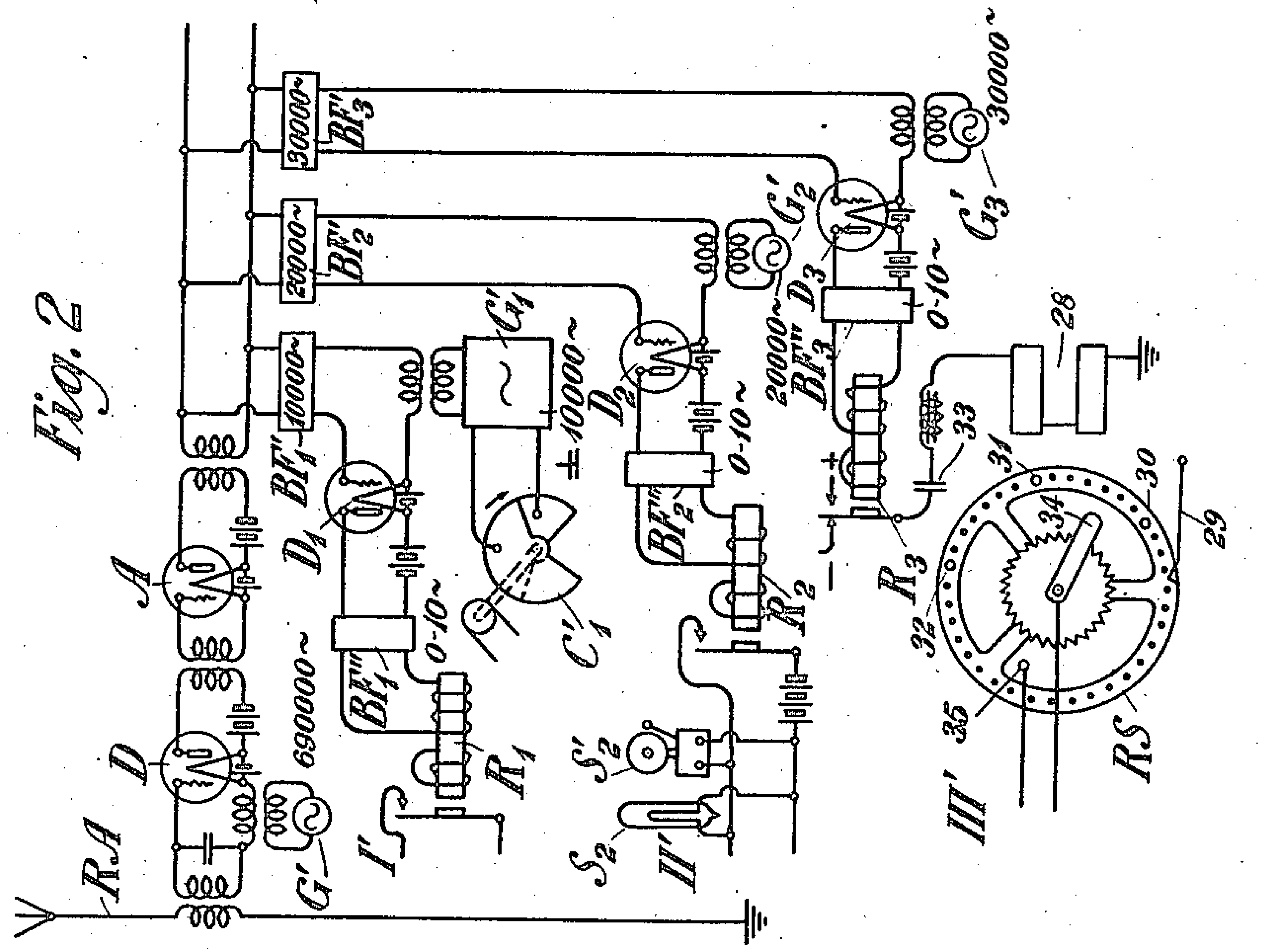
