of a plug in the spring jack 1 of the channel, as will hereinafter be described. If the relay 17 of the channel is not already energized, it will be put in its energized condition by the advance of the switch arm S^3 to the corresponding contact point, and in becoming energized it connects the filament and plate batteries F and P with the associated apparatus of the channel, thus making the receiving branch RC^1 of the channel responsive to its particular carrier wave frequency. Consequently if the particular channel corresponding to this carrier wave frequency is in use at any of its toll station branches, the relay 19 associated with the receiving branch of the channel C^1 at the called station is energized and closes the energizing

circuit of relay 16 by way of conductor 81, the relay 16 thereupon causing the energization of the relay 10 by way of the right-hand winding of the last-mentioned relay. Relay 10, in closing its inner right-hand front contact and armature, applies ground to the previously-traced energizing circuit of the stepping magnet 60 that extends to the switch arm S^1, thus causing the stepping magnet again to attract and release its armature and advance the switch arms another step.

This action continues as long as the switch arms are in engagement with contacts associated with channels that are in use either locally or at distant stations. When the switch arms encounter contacts associated with a channel that is not in use, the relay 19 of the particular channel tested is not operated when it is made responsive by the operation of the associated relay 17. As a result the associated relays that correspond to relays 16 and 10 of the first communicating channel are not operated, and the energizing circuit of the stepping magnet 60 terminating upon switch arm S^1 is opened and remains open. When this condition comes about, the continuing interruption of the stepping circuit permits the slow release relay 54, which may be of any desired slow releasing type, to release its armature and close a circuit that extends from battery through contacts 91 associated with the holding pawl of switch S, back contact and armature of release magnet 62, armature and back contact of slow release relay 54, switch arm S^2 and the contact upon which it is at the time resting, the conductor of the communicating channel under test which corresponds with conductor 82 of channel C^1, and the winding of the relay 18 of this channel to ground. The consequent operation of relay 18 of the tested channel connects the associated filament and plate batteries with the transmitting apparatus of that channel to energize the same and cause the application to the toll line of the corresponding carrier wave frequency.

Returning now to a consideration of the operations at the calling toll station, the application at the called station of the particular carrier wave frequency of the selected channel, as described above, causes the response of the relay 19 associated with the receiving branch of this channel at the calling station. Assuming that it is channel C^1 that has been found idle and available, the operation of the relay 19 of this channel causes the operation of the relay 16, which in turn causes the operation of the associated relay 10. It will be remembered that only such of the relays 10, 20, etc., at the calling station have remained unenergized as were associated with idle or available channels at the time that the operator at the calling toll station pressed the station selecting key, and that the only ones of the relays 14, 24, etc., that were operated and locked up by the operation of the timer 55 were those whose associated relays 10, 20, etc., had remained back. Therefore when the relay 10 of one of these channels, in this case channel C^1, is operated as a result of the application of the corresponding carrier frequency at the called station, a circuit is closed that extends from battery through the outer lower armature and back contact of relay 15, resistance 14^1, armature and front contact of relay 14, outer right-hand armature and front contact of relay 10, and winding of relay 13 to ground. Relay 13 in closing its outer armature and front contact applies battery to relay 17 of the associated communicating channel C^1 to maintain this relay operated and the receiving branch apparatus of the channel C^1 energized after the relay 50 releases, which occurs a moment later. Relay 13 in operating also closes a circuit that extends from battery by way of the inner armature and front contact of relay 13, assigning lamp 11, and the lower winding of relay 51 to ground. The illumination of the assigning lamp 11 notifies the calling toll operator that the channel that has been selected for use in response to her call is the channel terminating in spring jack 1.

Relay 51 in operating closes at its inner front contact and armature a path for maintaining the illumination of the selecting key pilot or guard lamp 79; and at its outer armature and back contact opens the energizing circuit including the windings of relays 50 and 9 closed at the time selecting key KD was pressed. These two relays thereupon release. Relay 9 in releasing deenergizes the associated modulating branch MD, thus withdrawing from the calling carrier wave the modulating frequency to which the distant station D has responded. Relay 50 in releasing opens at its contacts *e*, *f*, *g* and *h* the branch energizing paths by way of these contacts for the relays 17 of all of the communicating channels C^1, C^2, C^3 and C^4. The relay 17 of channel C^1, however, remains energized by way of the path completed through the outer front contact and armature of relay 13, as previously explained; and the relays 17 of such of the other channels as may have been in use locally at the time the operator pressed the calling key remain under the control of the branch paths completed from their conductors 83 through contacts closed when a plug is inserted in the corresponding channel spring jack.

Relay 50 in releasing as a result of the operation of relay 51 upon the lighting of the assigning lamp 11, also opens at its contacts *a* the energizing circuit of relay 57, and

that relay in releasing opens conductor 49 to permit the relays 18 of the various channels thereafter to be under the exclusive control of their energizing paths by way of the associated conductors 82. Likewise relay 50 at its contact *d* opens conductor 89 to break the locking paths by way of the left-hand windings of relays 10, 20, etc., and thus leave these relays under control of their right-hand windings. At its contacts *b* the relay 50 in releasing interrupts conductor 37, thus releasing relay 78 to withdraw the calling carrier frequency from the toll line, and also releasing relay 68 to reapply the associated plate and filament batteries and restore the normal responsiveness of the receiving branch RC of the calling channel C. At its contact *c* relay 50 opens the energizing circuit of timer 55; and the timer in releasing its plunger first disconnects battery from the conductor 39, and then at the limit of the outward movement of the plunger connects the conductor 39 to ground. This application of ground to conductor 39 short circuits such of the relays 14, etc., as have been locked up as a result of being associated with available communicating channels and whose associated channels have not been chosen for use in the selecting operation. These relays therefore release, the relay 14, however, remaining locked up by reason of its associated relay 10 having been operated upon the selection of the corresponding channel, and therefore having disconnected the winding of relay 14 from the short circuiting action of conductor 39 when ground is applied to it upon the release of timer 55.

