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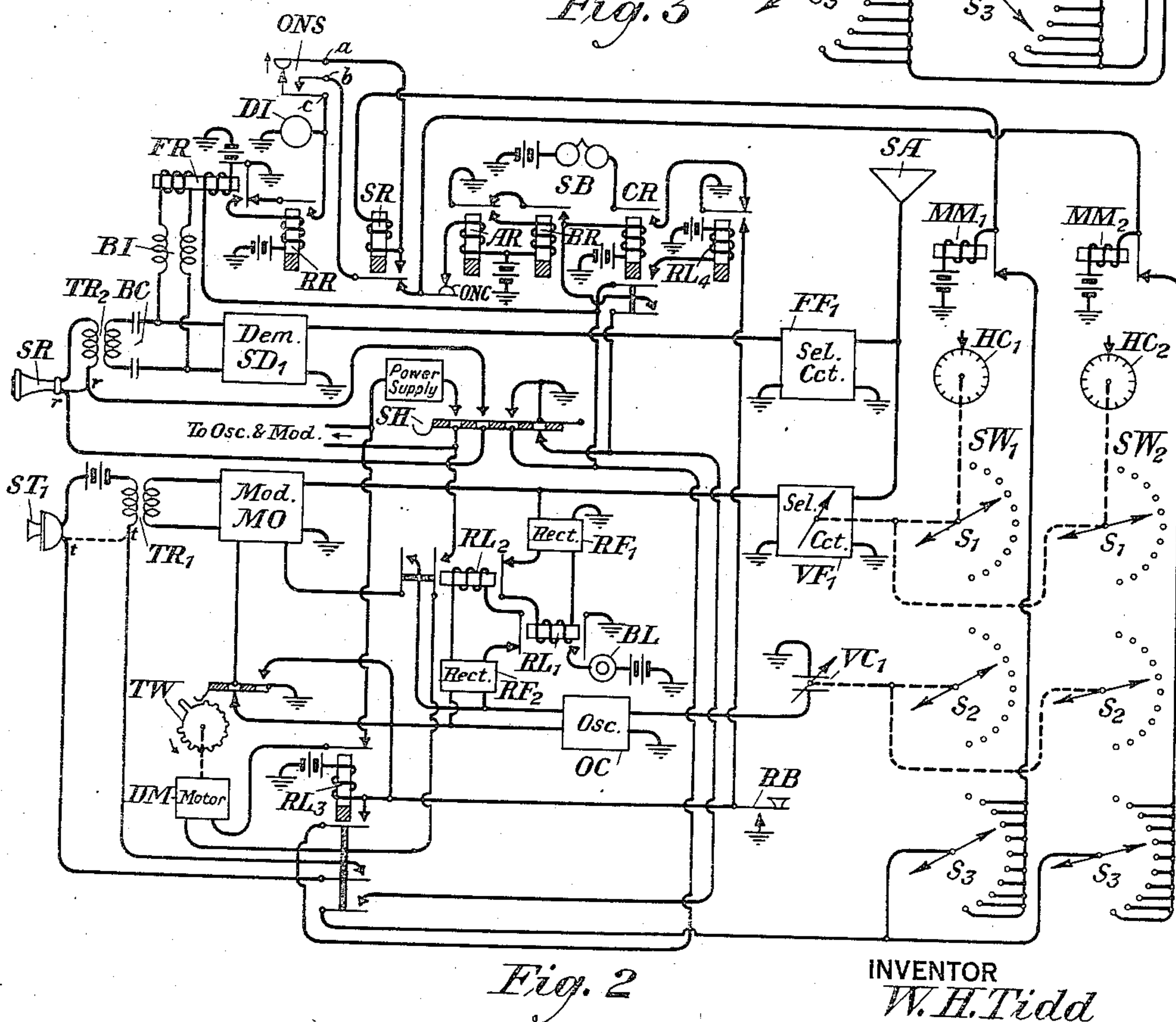
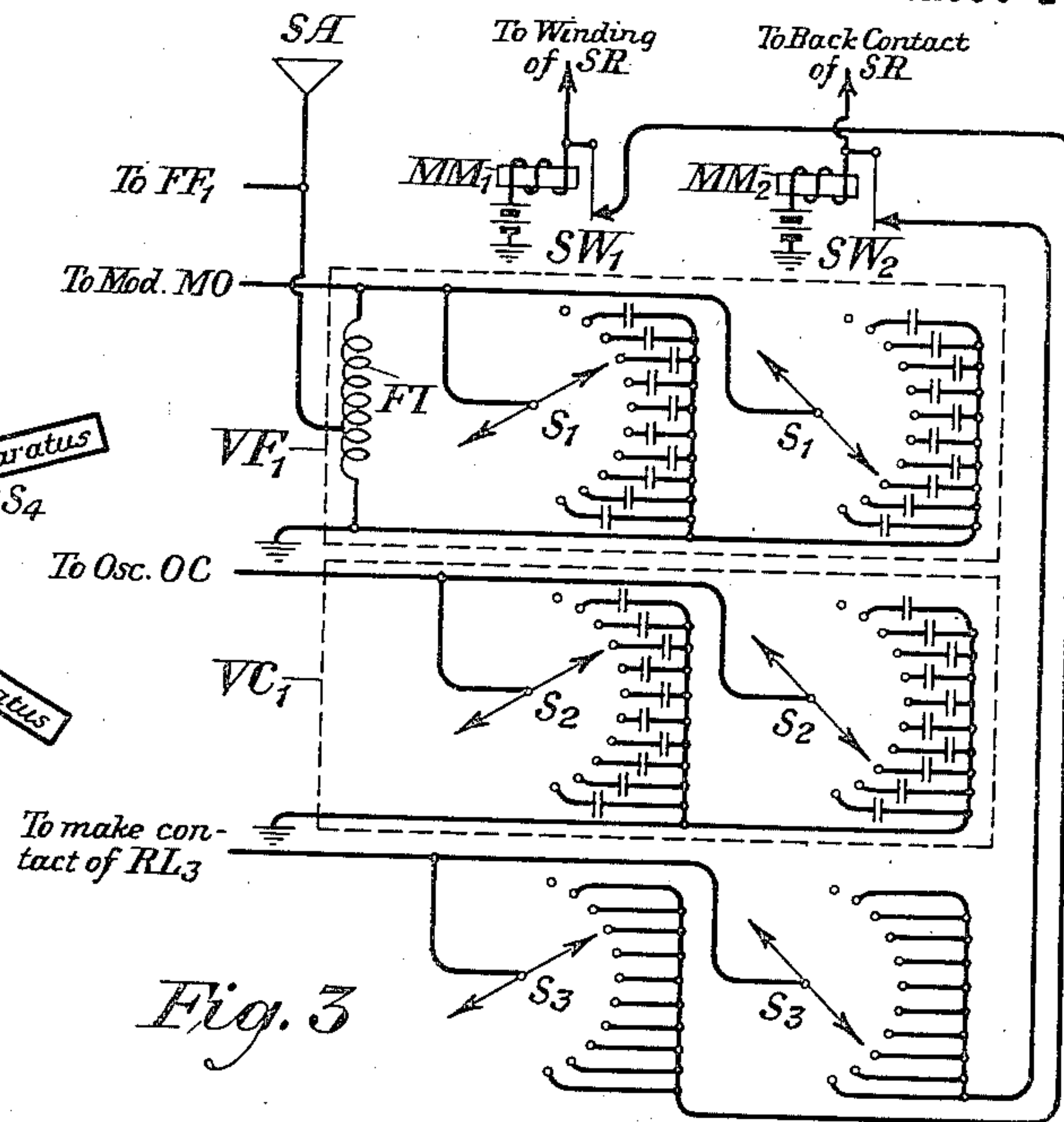
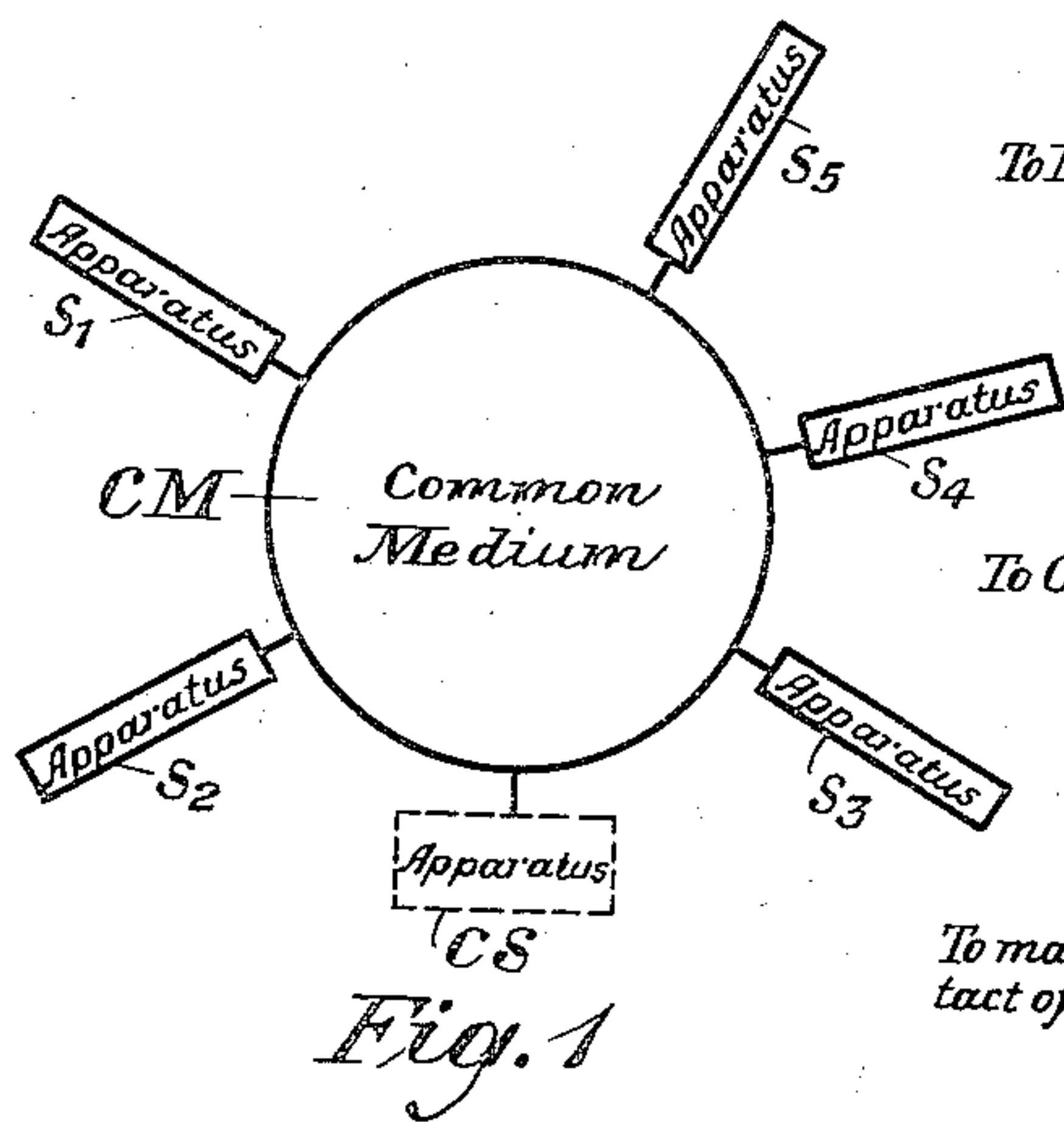
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2,064,961