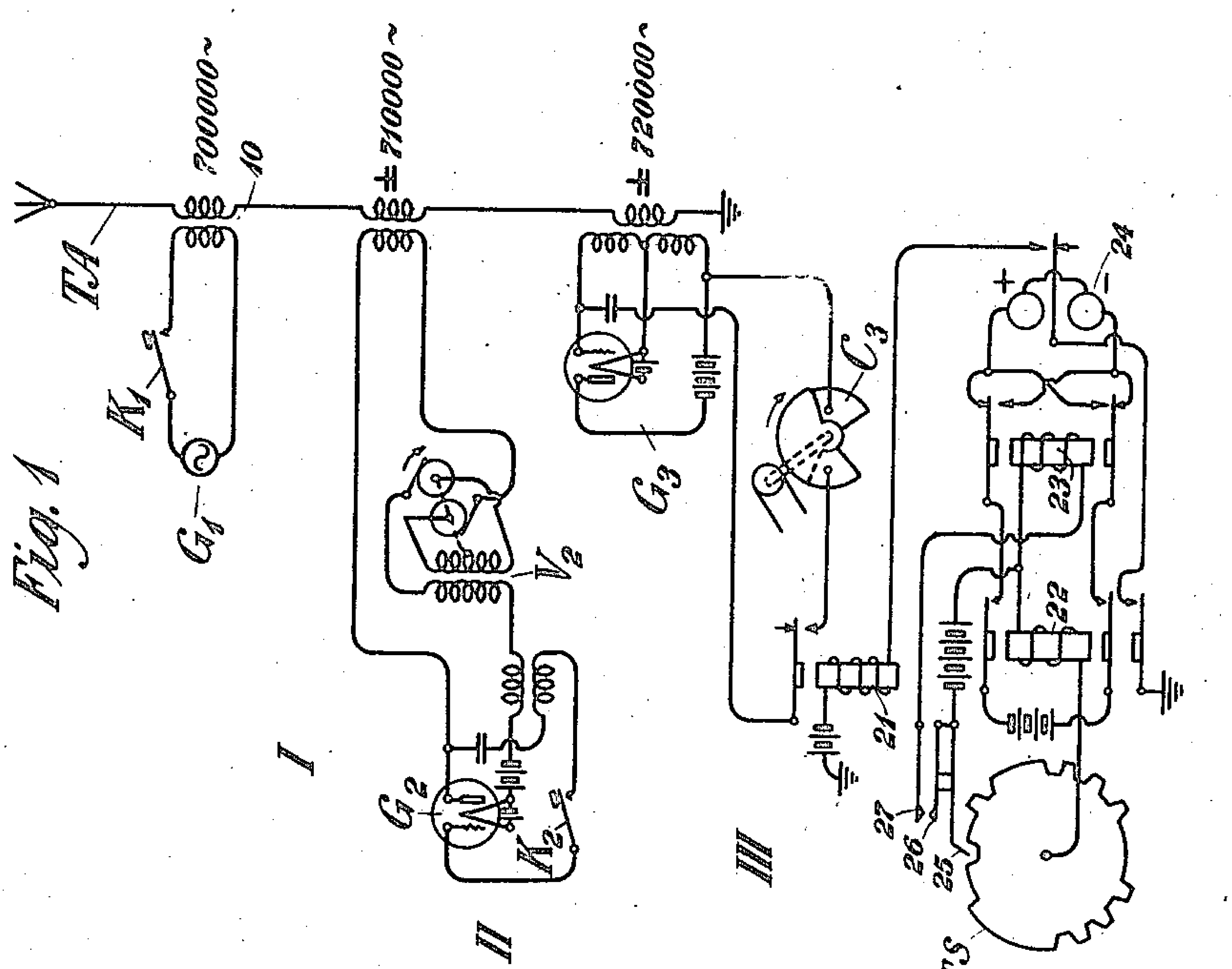
Aug. 14, 1923. 1,464,565