When the calling carrier wave with its station-selecting modulating frequency is withdrawn as a result of the selection of an available communicating channel, as described above, the relays 66 and 58 at all of the distant toll stations are released. The relay 58 at each of the distant stations in releasing applies ground to the associated conductor 33 to make the station selecting keys at that toll point again operative, and also breaks the energizing circuit of the associated relay 57. Relay 57 in releasing extinguishes the key guard or pilot lamp 79 and also opens conductor 49 to permit the relays 18 of the various communicating channels at the associated toll point to be again solely under the control of the energizing paths by way of their conductors 82. In this way the normal condition is restored at the various distant toll stations, and these stations are again enabled to use the calling channel C for calling other stations.

In addition to the above described results due to the withdrawal of the calling carrier frequency, there is at the called toll station a further result due to the withdrawal of the particular modulating frequency that has been superposed upon the calling carrier wave. The withdrawal of this modulating frequency permits the de-energization of relay 67 of the receiving branch RC, and the consequent de-energization of relay 53. Relay 53 in releasing closes at its left-hand back contact and armature a short circuit of its own winding that extends to ground by way of the switch arm S^5. The effect o his is to render it impossible for a subsequent energization of relay 67 to effect the operation of the relay 53 until the switch S has been restored to normal and has thus been placed in condition to respond properly to a subsequent call for this station. A further effect of the release of the relay 53 at the called station is to prepare for subsequent closure the circuit that extends through the right-hand armature and back contact of the relay 53.

Taking up again the sequence of events at the calling toll station, when the calling operator has been informed by the lighting of the assigning lamp 11 of the particular communicating channel selected, she inserts the plug 72 of the cord circuit 70 into the associated spring jack 1. This closes a circuit that extends from battery through the cord circuit supervisory lamp 76, co-operating sleeve contacts of the plug 72 and spring jack 1, and thence to ground by way of both windings of the relay 15. The relay 15 thereupon operates and closes by way of its two lower armatures and front contacts the energizing paths 82 and 83 of the relays 18 and 17 respectively, at the same time opening at its outer lower back contact the energizing circuit of the relays 14 and 13, thus releasing these relays. As hereinbefore described, the relay 13 has been kept operated since the selection of this communicating channel to hold energized the relay 17, so that the relay 17 as a result of the insertion of the plug continues energized to keep the receiving branch RC^1 of the selected channel in its operative condition. The relay 18 of the transmitting branch TC^1 of this channel however has not heretofore been operated, and this relay now operates to apply the characteristic carrier frequency of the selected channel C^1 to the toll line. Relay 15 in operating also closes at its inner upper front contact and armature a circuit by way of conductor 87 for the energization of relay 88. Relay 88 in operating connects the two-way repeating coil 33 of channel C^1 with the artifical line or network N designed to match the changed characteristics of the circuit lying to the other side of the hybrid coil when it is extended by the insertion of the plug 72.

When the characteristic carrier frequency of the channel C^1 is received at the called toll station, it causes the energization of the

relay 19 in the receiving branch RC¹, and this causes the energization of relay 16, which in turn causes relay 10 to operate. Relay 10 in operating closes a circuit that extends from battery through the winding of relay 59, upper winding of relay 51, calling lamp 12 associated with spring jack 1 of the selected channel, upper armature and back contact of relay 15, the switch contact associated with the selected channel and switch arm S⁴ that is resting upon it, winding of release relay 56, right-hand back contact and armature of relay 53, switch arm S¹ and its associated contact corresponding to the selected channel, and inner right-hand armature and front contact of relay 10 to ground. As a result relays 59, 51 and 56 are operated, and the calling lamp 12 of the selected channel is lighted. Relay 59 in operating extinguishes the calling pilot lamp 27. Relay 51 in operating closes a branch energizing circuit to keep the key guard or pilot lamp 79 lighted after the energizing branch by way of the inner front contact and armature of relay 52 has been opened by the release of relay 52 upon the operation of relay 59. Relay 51 also introduces another break into the calling relay energizing circuit by way of conductor 34 to continue the inoperativeness of the associated relays after the path has been closed by the release of relay 52. The lighting of calling lamp 12 informs the operator at the called station that the call of which she is first notified by the lighting of pilot lamp 27 is to be extended over the channel terminating in spring jack 1. The operation of relay 56 operates the release magnet 62 of switch S, and this magnet in operating draws its lever 64 into operative relation with the holding pawl 61 preparatory to the release of switch S upon the deenergization of magnet 62, and also opens at the armature and resting contact of magnet 62 the circuit by way of switch arm S³ and the selected channel contact upon which it is resting that has been maintaining the relay 18 of the selected channel operated from the moment of selection. When relay 18 releases it withdraws the characteristic carrier frequency of channel C¹ from the toll line and the effect of this at the calling station is to release relay 19 of the receiving branch RC¹ and the associated relay 16. When relay 16 at the calling station is thus released it short circuits the lower half of the winding of sleeve relay 15. The resistances of the windings of relay 15 are so proportioned with rspect to the operating characteristics of the cord circuit supervisory lamp 76 that when both windings are included in series in the circuit the lamp does not receive enough current for its illumination, but when the lower winding is short-circuited the current is sufficiently increased to light the lamp. As a result therefore of the withdrawal of the carrier frequency of channel C¹ at the called station, the cord circuit lamp 76 at the calling operator's position is lighted to indicate to the operator that the calling lamp at the called station has been lighted but that the operator at that point has not yet answered.

When the operator at the called toll station sees the lighted calling lamp 12, she inserts the plug 72 of one of the connecting cord circuits into the associated spring jack 1. This closes a circuit that extends from battery through the cord circuit supervisory lamp 76, co-operating sleeve contacts of the plug 72 and spring jack 1, and to ground by way of both windings of the sleeve relay 15, the normal short circuit of the lower winding being at this time opened as a result of the operation of relay 16 due to the application of the carrier frequency of this channel at the calling station. Therefore when the operator at the called station inserts plug 72 into spring jack 1 the supervisory lamp 76 remains dark, indicating to her that the calling operator has established connection with the corresponding channel.