COMMON MEDIUM MULTICHANNEL EXCHANGE SYSTEM

Filed May 26, 1934

2 Sheets-Sheet 1



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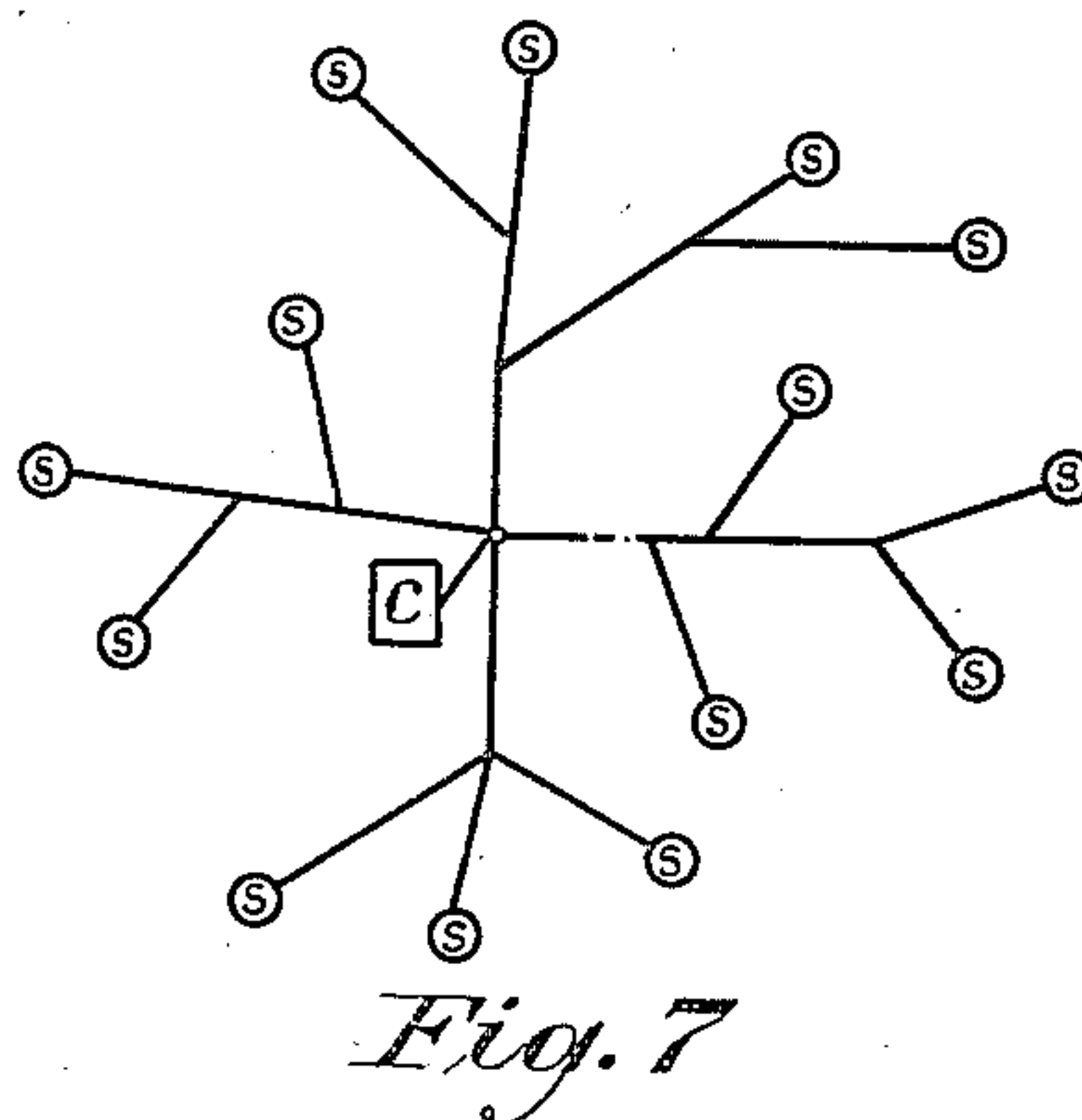