L. ESPENSCHIED ET AL

CALL SYSTEM FOR RADIOTELEPHONY

Filed April 13, 1921 3 Sheets-Sheet 1





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Filed April 13, 1921 3 Sheets-Sheet 2

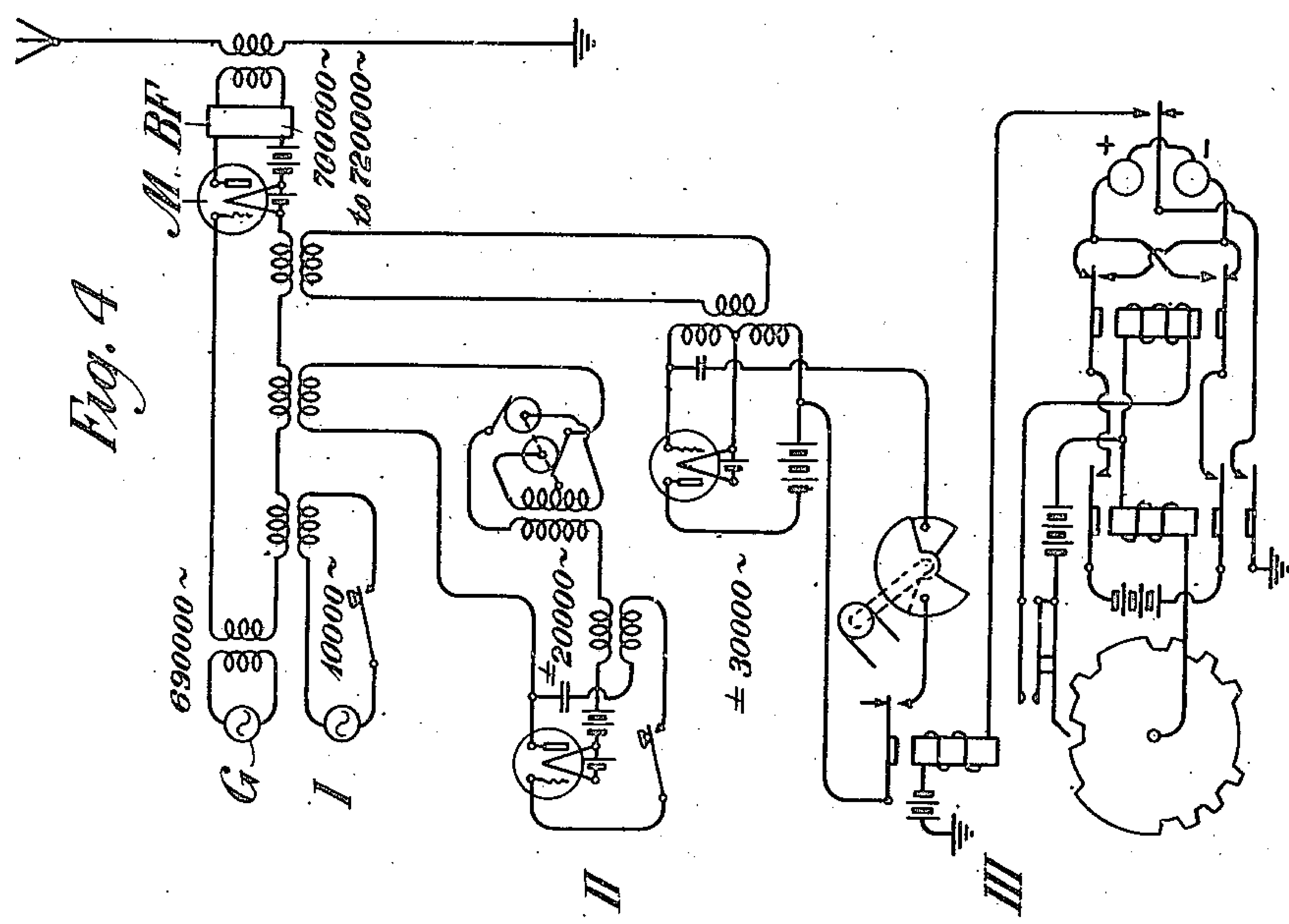

Fig. 4

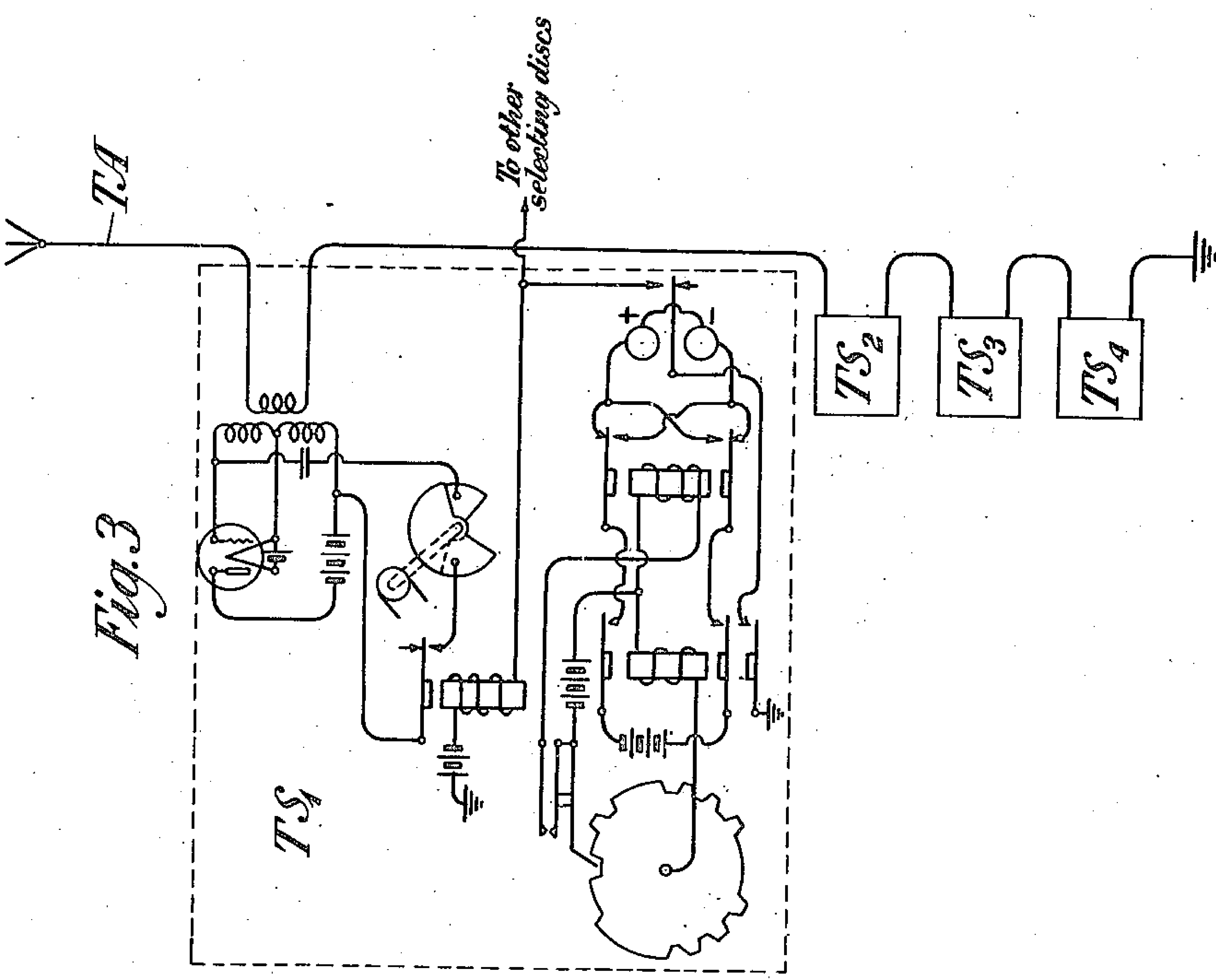

Fig. 3

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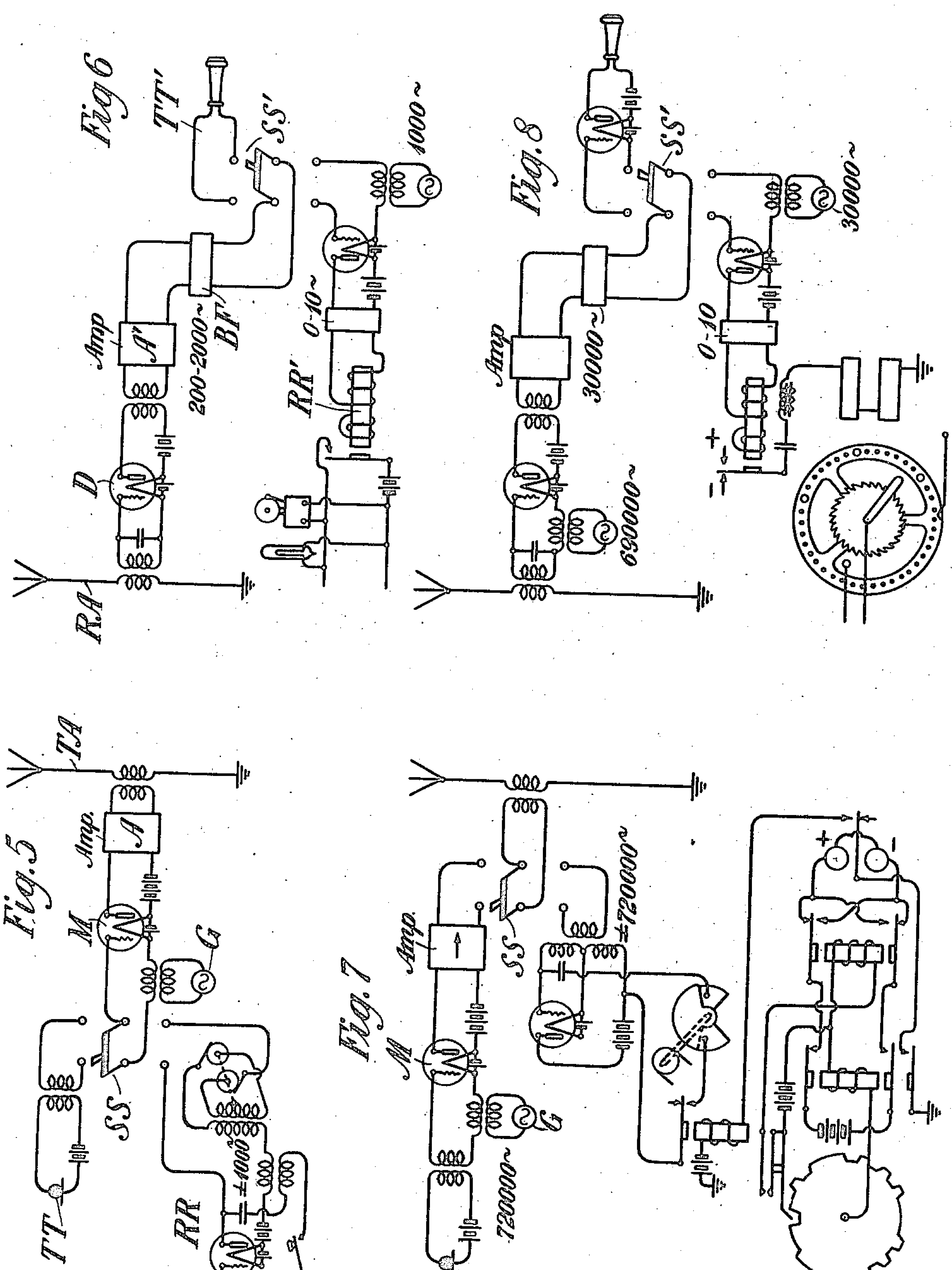
3 Sheets-Sheet 3



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Patented Aug. 14, 1923. 1,464,565

UNITED STATES PATENT OFFICE.

LLOYD ESPENSCHIED, OF QUEENS, NEW YORK, AND RALPH BOWN, OF EAST ORANGE, NEW JERSEY, ASSIGNORS TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

CALL SYSTEM FOR RADIOTELEPHONY.