When relay 15 at the called station operates as a result of the operator's answering the call, as described above, it breaks at its upper back contact and armature the previously traced circuit including windings of relay 59, 51 and 56 and the calling lamp 12. As a result the calling lamp 12 is extinguished, the circuit by way of conductor 34 for the energization of relays 50, 7, 8 and 9 is again made effective and the key guard lamp 79 extinguished by the release of relay 51, and release relay 56 is de-energized to open the circuit of release magnet 62. When the magnet 62 releases the engagement between the end of the arm 64 associated with the right-hand armature and the holding pawl 61 causes the lifting of the pawl to permit the release and restoration to normal of the switch arms S¹, S², S³, S⁴ and S⁵. At the same time the mechanical relation that exists between the holding pawl 61 and contacts 91 causes the opening of these contacts during the release of the switch, so that switch arms S² and S³ are disconnected from battery during the return movement of the switch. The return of switch arm S⁵ to normal opens the short circuit of the winding of relay 53, so that the relay is again responsive to relay 67 in the receiving branch RC of the calling channel C. This completes the restoration to normal of the station calling and channel selecting apparatus at all of the toll points or stations, and the conversation is now free to proceed between the calling station and the called station over the communicating channel that has been selected.

The operators at both toll points may now complete the connection with the subscriber's station that is calling and the subscriber's

station that is being called. In the present instance this is illustrated as being accomplished by means of connecting cord circuits provided with the usual plugs 71 and 72 with their associated connecting cords and intermediate apparatus, operator's set 92, listening key 73, ringing key 74, and supervisory lamps 75 and 76. The cord circuit may be connected with any one of a number of lines extending to subscriber's stations SS by inserting the plug 71 into the spring jack 77 of the line with which connection is to be established. The subscriber's lines may be provided with the usual cut-off and line relays and line lamps. The apparatus shown in this connection is merely illustrative, as any desired one of a large number of well-known terminal and connecting arrangements may be employed.

When the conversation between the connected subscribers is completed, the subscribers' disconnect signals are received in the usual manner upon the supervisory lamps 75 at the two toll stations. When either operator withdraws the plug 72 from the communicating channel spring jack in which it has been inserted, the sleeve relay 15 is released. This releases relays 17 and 18 of the channel, thus withdrawing the characteristic carrier frequency from the channel at the end where the plug is removed, and also rendering the receiving relay 19 of the channel unresponsive. Upon the withdrawal of the carrier frequency at either end of the channel the relay 19 at the other end releases, thus releasing the associated relay 16 and short circuiting the lower winding of the corresponding relay 15. This has the effect of increasing the flow of current in the sleeve circuit so that the supervisory lamp 76 associated with the plug 72 that is still inserted is lighted. Thus either operator by taking down the connection causes the lighting of the cord circuit supervisory lamp 76 at the other end of the channel, and gives the disconnect signal to the distant operator.

In the foregoing description of the operation, it has been assumed that when the switch S tests the channels as a result of the pressing of the station-selecting key at the calling station, one of these channels is selectable. If it should happen that at this time all of the channels are in use, or that for any reason the arms of the switch S pass over their contacts without selecting, means are provided for automatically terminating the calling condition on the toll line and for restoring the selecting switch to normal. These results are accomplished as follows: When the slow acting device or timer 55 operates a predetermned interval after the pressing of the key at the calling station and applies the station-selecting modulating frequency and starts the movement of the selecting switch S at the called station, it also closes a circuit for the energization of another slow acting relay device or timer 132. The timer 132 thereupon starts to draw in its plunger. The interval required for the complete inward movement of the plunger of timer 132 is so regulated as to be somewhat greater than the interval required for the selecting switch S at the called station to test all of the channels to which it has access. Consequently if the switch S does not make a selection, the relay 50 at the calling station is not released and therefore the timer 55 at the calling station is also not released. The timer 55 consequently holds the energizing circuit of the timer 132 closed long enough to permit the full inward movement of the plunger of the timer 132. When this occurs the inner contacts of timer 132 are opened, and the energizing circuit including the relay 50 and the particular one of the relays 7, 8 and 9 that has been operated is opened, thus releasing these relays. This effects the restoration of the calling station apparatus to normal, in the manner previously described, thus withdrawing the calling carrier wave and its modulating frequency. Upon the withdrawal of the calling carrier wave and its modulating frequency the relay 53 at the called station is released. The switch S, having failed to make a selection, has advanced beyond the contact points associated with the various channels and has left its switch arms resting upon the first contacts beyond the channel contacts. Therefore, when relay 53 at the called station releases, a circuit is closed that extends from battery through contacts 91 associated with the holding pawl of switch S, contacts 98 associated with the releasing lever 64 of release magnet 62, the contact upon which switch arm S^4 is resting and that switch arm, winding of release relay 56, right hand back contact and armature of relay 53, and switch arm S^1 and the contact upon which it is resting to ground. This energizes release relay 56, and this relay in operating energizes release magnet 62. Release magnet 62 in operating moves the associated lever 64 to bring its end into operative relation with the holding pawl 61, and in doing so opens the contacts 98. The opening of these contacts breaks the energizing circuit of relay 56, which thereupon releases and brings about the release of the magnet 62. The magnet 62 in releasing lifts the holding pawl 61 and permits the arms of the switch S to return to normal. Thus the calling condition upon the line is withdrawn and the switch S restored to normal upon the failure of the switch to select a channel.

When the energizing circuit at the calling station for the relay 50 and the particular one of the relays 7, 8 and 9 that has been operated is broken by the complete inward

stroke of the timer 132 as a result of the switch S at the called station failing to find and energize an idle channel, as described, the circuit for relay 57, and consequently the circuit for lamp 79, are also broken so that the calling operator upon observing that the lamp 79 is extinguished is apprised of the fact that no idle channel is available.

The invention is not to be construed as limited to the specific details of the foregoing description or of the drawing, but its scope is defined in the appended claims.

What is claimed is:

1. In a carrier wave communicating system, the combination with a line and three or more stations connected thereto, of frequency responsive means operatively associated with said line at each station and selectively responsive to a particular frequency wave differing from the waves to which the other stations are responsive, and means at each station dependent for its operation upon the character of waves being transmitted at any instant by said line for producing and applying to said line said waves to which the various other stations are adapted to respond.

2. In a carrier wave communicating system, the combination with a line having a plurality of stations connected thereto, of wave responsive means at each station, means at each station controlled by said wave responsive means for producing and applying to said line a plurality of different frequency waves, and means at each of a plurality of said stations selectively responsive to a particular one of said waves.