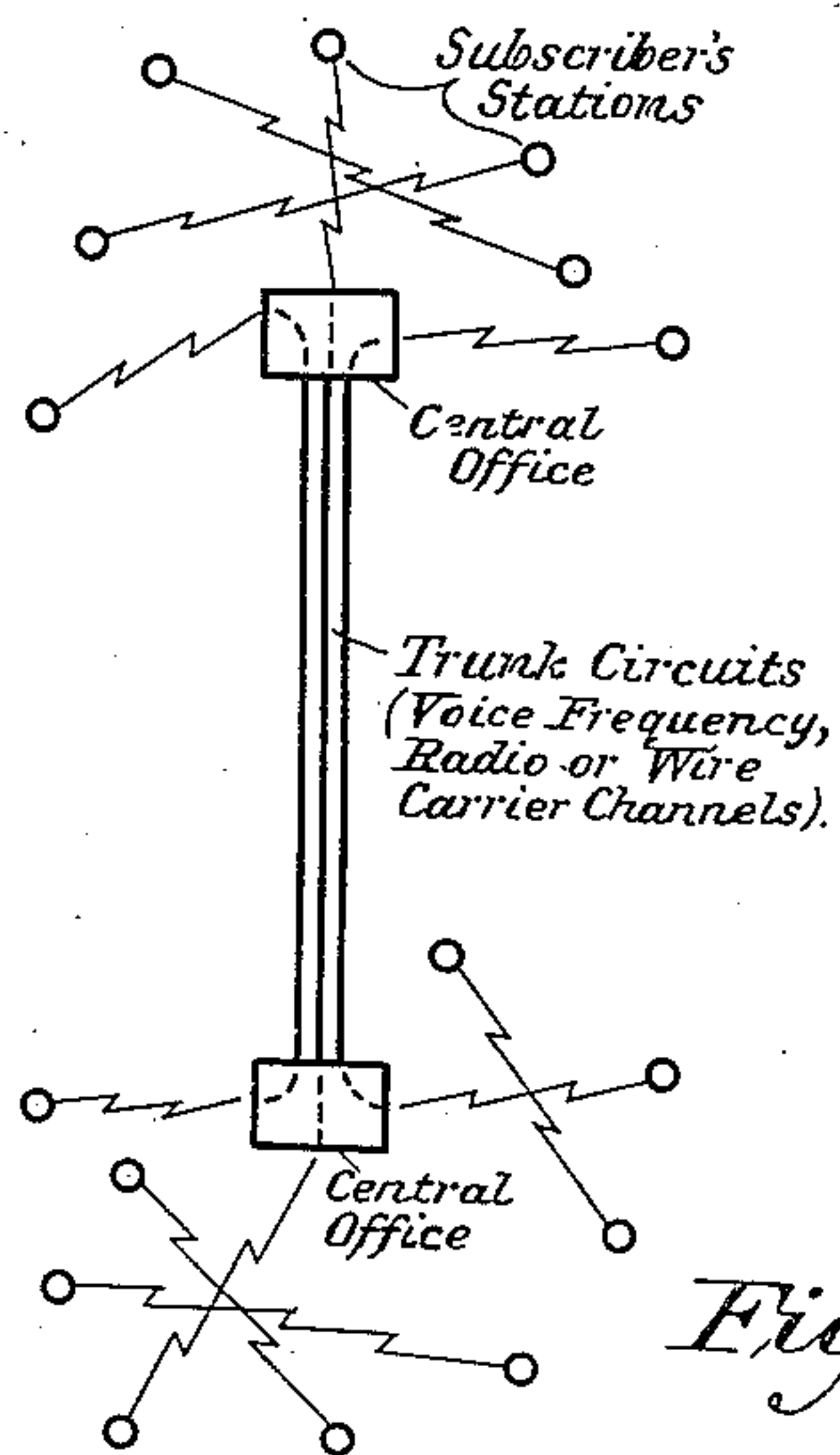
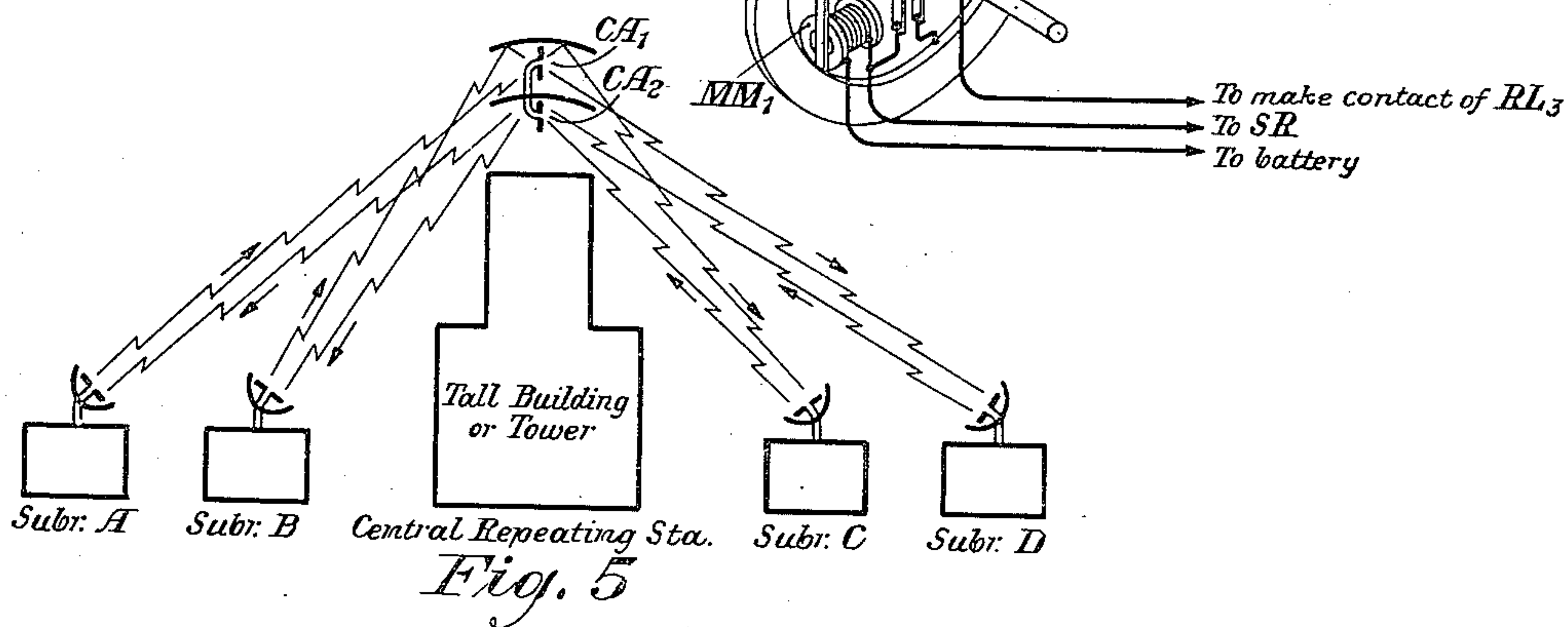
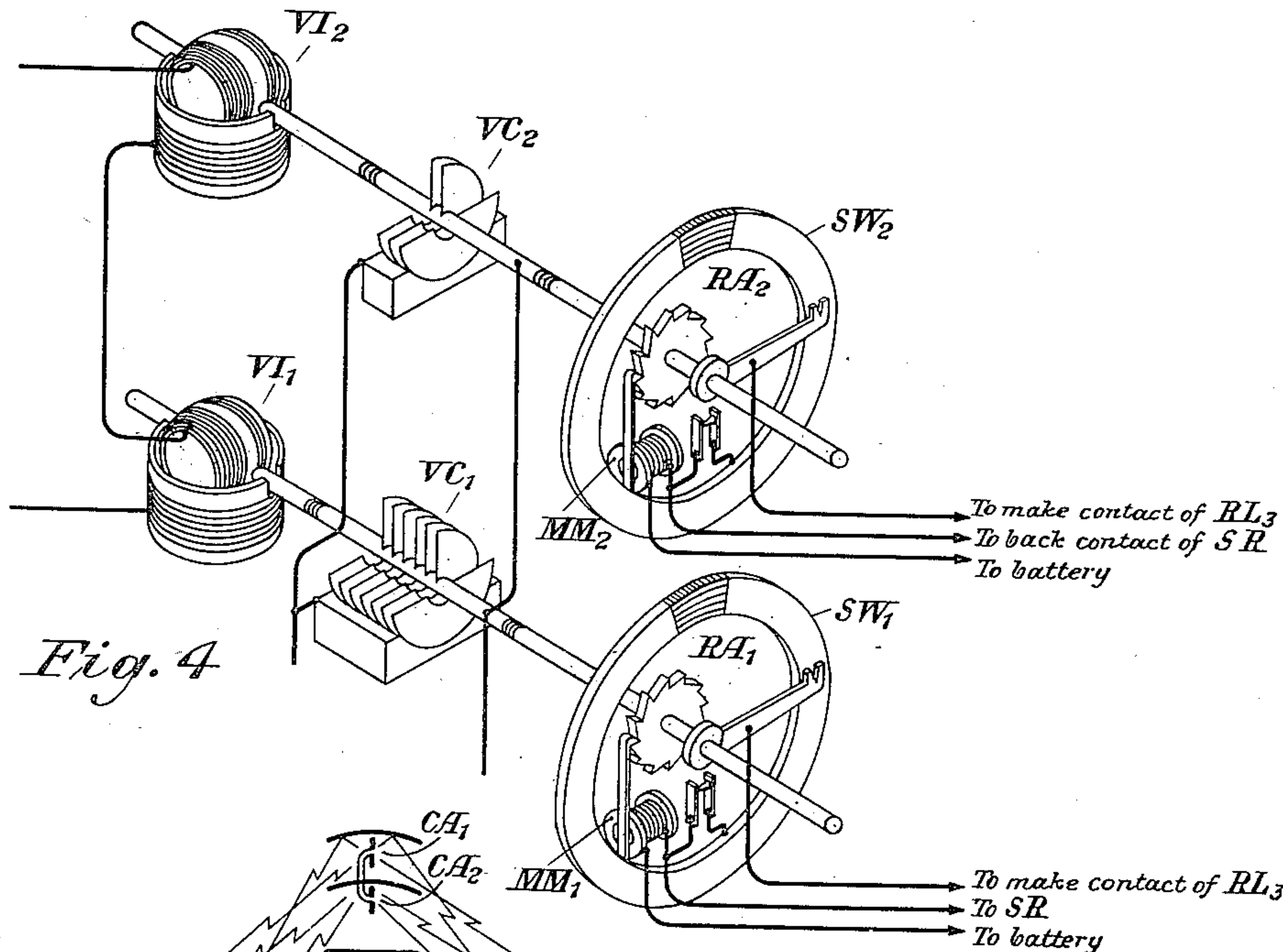
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2,064,961