Application filed April 13, 1921. Serial No. 460,869.

To all whom it may concern:

Be it known that we, Lloyd Espenschied and Ralph Bown, residing at Queens and East Orange, in the counties of Queens and Essex and States of New York and New Jersey, respectively, have invented certain Improvements in Call Systems for Radio-telephony, of which the following is a specification.

This invention relates to a system for the remote control of mechanism by radio transmission, and more particularly to the application of such remote control to signaling or ringing systems for use in connection with radio telephony.

In accordance with the present invention, the devices to be remotely controlled are made extremely selective for the purpose of preventing interference due to static or other disturbances, and in order to insure the uniformity of operation of the remotely controlled devices, special means are provided to prevent uncertainty of operation due to the extreme selectivity employed.

In practicing the invention as applied to a signaling or ringing system for radio telephony, for example, a signal frequency is generated at the transmitting station and transmitted to the receiving station, at which point it coacts with a locally generated frequency. The ringing mechanism at the receiving station is operated only in the event the difference between the local and incoming frequencies is less than a few cycles per second. In order to insure that this condition will be realized, one of the frequencies is caused to vary slowly over a range sufficient to include any variations which may occur in the other frequency.

One difficulty encountered in the practical development of a suitable ringing system for radio telephony resides in the fact that, owing to the extreme sensitivity of the receiving ringing apparatus to be employed, the apparatus is liable to produce false alarms, due to static or other interferences. In order to meet the requirement of freedom of interference, it is proposed to take advantage of the slow speed nature of the calling or ringing channel by working near the limit of this condition. This is accomplished by reducing to a minimum the frequency band to which the receiving ringing apparatus is made selective, the selectivity of such receiving apparatus being carried to an extreme. In this way, the amount of interfering energy obtained in the very narrow band of a few cycles per second, for example, is made very small, and by concentrating all of the transmitter energy in this very narrow band, the ratio of desired to undesired energy is made very large.

This introduces an undesirable factor, due to the difficulty encountered in maintaining frequency agreement between the transmitted energy and the frequency admitted by the receiving system. This difficulty is overcome in accordance with the present invention by continually varying up and down in the frequency range over a band lying within the corresponding transmitted telephone band, either the transmitting frequency or the beating frequency at the receiving station. This results in bringing the two frequencies into periodic agreement and the circuit may be so arranged that each time frequency agreement is obtained, energy is applied to the receiving ringing apparatus or other remotely controlled device.

A further degree of selectivity and insurance against interference is obtained by rendering the operation of the receiving system reliant upon a certain predetermined time element, such as a certain number of successive impulses. This predetermined time element may also be utilized in connection with coding and code selecting terminal apparatus for selective signaling of any one of a number of receiving stations from a given transmitting station.

The invention may now be more fully understood by reference to the following detailed description, when read in connection with the accompanying drawing.

In the drawing, Figure 1 is a simplified circuit arrangement of a transmitting station, illustrating three forms of transmitting channels which may be employed; Fig. 2 is a corresponding receiving circuit illustrating three forms of receiving apparatus; Fig. 3 illustrates a transmitting station adapted for selectively calling any one of a number of receiving stations; Fig. 4 is a transmitting circuit arrangement similar to that of Fig. 1, but differing therefrom in that successive modulating steps are utilized in generating the signaling frequencies; Figs. 5 and 6 are simplified diagrams of transmitting and receiving stations arranged for radio telephonic transmission and for the transmission of ringing signals in connection with the telephone system; Figs. 7 and 8 are similar diagrams but differing from Figs. 5 and 6 in that a mechanically selective calling device is employed.

Referring to Figs. 1 and 2, TA is a transmitting antenna with which are associated three transmitting channels I, II and III, while RA represents a corresponding receiving antenna having associated therewith corresponding receiving channels I′, II′ and III′.

The simplest form of transmitting apparatus for highly selective remote control is that shown in connection with channel I, which consists of a generator G_1 generating some suitable radio frequency as, for example, 700,000 cycles, said generator being coupled with the antenna TA through a transformer 10. A key K_1 is provided for controlling the application of energy from the generator to the transmitting antenna.

At the receiving station, a detector D is coupled with the receiving antenna. This detector may be of any well-known type, but for purposes of illustration, is shown as a vacuum tube detector. A local source of beating energy G′ is provided, said source being associated with the input circuit of the detector D. This source may have any desired frequency so chosen that the difference between the received frequency and the local frequency will be comparatively small. In the case illustrated, the beating frequency is 690,000 cycles. An amplifier A, of any well-known type, is associated with the output circuit of the detector D, this amplifier being, in the case illustrated, a vacuum tube amplifier. The output circuit of this amplifier is associated with the several selective receiving channels.