3. In a carrier wave communicating system, the combination with a line having a plurality of stations connected thereto, of means at each station for producing and applying to said line a plurality of different frequency waves, means at each other station selectively responsive to a particular one of said waves, signals at the stations at which the waves are being produced and at the station selectively responsive to the corresponding wave, and means for actuating said signals responsive to the means at the station selectively responsive to the corresponding wave when said means is actuated.

4. In a high frequency communicating system, the combination with a plurality of high frequency stations, of means at each station for producing and transmitting a plurality of differing high frequency waves, means at each station selectively responsive to a particular one of said high frequency waves, a high frequency communicating channel having terminals at said station, and means operated by the response of the station to its corresponding wave for preparing said channel for communication.

5. In a carrier wave communicating system, the combination with a line and a plurality of stations connected therewith, of a calling channel associated with said line and having a plurality of branches at each station, means for energizing said calling channel and any one of the branches thereof at any of said stations, and means responsive to the energization of said channel and one of its branches for selecting a particular corresponding one of said stations.

6. In a high frequency communicating system, the combination with a plurality of stations, of a high frequency calling channel having a plurality of branches at each of said stations, means for energizing said calling channel and any of said branches at any of said stations, and apparatus at each station adapted to be selected and operated at a particular one of said stations in accordance with the particular calling channel branch that is energized.

7. In a carrier wave communicating system, the combination with a line and a plurality of stations connected therewith, of a calling channel associated with said line and having a plurality of frequency selective branches at each of said stations, means for energizing said calling channel and any of said branches at any of said stations, apparatus at each station selectively operated in accordance with the particular calling channel branch that is energized, a plurality of frequency selective communicating channels connected with said line and available for use at each of said stations, and apparatus at the calling station and the selected station for establishing communication over one of said communicating channels.

8. In a high frequency communicating system, the combination with a plurality of high frequency stations, of means at each station for producing and utilizing a plurality of high frequency waves, means controlled at a calling one of said stations for utilizing one of said waves to select another one of said stations, means at the selected station for selecting another of said high frequency waves, and means for establishing communicating relation between said calling station and said selected station through the medium of said selected high frequency wave.

9. In a high frequency communicating system, the combination with a plurality of stations each having means for producing and utilizing a plurality of high frequency waves, of means controlled at a calling one of said stations for selecting another of said stations through the medium of one of said high frequency waves, means at the selected station for selecting another of said high frequency waves for communicating purposes, means for identifying the selected wave at said calling station, and means at the calling and selected stations for establishing communicating relations therebe-

tween through the medium of said selected high frequency wave.

10. In a carrier wave communicating system, the combination with a line having a number of stations connected therewith, of a plurality of frequency selective channels associated with said line and available for use at each of said stations, means operating automatically in response to the initiation of a call for selecting a particular one of said stations, and means for selecting a desired one of said channels for communication with the selected station.

11. In a carrier wave communicating system, the combination with a line and a plurality of stations connected thereto, of a plurality of frequency selective channels associated with said line and available for use at each of said stations, means for enabling a calling one of said stations to select another of said stations, and means for selecting and utilizing one of said channels for establishing communicating relation between said calling station and said selected station.

12. In a carrier wave communicating system, the combination with a line and a plurality of stations connected thereto, of a plurality of frequency selective channels associated with said line and available for use at each of said stations, means controlled at a calling one of said stations for selecting another of said stations through the medium of one of said channels, and means for establishing communicating relation between said calling station and said selected station over another of said channels.

13. In a high frequency communicating system, the combination with a plurality of stations, of a plurality of high frequency channels available for use at each of said stations, means for utilizing one of said channels under the control of a calling one of said stations to select another of said stations, means at the selected station for selecting another of said high frequency channels, and means for establishing communicating relation between said calling station and said selected station ver said selected high frequency channel.

14. In a carrier wave communicating system, the combination with a line and a plurality of stations connected therewith, of a plurality of frequency selective communicating channels connected with said line, each of said communicating channels having a multiple terminal at each of said stations, communicating apparatus at each station adapted to be connected with the multiple terminal of any of said communicating channels at the corresponding station, a frequency selective calling channel connected with said line and having controlling and responsive devices associated therewith at each station, and means under the control of said responsive devices at the various stations for selecting a particular station and determining a particular communicating channel with the terminals of which the communicating apparatus of two stations is to be connected.

15. In a carrier wave communicating system, the combination with a line and a plurality of stations connected therewith, of a calling frequency selective channel and a communicating frequency selective channel associated with said line and available for use at each of said stations, means controlled over said calling channel by a calling one of said stations for selecting another station, and communicating means at said calling station and said selected station adapted to be brought into operative relation through the medium of said communicating channel.

16. In a carrier wave communicating system, the combination with a line and a plurality of stations connected therewith, of a frequency selective communicating channel, a switch at each station operating automatically in response to energy on said line for controlling connection with said communicating channel, a high frequency calling channel, and means at each station acting through the medium of said calling channel for selecting and making operative said automatic switch at any desired one of the distant stations.

17. In a carrier wave communicating system, the combination with a line and three or more stations connected therewith, of a plurality of high frequency channels associated with said line, and means controlled by high frequency waves transmitted over said line for establishing communicating relation between any two of said stations over any one of said channels.

18. In a carrier wave communicating system, the combination with a line and three or more stations connected thereto, of a plurality of high frequency communicating channels associated with said line and accessible from each of said stations, and means for appropriating any of said high frequency communicating channels for use exclusively in establishing communication between any two of said stations.

19. In a carrier wave communicating system, the combination with a line and a plurality of stations connected therewith, of a plurality of high frequency channels associated with said line and available for use at each of said stations, and means at each station for simultaneously utilizing as many of said channels for establishing communication as are not at the time in use for establishing communication between other stations.

20. In a high frequency communicating system, the combination with three or more stations, of a plurality of simultaneously existing high frequency channels having per-

manently established branches of each channel at all said stations, and means at each station for establishing communicating relation with any other station over the associated branch of any of said channels that is not at the time in use.

21. In a carrier wave communicating system, the combination with a line and three or more stations connected therewith, of a plurality of high frequency channels associated with said line, a terminal for each of said channels at each of said stations, means at each station for selecting a desired other station and communicating apparatus at said stations adapted for connection with said channel terminals.