COMMON MEDIUM MULTICHANNEL EXCHANGE SYSTEM

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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COMMON MEDIUM MULTICHANNEL
EXCHANGE SYSTEMWarren Hitchcock Tidd, White Plains, N. Y., as-
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Application May 26, 1934, Serial No. 727,798

27 Claims. (Cl. 250—6)

This invention has for its object the provision of an exchange system in which communication between subscribers is carried out over channels of different frequency derived from a common transmission medium. More particularly, the invention is designed to utilize as a substitute for the many subscriber pairs which are employed in the ordinary telephone exchange system the many channels which are obtainable in the high-frequency art as it is now unfolding and to provide means whereby these channels may be selected by subscribers at will and employed for interconnection.

In the telephone exchange systems which have heretofore been provided it has been the practice to group subscribers in central office areas. Each subscriber is connected to his own central office by means of an individual wire circuit or by a party line arranged for non-simultaneous use by a few subscribers. When a subscriber desires to call another subscriber he utilizes his own line to the central office, and upon passing the desired number either to an operator or to an automatic switching mechanism is connected to another line which extends either directly or via another office or offices to the called party. For a system of this kind many thousands of subscriber circuits are necessary in each central office area. These are commonly provided in the form of a network of multiple pair cables extending over the area.

In accordance with the present invention it is proposed to substitute for such individual wire circuits extending to each subscriber a transmission medium which is common to all subscribers and which will accommodate a range of frequencies sufficiently wide for a large number of telephone channels. Interconnection between subscribers is then carried out over these high-frequency channels.

The essence of the invention resides in making available to a large number of subscribers a transmission medium capable of accommodating a wide range of frequencies so that the subscribers may utilize, for the purposes of intercommunication, a plurality of signaling channels derived from the wide-band medium. A transmission medium capable of handling the large number of channels required for the exchange system of the invention may be obtained by utilizing either radio transmission in space or high-frequency transmission over a conducting or guiding medium.

Considering, first, the use of radio as the medium for transmitting the wide band of frequencies contemplated by the invention, the invention is designed to employ whatever part of the frequency range may be available. Heretofore, however, the radio frequency spectrum has scarcely afforded sufficient frequency space to

yield the channel capacity required for a local telephone exchange system. With the opening up of the field of ultra-short waves this limitation as to channel capacity is removed. Thus, for example, between one and two meters there is a total frequency range of 150 megacycles while the range between 10 and 20 centimeters is 1500 megacycles. The frequency ranges obtainable through the use of still shorter waves are much greater.

With these ultra-high frequencies, however, nature imposes another limitation, i. e., the tendency of the waves to take on quasi-optical characteristics, so that they project only in straight lines and do not bend around corners to any considerable extent. Thus, it becomes necessary that subscribers utilizing such waves have a fairly clear line of sight between their antennas. Some diffraction around obstacles may, of course, be obtained, but, in general, reasonably clear line-of-sight projection without intervening obstacles appears to be called for. This, of course, has the advantage of making it possible to utilize the same ultra-high frequencies in different areas.

The line-of-sight characteristics of the ultra-short waves must be recognized in the design of a telephone exchange system utilizing this technique. In one form of the invention it is proposed to provide in the center of a community a repeating station with antennas mounted sufficiently high above the surrounding buildings to make possible the necessary directness of transmission between these antennas and practically any point in the territory to be served. One subscriber's station is then placed in connection with another by transmitting first to the central repeating station and having the repeating station repeat the transmission to the desired other subscriber located in another part of the community. The central repeating station acts as a means for catching the waves from one subscriber at a relatively high point and transmitting them down again to a second subscriber, thus lifting the transmission path above any obstacles lying between the subscribers' antennas.

In order that such a repeating station may be economical, it is proposed to make it capable of handling simultaneously a wide band of frequencies such as would accommodate hundreds or perhaps thousands of channels. The particular arrangement of the repeating station will be hereinafter described.

As an alternative to the use of a radio transmission medium, the invention contemplates the employment of a guiding or conducting transmission path suitable for the required band of frequencies. Such a transmission path would be provided in the form of a network, extend-

ing to all the subscribers within a given area. Conceivably, such a network might be composed of ordinary wire circuits branched and interconnected so as to make the common circuit available to each subscriber. Thus, the wire network might be somewhat similar to the network employed for distributing light and power currents, except that a simple two-wire network without multi-phase connections, voltage transformation arrangements, etc., would suffice. It would, however, be possible to carry out the invention by employing the light and power network itself and this is contemplated within the scope of the invention.

The preferred form of guiding transmission medium, however, is one which is designed for the transmission of a wide band of frequencies with comparatively low attenuation and preferably also with shielding to minimize the effect of external disturbances. Such a transmission medium may be found in a circuit consisting of two conductors disposed coaxially with respect to one another. In a properly designed coaxial circuit, as will be hereinafter explained, low attenuation at high frequencies may be attained by the employment of conductors of suitably low high-frequency resistance and the use of a substantially gaseous dielectric between the conductors. With this type of circuit the outer conductor serves also as a shield whose protective effect becomes more nearly perfect as the frequency is increased, so that at high frequencies practically complete immunity from external disturbances may be obtained.

The invention contemplates also as an alternative to the coaxial circuit of a high-frequency transmission medium comprising a circuit consisting of two conductors surrounded by a shield. Here, again, the high-frequency attenuation may be minimized by proper design with substantially gaseous insulation and the thickness of shield may be determined so as to minimize interference from external disturbances.

Yet another form of transmission medium suitable for carrying out the invention is a dielectric wave guide comprising a cylindrical dielectric material which may or may not be surrounded by a conductor. An advantageous form of such a transmission path is a hollow cylindrical conductor containing air or some other gas as the dielectric. This type of circuit is particularly adapted to transmit waves of very high frequencies, for example, of the order of a few centimeters or less in wave-length.

Using any of the above types of transmission media, the interconnection of subscribers at will from the available channels involves a number of new and difficult problems which are solved by the various features of the invention as hereinafter disclosed.

It is contemplated in the present invention that subscribers will be connected together directly by means of the common medium, without necessitating the interposition of a central office. Direct connection between subscribers is effected by a process of tuning or selection. This method takes advantage of the fact that the transmission medium is common to all of the subscribers, with all of the channels accessible to each subscriber at will. The switching function is placed in the hands of the individual subscribers by eliminating the central office in so far as connections within the given area are concerned. Connection to subscribers in other areas is carried out through the respective central

offices which are joined by trunk channels of circuits suitable for the purpose.