The receiving channel I′, corresponding to the transmitting channel I, includes a band filter BF_1' for selecting the difference frequencies in the neighborhood of 10,000 cycles, said filter being associated with the input circuit of a detector D_1. The detector D_1 may also be supplied with energy from a local source G_1', the frequency of which will also be in the neighborhood of 10,000 cycles. The frequency of the generator G_1' may be caused to vary over a narrow range, sufficient to include any possible variation of the generator G_1 at the transmitting station. This is accomplished, for example, by means of an adjustable capacity C_1', arranged to determine the frequency of the generator (which may be of the well-known vacuum tube type) in a well-known manner. The capacity C_1' may be periodically varied by mechanically rotating its plates with respect to each other, as indicated schematically in the drawing. The detector D_1 detects a frequency corresponding to the difference between the step-down receiving frequency passed through the band filter BF_1' and the frequency supplied by the generator G_1', and this difference may be made quite small if the transmitting and receiving frequencies are properly adjusted. In the output circuit of the detector D′ a band filter BF_1'' is provided, this band filter being rendered selective to an extremely narrow band of frequencies, extending for example, from zero to 10 cycles per second. Each time the frequency of the generator G_1' is cyclically varied, the received and locally generated frequencies will be periodically brought into harmony, so that a frequency variation extending from zero to 10 cycles per second will be passed through the filter BF_1''. A receiving relay R_1 is provided on the output side of the filter, this relay being slow-acting so that its armature will be held up so long as its winding is energized by successive pulses corresponding to the cyclic variation of the frequency of the generator G_1'. The relay R_1 may be made to operate any desired form of translating device.

In the case of the transmitting and receiving channels just described, the cyclic frequency variation is introduced at the receiving station. In many instances it may be preferable to introduce this variation at the transmitting station, and the channels II and II′ are accordingly so arranged. The transmitting channel II includes a vacuum tube generator G_2 having a variometer V_2 in its plate circuit for controlling the frequency supplied by the generator. The variometer V_2 comprises two windings, one of which may be mechanically rotated with respect to the other, thereby changing the inductance in the plate circuit. If the movable winding be mechanically rotated at a given speed, a corresponding cyclic variation will be produced in the frequency generated by the generator G_2. The corresponding receiving channel includes a band filter BF_2', a detector D_2, a band filter BF_2'' in the output circuit of the detector and a receiving relay R_2. The detector D_2 is supplied with a locally generated frequency from a source G_2'. The channel II′ differs from the receiving channel I′ in that the generator G_2 in this instance is not cyclically varied. As indicated, the receiving relay R_2 is utilized to operate a lamp S_2 or a ringer S_2'.

Assuming that the generator G_2 is designed to generate frequencies in the neighborhood of 710,000 cycles, each time the key K_2 is closed, the generator will become active and will generate oscillations whose frequency will undergo a cyclical change determined by the variometer V_2. At the receiving station, the cyclically varying frequency will beat with the locally generated frequency of 690,000 cycles to produce a difference frequency in the neighborhood of 20,000 cycles. The cyclically varied difference frequency will be selected by the band filter BF_2' and applied to the detector D_2. By beating with the locally generated frequency of 20,000 cycles, a difference frequency varying from zero to a few cycles per second will appear in the output circuit of the detector D_2 and successive pulses of current corresponding to the cyclical variations of the frequency transmitted through the band filter BF_2'' will energize the sluggish relay R_2 to close and maintain closed the signaling circuit as long as the key K_2 is operated.

Transmitting channel III and receiving channel III′ illustrate the use of a mechanical selecting device in connection with the general type of signaling channel previously described. The channel III includes an oscillator G_3 which may be of the vacuum tube type and is arranged to generate any desirable carrier frequency. In the case illustrated, the frequency generated is in the neighborhood of 720,000 cycles but may be periodically varied by means of an adjustable condenser C_3 so arranged that its capacity may be periodically varied by some suitable mechanical means. The circuit of the generator G_3 is arranged so that code signals may be transmitted under the control of a relay 21, which is in turn controlled by a code sending apparatus of some well-known type. For purposes of illustration, a code sender of the type illustrated in the patent to Field, No. 1,343,256, of June 15, 1920, is schematically indicated in the drawing. As the mechanical details of this code sender are somewhat complicated and an understanding of these details is not necessary to a complete understanding of the present invention, the apparatus is not illustrated in detail and will not be described in detail. The code sender comprises a transmitting disc TS having a toothed periphery adapted to engage with contact springs whereby a battery controlling relay 22 and a pole changing relay 23 may be operated. The relays 22 and 23 are arranged to transmit positive and negative impulses to polar relay 24 under the control of the disc TS. When the disc is in normal position, the contact 25 is disengaged therefrom and contacts 26 and 27 are opened so that relays 22 and 23 are deenergized. As soon as the disc is rotated in a counter-clockwise direction, the spring 25 rides upon the periphery of the disc, thereby completing a circuit through the spring 25 and the body of the disc to energize the relay 22. The circuit of the relay 22 remains closed throughout the rotation of the disc until the disc again assumes its normal position, when the circuit will be again opened. During the time that the relay 22 is energized, it connects battery to the circuit of the polar relay 24. The springs 26 and 27 control the circuit of the pole changing relay 23 and these springs are so set that when the spring 25 is riding over the surface of the disc, springs 26 and 27 will be maintained open, except during the times that the spring 25 is riding over the upper surface of the toothed portion of the periphery of the disc. Consequently, the springs 26 and 27 open and close the circuit of the relay 23 as the spring 25 rides up and down over the teeth in the periphery of the disc.