22. In a carrier wave communicating system, the combination with a line and three or more stations connected thereto, each having associated communicating apparatus, of a plurality of high frequency communicating channels associated with said line and having terminals at each of said stations, and means at said stations for selecting desired stations to be communicated with and for bringing the communicating apparatus of any two of said stations into operative relation through the medium of any of said high frequency communicating channels.

23. In a carrier wave communicating system, the combination with a line and a plurality of stations connected thereto, of a plurality of frequency selective channels associated with said line and available for use at each of said stations, connection switch terminals for each of said channels at each station, communicating apparatus at each station adapted to be brought into operative relation with any one of said channels by the operation of the connection switch terminal thereof, and means made operative upon the operation of the connection switch terminal of any of said channels for energizing the corresponding channel.

24. In a carrier wave communicating system, the combination with a line having two stations connected therewith, of a frequency selective channel associated with said line and available for use at said stations, means at one of said stations for energizing said channel for use in communicating, and means controlled at the other station for controlling said channel energizing means.

25. In a carrier wave communicating system, the combination with a line having two stations connected therewith, of a plurality of frequency selective channels associated with said line and available for use at said stations, each of said channels being provided with wave transmitting and receiving apparatus at each of said stations, and means controlled from one of said stations for making the transmitting apparatus of one of said channels employed for transmitting from the other station operative to transmit signals.

26. In a carrier wave communicating system, the combination with a line having two stations connected therewith, of a plurality of frequency selective channels associated with said line and available for use at said stations, each of said channels being provided with transmitting and receiving apparatus at each of said stations, means controlled from one of said stations for making the transmitting apparatus of one of said channels at the other station operative to transmit energy, and apparatus controlled by the consequent energization of the receiving apparatus of the corresponding channel at said first-mentioned station.

27. In a carrier wave communicating system, the combination with a line having a plurality of frequency selective channels associated therewith, of means for utilizing said channels for communication, and means operating automatically in response to the electrical condition of said line for testing said channels to select for use an idle channel.

28. In a carrier wave communicating system, the combination with a line and a plurality of stations connected thereto, of a plurality of frequency selective channels associated with said line and available for use at each of said stations, and means at each station operating automatically in response to the electrical condition of said line for testing and selecting for use a high frequency channel that is not at the time in use between any of said stations.

29. In a carrier wave communicating system comprising a line and a plurality of stations connected thereto, a plurality of frequency selective communicating channels associated with said line and having terminals at each of said stations, means at said stations operating automatically in response to the initiation of a call for selecting an idle one of said channels through the medium of the associated terminal, and means for utilizing the selected channel for establishing connection between a calling and a called station.

30. In a carrier wave communicating system, the combination with a line having two stations connected therewith, of a plurality of frequency selective channels associated with said line and adapted to serve for intercommunication between said stations, means for making one or more of said channels busy, means operating automatically in response to the busy or idle condition of said channels for testing for and selecting an idle channel, and means for establishing communicating relation over said selected channel between said stations.

31. In a high frequency communicating

system, the combination with a plurality of stations, of a plurality of high frequency channels available for use at each station, a channel testing and selecting switch at one of said stations operating automatically in response to the electrical condition of said channels, means at another station for controlling said switch, and means for establishing communication between said stations over the selected channel.

32. The combination of two communicating systems, a line interconnecting the same, a plurality of frequency selective channels associated with said line and available for the interconnection of said systems, mechanism controlled from one of said systems and operating automatically in response to the electrical condition of said channels for selecting an available one of said channels, and means associated with each system for controlling apparatus associated with said other system over the selected channel.

33. In a carrier wave communicating system, the combination with a line and a plurality of stations connected thereto, of a plurality of frequency selective channels associated with said line and available for use at each of said stations, said channels being provided with means for energizing the same in the use thereof, means at each station for successively testing said channels, automatically in response to a condition of energization of the tested channel, and means operated upon the failure of response of said testing means in testing a channel for appropriating said channel and energizing the same for the use of the associated station.

34. In a carrier wave communicating system, the combination with a line and a plurality of stations connected thereto, of a plurality of frequency selective channels associated with said line and available for use at each of said stations, means for energizing said channels when the same are in use, a testing switch arranged successively to test said channels and to be stopped upon coming into testing relation with a channel that is not energized, and means made operative upon the stopping of said switch for energizing said channel.

35. In a carrier wave communicating system, the combination with a line having a plurality of stations connected thereto, of a frequency selective channel associated with said line and having a connecting terminal at each station, a signal device associated with the terminal of said channel at each station, and means under the control of a calling one of said stations for causing said signal device at the particular station that is being called to display its signal.

36. In a high frequency communicating system, the combination with a plurality of stations, of a plurality of frequency selective channels available for use at each of said stations, a signal for each channel at each station, means under the control of a calling one of said stations for causing the operation of the signal associated with one of said channels at the particular station that is being called, and means under the control of said called station for causing the operation of the signal associated with the corresponding channel at the calling station.

37. In a carrier wave communicating system, the combination with a line having a plurality of stations connected thereto, of a plurality of frequency selective channels associated with said line and available for use at each of said stations, a signal for each channel at each station, means under the control of a calling one of said stations for selecting a particular one of the other stations and rendering operable the signal of said selected station, apparatus at the selected station controlled in response to the selection thereof for selecting an idle one of said channels and causing the operation of the signal associated therewith at said calling station, and means under the control of said calling station for operating the signal of the associated channel at the called station.

38. In a high frequency communicating system, the combination with a line having a plurality of stations thereon, of a plurality of frequency selective channels associated with said line, a terminal for each of said channels at each of said stations, a signal associated with each channel terminal, and means for controlling one of said signals responsive to the condition of use or non-use of the corresponding channel at any instant.

39. In a carrier wave communicating system, the combination with a line and two stations connected therewith, of a plurality of frequency selective channels connected with said line, each channel having a connection terminal at each of said stations, communicating apparatus at each of said stations adapted to be brought into operative relation with any of said channels through the associated connection terminal thereof, and means at each of said stations for identifying the channel with which connection is to be made.