One of the big functions involved in local exchange telephone systems is that of switching so that each subscriber is connected with any other subscriber. This operation is now carried out at the central offices by the switching of mechanical contacts either as a manual operation or by automatic equipment under remote control of the subscriber. In accordance with certain embodiments of the invention, it is proposed to carry out this function of interconnecting subscribers without the switching of mechanical contacts. This is accomplished by having the subscribers permanently connected to the common medium and completing the electrical path directly by the subscriber at his own premises by frequency selection. Thus, an important object of the invention is the provision of means whereby mechanical switching may be replaced by "electrical switching." This electrical switching or interlinking is carried out by shifting the tuning of the circuits, by selecting the frequency of the carrier current, by shifting the frequencies in a modulator, or a combination of these. Selecting, modulating and multiplexing methods are, therefore, important features of the invention.

In general, the invention contemplates the assignment to each subscriber of a particular frequency which might preferably be related to his telephone number. The assignment of frequencies should be such as to facilitate the interconnection of subscribers.

The foregoing outline having indicated some of the principles of the invention as well as a few of its major objects, the complete invention with its various details, features and purposes will now be understood from the following description when read in connection with the accompanying drawings, in which Figure 1 shows a schematic representation of the principal idea of the invention wherein a large number of stations are connected to a common transmission medium; Fig. 2 shows an arrangement for a subscriber's station whereby direct connection may be established with any other station; Fig. 3 shows a method of channel selection that may be used with the arrangement of Fig. 2; Fig. 4 shows another such arrangement; Fig. 5 shows an antenna arrangement which may be used with subscriber stations of the type shown in Fig. 2; Fig. 6 is a schematic diagram indicating how connection may be established directly between subscribers in the same area, while connections between subscribers in different areas are completed through central offices over trunk circuits; Fig. 7 is a schematic diagram of a guiding or conducting network which is available in common to a number of subscribers and a central station.

Referring to Fig. 1, there is illustrated one of the principal aspects of the invention. In this figure is shown a common medium CM, to which are connected a plurality of stations S₁, S₂, S₃, etc., each of which includes transmitting, receiving and associated apparatus. This apparatus, which will be hereinafter described, is arranged to permit intercommunication between different pairs of stations over the common medium CM employing different frequency bands to permit simultaneous communication between different pairs of stations.

In Fig. 2 is shown a detailed circuit arrangement for a subscriber's station illustrating a pos-

sible form of the invention. In this case only one frequency band is required for each subscriber. Outgoing transmission takes place on the called subscriber's frequency and incoming transmission employs the calling subscriber's frequency.

Before going into the detailed operation of the arrangement of Fig. 2, some of the elements forming a part of this arrangement may be briefly described. The arrangement includes two rotary switching units SW_1 and SW_2 which are similar to units familiar in the art. The wipers of these switches may be stepped around by the stepping magnets MM_1 and MM_2 in response to codes of impulses. The switches have the additional feature, however, that the position of the wipers may be controlled manually by means of the dials HC_1 and HC_2 . It will be understood that while the switches as shown are designed to provide for a system having a maximum of 99 subscribers, the subscriber capacity may be readily increased by the application of principles well known in the art.

Included also in the arrangement of Fig. 2 is a motor-driven toothed wheel TW , whereby the number assigned to the subscriber may be transmitted in the form of a series of interruptions of the transmitted carrier frequency.

The operation of the arrangement of Fig. 2 in the placing of an outgoing call will now be explained. By means of the controls HC_1 and HC_2 the subscriber first manually adjusts the switches SW_1 and SW_2 to a setting corresponding to the number of the called party. The setting of the s_1 rows of these switches determines the response frequency of the variable selecting circuit VF_1 , while the setting of the s_2 rows determines the value of the variable condenser VC_1 which in turn controls the frequency of the oscillator OC . Thus the frequency of the oscillator OC and the selecting circuit VF_1 is adjusted to the receiving frequency which is assigned to the called subscriber.

Instead of manually controlling the positions of the switches SW_1 and SW_2 by means of HC_1 and HC_2 , these switches may be adjusted by means of the dial DI from any location remote from the switches. The contacts of the dial DI are normally open. The operation of the dial DI for the first digit of the called party's number transmits a number of pulses corresponding to the digit dialed. These pulses are "make" pulses rather than interruptions of the circuit. The first pulse completes a circuit from ground, through the contacts a and c of the off-normal spring ONS , the relay SR and the stepping magnet MM_1 to battery. This operates the contacts of switch SW_1 one step. The off-normal springs ONS are operated to the off-normal position and relay SR is operated. The second and succeeding pulses of the first digit actuate MM_1 by a new path through contacts b and c of the off-normal springs ONS and the make contact of relay SR . Relay SR being of the slow release type does not fall back during the interruptions of the first digit.

After the first digit a pause allows relay SR to fall back. The pulses of the second digit actuate stepping magnet MM_2 by completing a circuit from ground through contacts b and c of the off-normal springs ONS and the back contact of relay SR . The operation of these two banks of switches adjusts the selecting circuit VF_1 and the frequency of the oscillator OC to the called party's receiving frequency. Energizing of relay AR during the operation of MM_2 is prevented by

the off-normal contact ONC which is opened during the operation of the dial DI .

If, having adjusted the apparatus as described, the called party is busy, his receiving carrier will be received by the antenna SA as well as by his own antenna. The variable selecting circuit VF_1 will pass this carrier frequency to the rectifier RF_1 . The output of the rectifier will energize the relay RL_1 whose winding is connected through a back contact of RL_2 . The operation of RL_1 closes a circuit from battery through the busy lamp BL to ground. (It will be understood that the separate sources of power supply shown in various places in Fig. 2 may, if desired, be replaced by a single source.) The busy lamp indicates to the subscriber that the called party is busy. He may then wait until the called party's frequency becomes idle, or restore the switches to their normal positions by pressing the release button RB . This energizes relay RL_3 and completes the circuit through the off-normal contacts in banks S_3 of switches SW_1 and SW_2 and stepping magnets MM_1 and MM_2 . RL_3 holds up long enough for SW_1 and SW_2 to reach their normal position.

When the called party is not busy, the relay RL_1 is deenergized and the busy lamp is not lighted. The calling subscriber now takes his receiver off the switchhook SH . This connects power supply to the oscillator OC and the modulator MO . The carrier from the oscillator OC is rectified in the rectifier RF_2 and energizes the relay RL_2 whose winding is connected through a make contact of the switchhook and a back contact of RL_1 . The operation of RL_2 accomplishes several results. First, it connects carrier from the oscillator OC to the modulator MO . Second, it disables the relay RL_1 so that the transmitted carrier does not affect this relay. Third, it connects power supply to the motor DM which drives the toothed wheel TW . The circuit for the power supply may be traced through a break contact of the slow-release relay RL_3 , a make contact of the switchhook, and a make contact of RL_2 . The rotation of the toothed wheel TW serves to interrupt the carrier supply in accordance with the digits of the number of the calling subscriber. These interruptions operate switching units at the station of the called party which, in turn, adjust the called party's equipment so as to transmit on the frequency of the calling party as will be explained below.

After one revolution of the wheel TW , during which the complete code has been dialed, an auxiliary lug on the dial closes a contact which completes a circuit through the winding of the slow-release relay RL_3 . This relay RL_3 thereupon forms for itself a locking circuit through one of its make contacts and a make contact of the switchhook. Thus the relay RL_3 remains operated until the calling subscriber hangs up. The operation of RL_3 serves to interrupt the power supply to the motor DM so that no further rotation of the wheel TW can occur. RL_3 also completes a make contact whereby the circuit of the transmitter ST_1 is completed. Since the calling subscriber has adjusted his transmitting equipment to the receiving frequency of the called party, and since the impulses transmitted by the wheel TW have served to adjust the transmitting frequency of the called party to the receiving frequency of the calling party, conversation may now take place.