The code transmitted may consist of a series of groups of positive and negative impulses, each group being separated by impulses of longer duration. Various combinations of the groups of impulses may be made. The particular disc illustrated is designed to transmit a code consisting of a group comprising a positive impulse, a negative impulse and a positive impulse followed by a prolonged negative impulse, another group comprising a positive, a negative, a positive, a negative, a positive and a negative followed by a prolonged positive impulse, and the final group comprising a negative, a positive, a negative, a positive, a negative and a positive followed by a prolonged negative impulse. The purpose of the last prolonged negative impulse is to provide a ringing interval at the receiving station, as will be described later. At the end of the ringing interval another positive impulse is transmitted to restore the selected selector at a distant receiving station. The polar relay 24 responds to the positive and negative impulses transmitted to open the circuit of the relay 21 for a negative impulse and to close the circuit for a positive impulse. Consequently, the generator G_3 will transmit groups of high frequency oscillations during the continuance of each positive impulse and each group of high frequency oscillations will cyclically vary in frequency under the control of the capacity C_3. During the continuance of the negative impulses, the generator G_3 will be inactive.

At the receiving station, the channel III′ includes a filter BF_3' for selecting the proper difference frequency, a detector D_3 supplied by a locally generated beating frequency of the same order as the selected difference frequency, a filter BF_3'' for selecting the low detected frequency in the output circuit of the detector D_3, and a receiving relay R_3 arranged to respond to the groups of oscillations in a manner similar to the relays previously described. The relay R_3 controls a mechanical receiving selector RS, which may be of any well-known type, but as schematically illustrated, comprises a selector of the type illustrated and described in the patent to Field, previously referred to. This type of selector includes a rotatable disc adapted to be stepped by a polar magnet 28. The polar magnet controls an apparatus whereby the disc of the receiving selector is stepped forward one step for each positive and each negative impulse, regardless of its length. The mechanical details whereby this result is accomplished are not illustrated, but are fully described in the patent to Field above referred to. The armature of the polar magnet 28 has a normal neutral position and when the armature is in the neutral position, the disc will be free to return to its normal position under the influence of a spring (not shown) unless the disc is maintained in the position to which it is stepped by the engagement of a latch 29 with one of the pins 30, 31 or 32, located by the periphery of the disc. A condenser 33 is included in the circuit of the polar magnet 28, which circuit is controlled by the receiving relay R_3. Consequently, the polar magnet 28 responds to each positive and negative impulse to step the disc one step. When a prolonged impulse, either positive or negative, occurs, however, the condenser 33, which is charged at the beginning of the prolonged impulse, permits current to flow through the windings of the polar magnet and causes the disc to take a corresponding step, but the condenser discharges before the end of the prolonged impulse and consequently, the armature of the polar magnet will be permitted to resume its neutral position. The pins 30, 31 and 32 will be differently arranged about the peripheries of the various selecting discs at different stations so that during the prolonged impulse following the first group of impulses all of the discs will be permitted to return to normal except those having pins 30 so arranged as to engage with the latch 29. In response to another group of positive and negative impulses followed by a prolonged impulse, the various selecting discs will be further advanced and of those which are advanced, only those will remain in advanced position which have pins 31 engaging with latches such as 29 during the prolonged impulses. This results in certain of the discs, which had previously remained advanced, being restored to normal. At the end of the last group of impulses followed by a prolonged impulse, only one disc will remain advanced, as only one disc will have a pin 32 so situated as to engage with the latch 29. Each disc carries a contact arm 34 so arranged as to make a contact with the segment 35 when that particular disc is advanced the right number of steps, and when a disc is advanced so that its pin 32 is in engagement with the latch 29, a transmitting circuit to actuate some receiving or other device will be closed. The disc illustrated in Fig. 2 has its pins 30, 31 and 32 so arranged that it will be selected when the transmitter TS shown in Fig. 1 is actuated. During the prolonged interval following the last group of impulses, the disc remains with the wiper 34 in contact with the segment 35 so that the ringing or other signal circuit will remain closed. At the end of this prolonged impulse, a restoring impulse will be transmitted which will step each selector one additional step, and at the end of this step, all of the discs will be restored. The selected disc will obviously be restored by reason of the fact that there will be no pin in position to engage with the latch 29 while the armature of the magnet 28 is in neutral position.