40. In a high frequency communicating system, the combination with a plurality of stations, of a plurality of high frequency channels available for use at each of said stations, means at a calling one of said stations for selecting another station, means made operative by the selection of said station for selecting an idle one of said channels, and means made operative by the selection of said channels for identifying the selected channel at the calling station.

41. In a carrier wave communicating system, the combination with a line and a plu-

rality of stations connected thereto, of a plurality of frequency selective channels associated with said line and available for use at each of said stations, means at a calling one of said stations for selecting another station, means made operative by the selection of said station for selecting an idle one of said channels, means made operative by the selection of said channel for identifying the selected channel at the calling station, a connection switch at the calling station adapted to be closed in establishing connection with the channel thus identified, and means at the selected station responsive to the closure of said connection switch for identifying the said channel at the selected station.

42. In a carrier wave communicating system, the combination with a line and a plurality of stations connected thereto, of a plurality of frequency selective channels associated with said line and available for use at each of said stations, a switch at a calling one of said stations and means controlled thereby for controlling the selection of another of said stations, testing means at the selected station responsive to the selection thereof for selecting an idle one of said channels, channel identifying means at said calling station, means made operative upon the operation of said station selecting switch for bringing said channel identifying means into operative relation with the channels that at the time are idle, and means made operative by the selection of a particular idle channel at said selected station for actuating said channel identifying means at said calling station to identify the selected channel.

43. In a high frequency communicating system, the combination with a plurality of stations, of a plurality of high frequency channels available for use at each of said stations, means under the control of a calling one of said stations for utilizing one of said channels to select another one of said stations, means at the selected station responsive to the selection of said station for selecting another of said high frequency channels, means responsive to the selection of said channel for identifying the same at the calling station, and means at the calling and selected stations for utilizing the selected channel for establishing communicating relation between said stations.

44. In a high frequency communicating system, the combination with two stations, each of said stations being provided with communicating apparatus, of a plurality of high frequency channels, manual terminals for each of said channels at each station for connecting said communicating apparatus with the corresponding channel, means operating automatically in response to the initiation of a call for selecting an idle one of said channels, and signal means associated with the manual terminals of each channel and responsive to said selecting means for identifying the selected channel.

45. In a carrier wave communicating system, the combination with a line and a plurality of stations connected thereto, of a plurality of frequency selective channels associated with said line, a connecting switch terminal at each station for each channel, communicating apparatus at each station adapted to be brought into operative relation with any of said channels through the medium of the connecting switch terminal thereof, a calling key at each station for each of the other stations, means responsive to the operation of any of said calling keys for automatically selecting the corresponding station and an idle one of said channels, and means associated with the connecting switch terminal of each channel for identifying the selected channel.

46. In a carrier wave communicating system, the combination with a line and a plurality of stations connected thereto, of a plurality of frequency selective channels associated with said line, a connecting switch terminal at each station for each channel, communicating apparatus at each station adapted to be brought into operative relation with any of said channels through the medium of the connecting switch terminal thereof, a calling key at each station for each of the other stations, means responsive to the operation of any of said calling keys for automatically selecting the corresponding station and an idle one of said channels, a signal associated with the connecting switch terminal of the selected channel at the calling one of said stations adapted to be operated upon the selection of the associated channel, means for closing the connecting switch of the selected channel in making connection therewith, a signal at the called station end of said channel adapted to be displayed upon the closure of the connecting switch at the calling end of the channel, and means for withdrawing said signal at each end of the channel in response to the closure of the associated connecting switch.

47. In a carrier wave communicating system, the combination with a line and a plurality of stations connected thereto, of a plurality of frequency selective channels associated with said line and available for use at each of said stations, and means operating automatically in response to the condition of use or disuse of said channels for excluding any station from the use of a channel that is in use by any other of said stations.

48. In a carrier wave communicating system, the combination with a line and a plurality of stations connected thereto, of a plurality of frequency selective channels associated with said line and available for use

at any of said stations, means at one of said stations operating automatically in response to the condition of use or disuse of said channels for selecting an idle one of said channels and utilizing the same for establishing communicating relation with another station, channel selecting means at another station, and means operating automatically in response to the condition of use or disuse of said channels for preventing the same from selecting for use the channel that has already been selected.

49. In a carrier wave communicating system, the combination with a line and a plurality of stations connected therewith, of a frequency selective calling channel connected with said line and available for use at each of said stations, selective controlling and responsive apparatus associated with said channel at each station for enabling any station to select any desired one of the other stations, and means for preventing the other stations from using said channel for calling while it is in use by any of said stations.

50. In a carrier wave communicating system, the combination with a line having a plurality of stations connected therewith, of a plurality of frequency selective channels associated with said line and available for use at each of said stations, means at each station for selecting for use and energizing an available one of said channels, means at each station for controlling said channel energizing and selecting means, and means for preventing more than one of said stations at a time from controlling said channel selecting and energizing means of a distant station.

51. In a carrier wave communicating system, the combination with a line and a plurality of stations connected therewith, of a frequency selective calling channel connected with said line and having a plurality of branches at each of said stations, means for energizing said channel and any desired one of its branches at each of said stations, mechanism at each station selectively responsive in accordance with the particular one of said branches that is energized, and guarding mechanism at each station responsive to the energization of said calling channel to guard said channel against use for calling by more than one of said stations at a time.

52. In a carrier wave communicating system, the combination with a line and a plurality of stations connected therewith, of a frequency selective calling channel and a plurality of frequency selective communicating channels associated with said line and available for use at each of said stations, means for energizing said channels in the use thereof, means operated from any station through the medium of said calling channel for selecting an idle one of said communicating channels for use between a calling and a called station, and means responsive to the energized condition or condition of use of said calling channel for preventing other stations on said line from using said calling channel.

53. In a carrier wave communicating system, the combination with a line and a plurality of stations connected thereto, of a plurality of frequency selective channels available for use at each of said stations, switching mechanism made operative by a calling one of said stations for selecting another one of said stations and one of said channels that is not at the time in use, and means made operative during the selecting operation for maintaining in their condition of use such of said channels as were in that condition at the outset of the selecting operation.