At the end of the conversation the calling party hangs up. At this time two circuits are

closed to ground through a make contact of the slow-release relay RL₃ and a break contact of the switchhook. One of these circuits leads through the wiper of the contact row s₃ of the switching unit SW₁ to one of the off-normal contacts of this row and thence through a back contact of the stepping magnet MM₁ and the winding of this magnet. The other path leads similarly through the wiper of row s₃ of switching unit SW₂, an off-normal contact of this row, a back contact of the stepping magnet MM₂ and the winding of this magnet. These circuits cause the stepping magnets MM₁ and MM₂ to buzz around until each reaches its normal contact position. Thus the switching units are placed in readiness for the next connection.

In receiving a call from some other station in the system, the arrangement of Fig. 2 operates as follows: The calling station adjusts its transmitting frequency to the mid-band frequency of the fixed selecting circuit FF₁. This frequency passes to the demodulator SD₁ which is continuously in operating condition. The rectified current in the demodulator output passes through the blocking inductances BI and energizes the relay FR. The operation of FR closes a circuit which pulls up the slow-release relay RR.

The dial at the distant party's station now interrupts the carrier frequency in accordance with the number of the calling party. The circuit of relay FR will first be interrupted in accordance with the first digit of the number. The deenergizing of the relay FR will break the circuit of the relay RR, but since the latter is a slow-release relay it will continue to hold until the relay FR pulls up again.

When the armature of the relay FR falls back at the first break, it closes a circuit through its break contact, a make contact of RR, contacts a and c of the off-normal springs ONS, the winding of the slow-release relay SR, and the stepping magnet MM₁. Hence the relay SR pulls up and at the same time the stepping magnet MM₁ operates to advance the wipers of the switch SW₁ by one step.

This circuit through the relay SR and the stepping magnet MM₁ is immediately broken by the reenergizing of the relay FR after the first break impulse. The stepping magnet MM₁ releases but since SR is a slow-release relay, it holds until the next impulse. The second break impulse again deenergizes FR and again closes a circuit through SR and MM₁. This time, however, the circuit is completed over a new path leading from ground over the back contact of FR, a make contact of RR, contacts c and b of the off-normal springs (closed when SW₁ was advanced one step), the make contact of SR, the winding of SR, and the stepping magnet MM₁. Thus SW₁ is advanced another step. Succeeding impulses serve to actuate MM₁ just as the second impulse did.

After the last break impulse there will be a time interval before the dialing of the next digit, so that the slow-release relay SR will be deenergized. This will break the circuit through this relay so that when the second set of impulses arrives, the stepping magnet MM₁ will be out of the circuit. The first break impulse of the second series causes the relay FR to fall back and thereby closes a circuit through the break contact of FR, the make contact of RR, off-normal contacts c and b, the break contact of SR, and thence in parallel through the winding of the stepping magnet MM₂ and the wind-

ing of the slow-release relay AR. The stepping magnet MM₂ will be deenergized at the end of the first break impulse, and the succeeding impulses will act each to advance the switch SW₂ by one step just as the first one did. Consequently at the conclusion of the dialing the wipers of the switches SW₁ and SW₂ will be in positions which correspond to the number of the calling party. The position of these switches in turn sets the frequencies of the variable selecting circuit VF₁ and the oscillator OC at the receiving frequency of the calling subscriber.

The operation of the slow-release relay AR at the first impulse of the second digit energizes the relay BR whose winding is connected through the make contact of AR. Since AR is a slow-release relay, it will remain energized throughout the pulses corresponding to the second digit. At the conclusion of these pulses, however, the operation of FR will serve to deenergize AR, whereupon a circuit will be completed from the winding of the slow-release relay CR, through the make contact of BR and the break contact of AR. Relay CR thereupon establishes for itself a new circuit leading through a break contact of the switchhook to ground. The operation of CR closes the circuit of the subscriber's bell SB which is connected through a back contact of RL₄.

When the called subscriber takes the receiver off the switchhook to answer, power supply is connected to the oscillator OC and the modulator MO as already described. The pulsing circuit is now disabled by the energizing of an auxiliary winding of relay FR through a make contact of the switchhook. The operation of RL₂ connects carrier supply from the oscillator OC to the modulator MO. Since CR is a slow-release relay, it holds up for an instant after the operation of the switchhook. At this time a circuit is completed through the winding of the slow-release relay RL₄, a make contact of CR, and a make contact of the switchhook, which operates RL₄. Operation of RL₄ opens the bell circuit and energizes RL₃. RL₃ locks itself up through one of its make contacts and a make contact of the switchhook SH. RL₃ also cuts off the power supply to the motor DM so that the dialing mechanism becomes inoperative and completes the circuit of the transmitter ST₁.

The equipment is now in readiness for conversation. The slow-release relay RL₃ remains operated during the conversation and is deenergized when the receiver is replaced on the hook, but remains operated for an interval. This closes two circuits through the back contact of the switchhook SH, a make contact of RL₃, the wipers in the s₃ rows of SW₁ and SW₂ and thence through the windings of MM₁ and MM₂ so that the switches are stepped around to their normal positions. When the various relays have released, the equipment is in readiness to handle another call.

Fig. 3 shows in detail a possible embodiment of the variable filter VF₁ of Fig. 2. The variable filter, VF₁ of Fig. 3, comprises a fixed inductance FI to which condensers of various values may be connected in parallel by means of the banks of contacts s₁ of switches SW₁ and SW₂. The inductance and condensers constitute a simple anti-resonant circuit. The frequency band passed by this circuit may be adjusted by operation of the switches SW₁ and SW₂ as has been described in connection with Fig. 2. The con-

condensers connected to bank s_1 of SW_2 may have suitable values so that the frequency interval determined by two successive condenser values of SW_1 is divided into ten parts. This makes a total of 99 frequency bands available through combinations of the condensers in the s_1 banks of SW_1 and SW_2 , and the inductance FI . It would be possible of course to obtain larger numbers of frequency bands by adding other switches.

It will be obvious to those skilled in the art that more complex variable filter structures can be utilized by connecting other elements in the circuit by means of additional banks of the switches SW_1 and SW_2 . This is also included in the scope of the invention.

The banks of contacts s_2 connect various values of capacity in the circuit of the oscillator OC of Fig. 2, thereby adjusting its frequency as has been previously explained. The operation of the rest of Fig. 3 has been detailed in connection with Fig. 2.

Another possibility would be to derive the desired values of inductance and capacitance for the variable filter VF_1 of Fig. 2 from variable condensers and inductances which might either be mounted directly on the shafts of the switching units or controlled by them. For this purpose the condensers and inductances to be controlled by the stepping magnet MM_1 may be mounted on a common shaft which is provided with a wiper traversing an annular ring. This is shown in the perspective drawing of Fig. 4. The condensers and inductances to be controlled by the stepping magnet MM_2 are similarly shown mounted on another shaft. The condensers and inductances controlled by MM_1 may be divided into steps approximately ten times those of the condensers and inductances controlled by MM_2 . The corresponding units on the two shafts may be suitably connected together and to the proper place in the variable filter VF_1 .

Referring to Fig. 4 in response to the stepping magnet MM_1 the shaft is stepped around to a position corresponding to the first digit of the desired number thus adjusting the values of the inductance VI_1 and the condenser VC_1 . The first 180° of rotation of the shaft covers the useful range of the circuit elements. Since these elements are continuously variable any number of positions may be included in this range. The number of teeth on the ratchet RA_1 should therefore be twice the number of positions employed. For ten digits the ratchet should have 20 teeth. The adjustment of VI_2 and VC_2 is similarly controlled by MM_2 .

When the connection is taken down, a circuit is completed through the stepping magnet and its back contact, the wiper and annular ring, and the make contact of RL_3 (Fig. 2) to ground. This completes the revolution of the shaft around to the starting point where an insulated segment breaks the circuit. The mechanism is now in readiness for the next operation.

It will be noted that the arrangement of Fig. 4 eliminates all switched contacts in the selecting circuits. It will be seen in Fig. 2 that the contacts which complete the circuit of the transmitter ST_1 and that of the receiver SR might be deleted, permanently closing the circuits of these elements, as shown by the dotted lines $r-r$ and $t-t$ in Fig. 2, without in any way interfering with the operation of the apparatus. This would completely eliminate switched con-

tacts from the circuit between two subscribers. This is one of the features of the invention.

Radio transmission between subscribers who are provided with the station arrangement of the type shown in Fig. 2 may be accomplished directly, using any suitable type of antenna. However, in order to obtain substantially line-of-sight transmission for the ultra-short range of frequencies, the transmission path may be carried over obstacles which intervene between the antennas of individual subscribers by employing an arrangement of the type shown in Fig. 5.

Referring to this figure, the frequencies transmitted by the various subscribers are carried through a central repeating station where they are received on the antenna CA_1 and re-radiated from the antenna CA_2 . These antennas CA_1 and CA_2 may be located upon a tall building or some other place having sufficient elevation. The antenna CA_1 is designed to receive from all subscribers' antennas within the assigned area while the antenna CA_2 is of a type suitable for radiating to all subscribers' antennas. Each subscriber's antenna may be designed to radiate a beam toward the antenna CA_1 and to receive radiation from the antenna CA_2 .

In using the antenna system of Fig. 5 in conjunction with the subscriber's arrangement of Fig. 2, subscriber A, for example, might be assigned a receiving frequency f_1 and subscriber D a receiving frequency f_3 . Subscriber A then would call subscriber D by setting his transmitting frequency at f_3 , and the pulses transmitted from his apparatus would adjust the transmitting frequency of subscriber D to the value f_1 .

As has been explained, the subscriber station arrangement of Fig. 2 is designed to provide a direct radio connection between the subscribers within a given area. It is proposed to interconnect such stations with subscriber stations in other areas by providing in each area a central office, so that a radio connection may be established between a subscriber and his central office, using one of several frequencies assigned for that purpose, and the connection completed over suitable interoffice trunks. The method is illustrated schematically in Fig. 6. The central office apparatus to be used in carrying out this method might be patterned after that shown in Fig. 2. The types of trunks which may be used to interconnect the central offices are well known in the art.

In the arrangements which have been described for selecting channels, the entire selection has been accomplished at the channel frequency. It will be evident that this method of selection might be replaced by the well-known superheterodyne method, with partial selectivity provided at the channel frequency and the remaining selectivity furnished by a sharp, intermediate frequency selecting circuit or filter.

It will be evident to those skilled in the art that arrangements for automatically controlling the volume of the signals delivered by the subscriber's equipment may be incorporated in any of the subscribers' station arrangements which have been described, so that conversation between different subscribers may take place over a substantially constant transmission equivalent.

It will be noted that in the subscriber station arrangement described above, the apparatus is designed to prevent a subscriber from listening in on the conversations of other subscribers.

This, of course, is a very desirable feature for a telephone exchange system.

In the arrangements described it has been assumed that free space is employed as the common transmitting medium. There will now be described arrangements in which transmission over a high-frequency conducting or guiding path is employed instead of radio transmission. Such a path would take the form of a network extending to all subscribers within a given area and to the central office for that area.

Probably the simplest form of such a network would be one comprised of ordinary two-conductor circuits suitably interconnected and branched so that the common circuit will be available at all desired points. The circuits comprising the network might, for example, consist of pairs of open-wire or cable conductors. A network of this kind is shown schematically in Fig. 7, where each line represents a pair of conductors, C designates the central office and S a subscriber's station.

It is contemplated also in accordance with the invention that the wire network employed for distributing light and power currents might be used as the common medium from which to derive high-frequency channels for the telephone exchange system. The high-frequency channels would be superposed upon the power network by carrier methods which are well known in the art.

Another form of transmission medium, and one which is peculiarly advantageous in that it is capable of transmitting a wide band of frequencies with comparatively low attenuation and which may be so shielded as to be practically immune to external disturbances, may be found in a circuit consisting of two conductors disposed coaxially with respect to one another. Such a circuit has been disclosed in the patents to L. Espenschied and H. A. Affel, No. 1,835,031, December 8, 1931; H. A. Affel and E. I. Green, No. 1,781,092, November 11, 1930, etc. In this form of circuit, low attenuation at high frequencies may be obtained by the employment of conductors whose high-frequency resistance is suitably small and by the employment of a substantially gaseous dielectric. The outer conductor provides shielding against external disturbances, which shielding becomes more nearly perfect as the frequency is increased, so that at high frequencies the noise due to thermal agitation in the conductors becomes the factor which determines the minimum transmission level.

As an alternative to the coaxial circuit, the high-frequency transmission medium might comprise a network of circuits, each consisting of two parallel conductors surrounded by a shield. Circuits of this type are disclosed in the applications of Green, Curtis and Mead, Serial No. 674,762, Green and Curtis, Serial No. 674,763 and Green and Liebe, Serial No. 674,764, all filed June 7, 1933.

The invention contemplates also utilizing as the high-frequency transmission medium a dielectric wave guide comprising a cylindric dielectric material which may or may not be surrounded by a conductor. Such dielectric guides are disclosed in the patent applications of G. C. Southworth, Serial No. 661,154, filed March 16, 1933, and Serial No. 701,711, filed December 9, 1933. An advantageous form of such a wave guide is a hollow cylindrical conductor containing air or some other gas as the dielectric. This type of circuit is particularly adapted to transmit waves of very high frequencies,

for example, of the order of a few centimeters or less in wavelength.

It is contemplated in accordance with the invention that the subscriber set which has been described may be employed with any of the above types of transmission paths. For this purpose, it is necessary merely to substitute the transmission network for the radio path, replacing the connection of the apparatus to the radio antenna by a connection suitable to the type of medium employed.

While the entire preceding discussion has been restricted to systems wherein a common transmission medium is employed for the provision of telephone exchange service between subscribers, it will be understood that the invention contemplates the use of the same general methods for other types of communication. In particular, it will be seen that there has been disclosed a medium which is capable of handling a wide band of frequencies from which a substantial number of television channels may be derived.

It will furthermore be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. In a telephone exchange system for establishing a plurality of simultaneous telephone connections between any one and any other of a plurality of stations taken in pairs over a common transmission medium, means for assigning to each station a fixed band on which it invariably receives, said band being different from those of other stations, means at each station as a called station whereby it may be adjusted in response to a signal to transmit on the frequency band corresponding to that signal, and means at each calling station to send the signal for the frequency band on which it is prepared to receive.

2. In a telephone exchange system, a plurality of stations, a common medium extending to each of the stations, means for assigning to each station a different carrier frequency at which it will receive, each station having a telephone number, the telephone numbers of the stations being arranged in substantially the same order as their assigned receiving frequencies, means at each one station for establishing a two-way telephone connection between that one station and any other station by employing the frequencies assigned to the two stations for transmission in respective directions, and manually controlled means at each one station by which to actuate the said establishing means at both stations.

3. A system for telephone communication between any one and any other of a plurality of stations, said system including a common transmission medium extending to each of said stations, said medium being capable of transmitting a plurality of frequency bands a different one of which is assigned to each station for reception, and means at each of said stations for selecting at will any one of said frequency bands for transmitting to another of said stations upon the band assigned to the desired station, and means under control of said first station for automatically adjusting said other station to transmit back on the frequency band assigned to said first station.

4. A high frequency transmission system, in-

cluding a plurality of stations, a common transmission medium, means at each of said stations for transmitting on any of a plurality of frequencies, each of said stations being arranged to receive on a different one of said frequencies, and means for adjusting by said transmission the transmitting frequency of the station receiving said transmission.

5. A station having a transmitter capable of sending on any of a plurality of frequencies and a receiver receiving on a fixed frequency, a variable filter having a range of adjustment extending to any particular one of said transmitting frequencies, and means responsive to an incoming frequency passed by said filter for disabling said transmitter.

6. A station having a transmitter capable of transmitting on any of a plurality of carrier frequencies and a receiver receiving on a fixed frequency, a variable tuned circuit having a range of adjustment extending to any particular one of said transmitting frequencies, means associated with said tuned circuit and responsive to any incoming frequency to which said circuit is tuned for preventing said transmitter from functioning, and means for indicating said condition.

7. A station having a transmitter capable of being adjusted and connected for sending on any of a plurality of carrier frequencies and a receiver receiving on a fixed frequency, a common transmission medium capable of transmitting any of said transmitting frequencies, means operative at an intermediate stage of the complete adjustment and connection of said transmitter for it to receive the carrier frequency to which it is being adjusted, and means responding to a carrier frequency so received to prevent said transmitter from sending on any carrier frequency which is being transmitted over said medium, and means for indicating that said carrier frequency is being transmitted over said medium.