54. In a high frequency communicating system, the combination with a plurality of stations, of a plurality of high frequency channels available for use at each of said stations, a switch for successively testing said channels to select one that is not in use, means controlled at a calling one of said stations for establishing a calling condition, means responsive to the establishment of said calling condition for causing the operation of said testing switch, and means made operative by the failure of said switch to select a channel for withdrawing said calling condition.

55. In a carrier wave communicating system, the combination with a line having a plurality of stations connected therewith, of a plurality of frequency selective channels associated with said line and avaliable for use at each of said stations, station-selecting mechanism at each of said stations, means under the control of each station for controlling said mechanism to select any desired one of said other stations, and apparatus made operative when all of said channels are simultaneously in use for rendering ineffective the control of said means over said station-selecting mechanism.

56. In a carrier wave communicating system, the combination with a line having two stations connected therewith, of a plurality of frequency selective channels associated with said line and available at each station for communication therebetween, a testing switch for testing and selecting for use an idle one of said channels, means made operative in the initiation of a call at one of said stations for causing the operation of said channel selecting switch, and means made operative when all of said channels are in use for restoring said channel selecting switch to normal.

57. In a carrier wave communicating system, the combination with a line and a plurality of stations connected therewith, of a

calling channel connected with said line and having a plurality of branches at each station, means at a calling one of said stations for energizing said channel and any desired one of its branches, mechanism at each station selectively responsive as between the stations to the energization of said calling channel and a particular corresponding one of its branches, means at each of said stations for holding said calling channel for the exclusive use of the station that is calling, and means made operative after said mechanism at the selected station has operated for releasing said calling channel for the use of other stations.

58. In a high frequency communicating system, the combination with two stations, of a plurality of high frequency channels available for use at each of said stations, a channel selecting switch at one of said stations, means controlled at the other station for effecting the energization of said switch to effect its channel selecting operation, and means controlled at said other station for effecting the release of said switch.

59. In a carrier wave communicating system, the combination with a calling and a called station and a line connecting the same, of a plurality of channels associated with said line and available for connection at each station, a channel selecting switch, made operative by said calling station in the act of calling for selecting an idle one of said channels, means for identifying the selected channel at each station, and means made operative in making connection with the identified channel for restoring said channel selecting switch to normal.

60. In a high frequency communicating system, the combination with a plurality of stations, a plurality of high frequency channels available for use at each of said stations, a channel selecting switch at one of said stations, means at another station for controlling the energization of said switch, means for restoring said switch after it has performed its function, and means for preventing the re-energization of said switch from a distant station until its restoration is completed.

61. In a high frequency communicating system having a plurality of stations, the combination with a plurality of high frequency channels having branches at each of said stations, a plurality of trunks at each station serving as extensions of said channels, communicating apparatus at each station adapted to be connected with the communicating apparatus of any other station through the medium of the associated trunks and high frequency channels, a communication initiating means, and means operating automatically in response to the actuation of said communication initiating means for selecting the particular trunks over which the communicating apparatuses of two of said stations are to be connected.

62. In a carrier wave communicating system having a plurality of stations, the combination with a plurality of carrier frequency channels in operative relation between said stations, each of said channels being adapted for the interconnection of any two of said stations, communicating apparatus at each station, a communication initiating means, and switching means operating automatically in response to the actuation of said communication initiating means for selecting an idle one of said channels to be used by said communicating apparatus in establishing connection with the communicating apparatus of another station.

63. In a carrier wave communicating system having a calling station and a called station, the combination with a plurality of carrier frequency trunks for establishing operative relation between said stations through the medium of carrier frequency waves, communicating apparatus at each station adapted for connection with any of said trunks, a communication initiating means, and switching means at the called station operating automatically in response to the actuation of said communication initiating means for selecting an idle one of said trunks for use in completing a connection initiated at the calling station.

64. In a wave transmission system having a calling station and a called station, the combination with a plurality of carrier frequency communicating channels, of a plurality of trunks forming branch terminals of said channels at each station, means operating automatically in response to the electrical condition of said trunks for selecting and designating for use an idle one of said trunks at each station, and means for employing said selected and designated trunk for establishing communicating relation between said stations.

65. In a high frequency communicating system having a plurality of stations and a plurality of high frequency communicating channels each provided with a trunk extension at each of said stations, means at each station operating automatically in response to the busy or idle condition of said trunks for successively selecting for use as many of said high frequency channels and trunk extensions as are idle, and means at each station for establishing simultaneous connections over all of said channels and trunk extensions.

66. In a high frequency communicating s stem having a plurality of stations, the combination with a plurality of high frequency channels provided with trunk extensions at each of said stations, automatically operating selecting mechanism at each of said stations operating under control of said

trunk extensions for selecting an idle one of said trunk extensions for use, station selecting means at each station adapted to respond when that station is called by any other station, and means under the control of said station selecting means for appropriating for communicating use the particular trunk selected by said selecting mechanism.

67. In a carrier wave communicating system having a calling station and a called station, the combination with a plurality of carrier frequency trunks in operative relation between said stations through the medium of high frequency channels, trunk selecting means at the called station for selecting an idle one of said trunks, means controlled from the calling station for calling said called station, and means made operative in the operation of said calling means for appropriating for use an idle trunk selected by said selecting mechanism.

68. In a high frequency communicating system having a plurality of stations, the combination with a plurality of high frequency trunks in operative relation between the various stations of the system through the medium of high frequency channels, means at each of said stations for establishing a plurality of simultaneously existing connections over said high frequency trunks with another station or other stations of the system, means at each station for successively selecting for use idle ones of said trunks, and means made operative when any station is called by another station for appropriating for use an idle trunk selected by said trunk selecting means of the called station.

69. In a high frequency communicating system having a calling station and a called station, the combination with a plurality of high frequency channels having trunk extensions at each of said stations, means at each station for alternatively using any idle channel for communication through the medium of the associated trunk extension, means at the called station for selecting an idle channel trunk extension, and means made operative when said station is called for establishing communication over the selected channel trunk extension.

70. In a carrier wave communicating system having a plurality of stations and a plurality of carrier wave channels and trunk extensions of said channels at each of said stations, means at each station operating automatically in response to the busy or idle condition of said channels for selecting any idle one of said channel extensions for use in completing an incoming call from another station.