8. A subscriber's station having a transmitter capable of sending on any of a plurality of carrier frequencies, a receiver at said station arranged to receive at only one carrier frequency, a second subscriber's station having a second receiver capable of receiving one of the frequencies transmitted by said first transmitter, a second transmitter associated with said second receiver, means for interrupting the carrier frequency sent out by said first transmitter in a code, and means responsive to the receipt of said code by said second receiver for adjusting said second transmitter to transmit on a carrier frequency which said first receiver is capable of receiving.

9. A station having a receiver and a transmitter, said receiver being capable of receiving a single fixed carrier frequency and being unresponsive at all times to any other frequency, said transmitter being capable of operating on any of a plurality of carrier frequencies, means responsive to signals received by said station upon said fixed carrier for adjusting the frequency on which said transmitter operates.

10. In a telephone exchange system, a plurality of subscribers' stations, a common transmission medium extending to each of said stations, each of said stations being continuously in readiness to receive transmission from said medium at a unique carrier frequency, means for transmitting from any one of said stations on any of said receiving frequencies, means at

the called station for signaling the subscriber, means under control of the calling station for adjusting the transmitting frequency of the called station to the receiving frequency of the calling station, and means enabling two-way conversation between said calling and called subscribers.

11. A station capable of receiving signals on only a single fixed frequency, said station having a transmitter capable of operating on any of a plurality of frequencies, means for locally adjusting the operation of said transmitter to any particular frequency, means responsive to signals received by said station for adjusting the operation of said transmitter to any particular frequency, and means to prevent one of said adjusting means from interfering with the operation of the other.

12. A station capable of receiving signals on only a single fixed frequency, said station comprising a transmitter capable of operating on any of a plurality of frequencies, means for locally adjusting the operation of said transmitter to any particular frequency, means responsive to signals received by said station for adjusting said transmitter from some remote point to operate on a particular frequency, and means for preventing said remote adjusting means from interfering with the operation of said local adjusting means.

13. A telephone exchange system, including a plurality of subscribers' stations each arranged to receive only at a fixed carrier frequency, this frequency being different for different stations, a common transmission medium extending to each of said subscribers' stations, means whereby a two-way telephone connection may be established over said medium directly between any one and any other of said stations without passing through a central switching office, and manual means at each single station to actuate said establishing means at both stations.

14. A telephone exchange system, including a plurality of subscribers' stations each arranged to receive only at a fixed carrier frequency, this frequency being different for different stations, a common transmission medium extending to each of said subscribers' stations, means whereby a two-way telephone connection may be established over said medium directly between any one and any other of said stations without passing through a central switching office, manual means at each single station to actuate said establishing means at both stations, and means whereby a plurality of such connections may be established and simultaneously maintained between different pairs of stations.

15. A system for telephone communication between any one and any other of a plurality of subscribers' stations, including means at each subscriber's station for transmitting on any of a plurality of frequencies and receiving only on a single different fixed frequency, said receiving frequency being different for each subscriber's station, means at each subscriber's station for establishing direct two-way communication with any other of said stations, and manual means at each single station to actuate said establishing means at both stations.

16. A system for telephone communication between any one and any other of a plurality of subscribers' stations, including means at each subscriber's station for transmitting on any of a plurality of frequencies and receiving only on a single different fixed frequency, said receiving

frequency being different for each subscriber's station, means at each subscriber's station for establishing direct two-way communication with any other of said stations, manual means at each
5 single station to actuate said establishing means at both stations, and means whereby a plurality of such communications may be carried on simultaneously between different pairs of stations.

17. A system for the exchange of intelligence
10 between any one and any other of a plurality of subscribers' stations, including an adjustable transmitting circuit and a fixed receiving circuit both at each subscriber's station, means at each station to adjust the adjustable transmitting cir-
15 cuits at that station and selectively at another station for direct communication therewith, and means to notify any station of said system that any desired frequency is in use.

18. A system for the exchange of intelligence
20 between any one and any other of a plurality of subscribers' stations, including an adjustable transmitting circuit and a fixed receiving circuit both at each subscriber's station, means at each station to adjust the adjustable transmit-
25 ting circuits at that station and selectively at another station for direct communication therewith, and means whereby a plurality of such communications may be carried on simultane-
30 ously between different pairs of stations at different frequencies.

19. A system for the two-way exchange of intelligence between any one and any other of a plurality of subscribers' stations, each subscriber's station having assigned thereto for com-
35 munication of intelligence in one direction a fixed frequency which is different from that of other subscribers' stations and being adapted to use a variable frequency for communication of intelligence in the opposite direction, each sub-
40 scriber's station having means whereby when it is a calling station it may be adjusted to utilize the fixed frequency assigned to the called subscriber's station, each subscriber's station also having means whereby when it is a calling sta-
45 tion it may control the adjustment of the called subscriber's station to utilize the fixed frequency assigned to the calling subscriber.

20. A system for the exchange of intelligence between any one and any other of a plurality of
50 subscribers' stations, each subscriber's station having assigned thereto for receiving purposes a fixed frequency which is different from that of every other station and being adapted to use a variable frequency for transmitting, each sub-
55 scriber's station having means whereby when it is a calling station it may be adjusted to utilize the receiving frequency assigned to the called station, each subscriber's station also having means whereby when it is a calling station it
60 may control the adjustment of the called subscriber's station to utilize the receiving frequency assigned to the calling subscriber's station.

21. A system for telephone communication between any one and any other of a plurality of
65 subscribers' stations, said system comprising a common transmission medium extending to each of said subscribers' stations, means whereby said transmission medium may be utilized simul-
70 taneously for a plurality of telephone connections directly between any one and any other of said subscribers' stations in pairs over different frequency bands, said means comprising a selec-

tive circuit of fixed frequency for receiving at each station and a selective circuit of adjustable frequency for transmitting at each station, means at each one station to adjust the circuits
5 of the adjustable frequency at that one station and also at one other station selectively, and means to notify any subscriber's station of said system that a desired frequency band is in use.

22. A telephone exchange system, comprising a plurality of radio telephone stations each ca-
10 pable of transmitting on any of a plurality of carrier frequencies and receiving on a fixed carrier frequency different for each station, means whereby a plurality of simultaneous two-way
15 telephone communications may be effected directly between any one and any other of said stations in pairs on the fixed carrier frequencies for receiving each way with adjustment thereto
of the corresponding transmitting frequencies, and means to notify any station of said system
20 that any desired carrier frequency is in use.

23. The method of attuning two of a large number of numbered stations for signaling be-
tween them which consists in making code im-
25 pulses at one station according to the call number of that one station, and thereby adjust-
ing apparatus at the other station to the same frequency as apparatus at the said one station.

24. In a system of numbered signaling stations each adapted to operate at a frequency value in
30 simple relation to its call number, the method of bringing one station to the same frequency as another which consists in making code im-
pulses at one of two stations involved according
35 to the call number of that one of the two stations, and thereby adjusting the frequency at the other station to a value corresponding to that number.

25. In combination, means to make code im-
40 pulses at one station corresponding to the call number of said one station of a plurality of more than two stations, and means controlled thereby to adjust the frequency of apparatus at another
station selectively to match the frequency of
45 apparatus at the said one station.

26. The method of selectively attuning two stations at one of them for two-way communica-
tion which consists in making code impulses at the one station according to the call number of
50 the other station and thereby adjusting the frequency of transmitting apparatus at the one station to match the frequency of receiving ap-
paratus at the other station, and sending code
55 impulses of the one station to the other station and thereby adjusting the frequency of transmitting apparatus at the other station to match the frequency of receiving apparatus at the one station.

27. Transmitting apparatus and receiving ap-
60 paratus at each of a plurality of more than two signaling stations, one apparatus at each station being adjustable as to frequency and the other employing a fixed frequency, means at each station as a calling station to adjust the fre-
65 quency of its adjustable apparatus to match the frequency of the fixed frequency apparatus of any one other station as a called station, and means also at such calling station to adjust the
frequency of the adjustable apparatus of the
70 called station to match the frequency of the fixed frequency apparatus of the calling station.

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