71. In a carrier wave communicating system having a plurality of stations, the combination with a plurality of carrier wave channels each provided with a branch at each of said stations, of means at each station operating automatically in response to the test condition of said channels for successively selecting and simultaneously utilizing all of said channels for calls.

72. In a carrier wave communicating system having a plurality of stations, the combination with a plurality of frequency selective channels having trunk extensions at each station and adapted for alternative use in establishing communicating relation between any two stations of the system, of mechanism at each station operating automatically in response to the busy or idle condition of the trunk extensions thereat to select an idle one of said extensions and to energize the same in response to a call from another station of the system.

73. In a carrier wave communicating system having a plurality of stations, the combination with a plurality of frequency selective channels, of trunks at each station adapted for establishing communicating relation between stations through the medium of said channels, means at each station for automatically selecting one of said trunks for use, and apparatus at each station responsive to an incoming call for controlling said automatic trunk selecting means.

74. In a carrier wave communicating system having a plurality of stations, the combination with a plurality of frequency selective channels, of trunks at each station adapted for establishing communicating relation between stations through the medium of said channels, controlling apparatus common to said trunks at each station, and means responsive to the receipt of a call from another station for bringing said controlling apparatus into operative relation with a particular trunk of the associated station.

75. In a carrier wave communicating system having a plurality of stations, the combination with a calling channel and a plurality of frequency selective communicating channels available at each of said stations, selecting switch mechanism at each station permanently associated with said calling channels, trunks at each station, each trunk being permanently associated with a different one of said communicating channels, means at each station for controlling the selecting switch mechanisms of the other stations through the medium of said calling channel, and means at each station under the control of said selecting switch mechanism for selecting for use a particular one of the associated trunks.

76. In a carrier wave communicating system having a calling station and a called station, the combination with a calling channel and a plurality of frequency selective communicating channels available at each station, of a plurality of trunks at each station, one permanently associated with each of said

communicating channels, selecting switch mechanism at said called station permanently associated with said calling channel, means under the control of said selecting switch mechanism at the called station for selecting for use a particular one of the associated trunks, and means under the control of said calling station for controlling said selecting switch mechanism at the called station.

77. In a carrier wave system, a line, a plurality of stations operatively associated therewith to communicate thereover, a normally energized call receiving channel at each station, other normally deenergized channels comprising a call transmitting channel and a plurality of signaling channels at each station, and means for energizing said call transmitting channel and each of said signaling channels when a particular one of said channels is selected for use.

78. In a carrier wave transmission system, the combination with a line having a plurality of high frequency channels associated therewith, of means operating automatically in response to the busy or idle condition of said channels for testing said channels to select an idle one for use.

79. In a carrier wave communication system, the combination with a line which provides a plurality of different frequency channels over which independent communications may be transmitted, of means set into operation by the seizure of the line on the initiation of a call to select an idle one of said channels for transmission of said call over said line.

80. In a carrier wave system, a line conductor, three or more stations arranged to communicate thereover, a multiple terminal frequency selective channel having a terminal at each station, a signal associated with each terminal, and means at each station for selectively operating the signal at any desired other station.

81. In a carrier wave system, a line conductor, three or more stations arranged to communicate thereover, a frequency selective channel over which any two of said stations may communicate, call signals at each station and means for selectively actuating said signals at any other station.

82. In a carrier wave system, a line conductor, a plurality of stations arranged to communicate thereover, a frequency selective channel over which any two of said stations may intercommunicate, and means whereby the operator at a station initiating the intercommunication excludes other stations from operative association with said channel while it is in use.

83. In a carrier wave system, a line conductor, three or more stations associated therewith to communicate thereover, call responsive devices at each station, a frequency selective calling channel, and means at each station for selectively actuating said call responsive devices at any desired other station through the medium of said calling channel.

84. In a carrier wave communication system, a line conductor, three or more stations associated therewith to communicate thereover, a frequency selective calling channel whereby any station may call any other station, and lockout means for said channel operative upon the initiation of a calling operation.

85. In a carrier wave transmission system, the combination with a line of a plurality of stations operatively associated therewith, a plurality of frequency selective channels associated with said line at each station and available for use in signaling from each station to any other station, and means for selectively calling any station from any other station over any one of said channels.

86. A carrier wave communication system comprising a line conductor, a plurality of stations associated therewith for signaling thereover, a plurality of frequency selective means at each station for communicating with other stations, and means at each station for selectively calling any other station in different manners depending on the frequency selected.

87. A carrier wave system comprising a line conductor, means for impressing a plurality of carrier frequency currents thereon, selective channels corresponding to the various carrier frequency currents, and means including a step-by-step switch operating automatically in response to the electrical condition of said channels for selecting one of said channels corresponding to one of said carrier frequencies not then impressed upon said line.

88. In a signaling system, an initiating station and a distant station, a high frequency wave transmitting channel therebetween, a selective switch at the distant station, means at the initiating station for transmitting a control wave over said channel to control actuation of said switch, and means controlled in the actuation of said switch for disabling the control wave transmitting means.

89. In a signaling system, an initiating station and a distant station, a frequency-selective channel therebetween, a selective switch at the distant station having a control relay, means at the initiating station for transmitting a wave through said channel to control the energizing circuit of said control relay, local circuits at said distant station under control of said relay for actuating said switch, and means controlled in the actuation of said switch for causing the means at the initiating station to withdraw said wave.

90. In a carrier telephone system, a line

conductor, three or more stations thereon, a plurality of distinct carrier telephone channels on said line, each channel having access to all of said stations, means to select a particular channel for use in talking between less than the number of stations to which that channel has access, and means to indicate the selected channel at only the stations between which that channel is to be used for talking.

91. A carrier telephone system comprising a line conductor, a plurality of stations associated therewith for talking thereover, a plurality of selective speech-transmission channels superposed on said line, and means at each station for selectively calling another station over any one of said channels, and conducting a conversation therewith by means of a selected channel.

92. In a carrier telephone system, a line conductor, three or more stations thereon, a plurality of selective wave-transmitting channels on said line, each having access to all of said stations, and means including said wave-transmitting channels for selectively calling any desired station from another station and selectively transmitting speech variations thereto.

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

EDWIN H. SMYTHE.