The operation is as follows: When the transmitting disc TS is rotated, the spring 21 rides up over the periphery of the disc, which energizes relay 22 to connect battery to the polar relay 24 during the complete rotation of the disc as previously described. The springs 26 and 27 will be opened until the first tooth is reached, and consequently, during this period the relay 23 will be deenergized so that the polar relay 24 will shift its armature in the positive direction, thereby energizing the relay 21 over a circuit including the contact of the polar relay and the lower make contact of the relay 22. The circuit of the generator G_3 is, therefore, closed, and during the continuance of this impulse a group of cyclically varying high frequency oscillations are transmitted to the receiving station. At the receiving station, the high frequency group of oscillations is stepped down by means of the detector D to a frequency in the neighborhood of 30,000 cycles, which is selected by the band filter BF_3' and applied to the detector D_3 to beat with the oscillations from the local source G_3 of 30,000 cycles frequency. During each cyclic variation a low frequency pulse is transmitted to the receiving relay R_3 as already described, and a number of these pulses will be transmitted for each direct current signal impulse transmitted by the disc TS. The relay R_3, being sluggish, remains energized during the continuance of this pulse and sends a positive pulse through the windings of the magnet 28 to step the disc RS one step. The spring 25 then rides over the first tooth and during this period the springs 26 and 27 are closed to energize the relay 23 which shifts the battery connected to the poles relay 23 and sends a negative impulse through said polar relay. Consequently, the circuit of the generator G_3 is opened and at the receiving station the relay R_3 will be deenergized to transmit a negative impulse through the stepping magnet 28 to advance the disc RS another step. Another positive impulse is now transmitted, stepping the disc RS a third step, this pulse being followed by a prolonged negative impulse due to the disc TS. During the prolonged negative impulse, no oscillations are transmitted and the relay R_3 remains deenergized, so that a negative impulse is transmitted to the magnet 28 and the disc RS advances a fourth step. During the continuance of this negative impulse, the magnet 28 is deenergized, due to the discharge of the condenser 33, and its armature assumes its neutral position. The disc RS at the desired station, however, will remain in its advanced position for the reason that pin 30 will be so positioned as to engage with the latch 29 at this time.

Another group of positive and negative impulses will be transmitted by the disc TS followed by a prolonged positive impulse occurring while the spring 25 is riding over the portion of the periphery of the disc at the bottom thereof. The high frequency oscillations are accordingly transmitted during the continuance of this prolonged positive impulse and the relay 23 will remain energized during this period, transmitting a positive pulse through the magnet 28. Owing to the condenser 33, this pulse is only effective upon the magnet 28 for an instant, after which the armature assumes its neutral position. The second group of impulses transmitted, however, results in bringing the pin 33 into position to be engaged by the latch 29. During the continuance of this prolonged pulse, other discs, not having pins so situated, will be restored to normal. A third group of positive and negative impulses is now transmitted, followed by a prolonged negative impulse. This results in stepping the disc RS to a position where the pin 32 engages with the latch 29 during the prolonged negative impulse, and consequently, the switch arm 34 is is contact with the segment 35 during the continuance of this impulse, and the signal will continue until the end of this impulse, which is followed by a positive impulse. The positive impulse restores the advanced selector to normal by stepping it forward an additional step so that no pin will be in position to engage the latch 29. At the end of this positive impulse, the spring 25 rides off of the periphery of the disc into the notch illustrated at the top of the disc, and the disc comes to rest.

The circuit of the relay 22 is at once broken and while the armature of the polar relay 24 will remain in its positive position, tending to close the circuit of the relay 21 and continue the transmission of high frequency oscillations, this result will be defeated by the opening of the circuit of the relay 21 at the lower armature of the relay 22, this armature falling off as soon as the spring 25 falls into the notch at the top of the disc.

Fig. 3 illustrates a sending station provided with a plurality of selective transmitters for selectively signaling any one of a plurality of receiving stations, each of which may be presumed to have selective receiving signaling channels such as channel III′ of Fig. 2. In this figure the transmitting antenna TA has associated therewith a plurality of transmitting senders TS_1, TS_2, TS_3 and TS_4, all of which, except the sender TS_1, are merely indicated conventionally. The sender TS_1 may be taken as illustrative of all four of the senders and is of the same general character as the sender illustrated in connection with channel III′ of Fig. 1. The nature of this apparatus and its method of operation will be clear from the preceding description of the apparatus of Fig. 1 and no further description is deemed necessary. When it is desired to signal the given receiving station, the selector disc, arranged to transmit the proper combination of impulses to properly actuate the corresponding receiving selector, will be rotated and the station having the proper receiving selector will be signaled to the exclusion of all of the other stations. A plurality of selectors may also be arranged to transmit at the same carrier frequency by connecting them in parallel in the frequency changing circuit as indicated by the multiple lead for sender TS_1.

Fig. 4 illustrates an arrangement having a plurality of transmitting channels I, II and III, similar to those illustrated in Fig. 1. The arrangement of Fig. 4 differs from that of Fig. 1, however, in that the frequencies initially generated in the three channels will be relatively low and will modulate by means of a modulator M a radio frequency supplied by a generator G. The generator G, for purposes of illustration, may generate frequencies of 690,000 cycles. The channel I is shown as generating 10,000 cycles, which, by modulation with the frequency of the generator G, will produce a sum frequency corresponding to the 700,000 cycles. The corresponding difference frequency will be eliminated by the band filter BF. Similarly, the generator of the channel II will generate oscillations in the neighborhood of 20,000 cycles, which, combined with the frequency from the generator G, will produce sum frequencies in the neighborhood of 710,000 cycles. Likewise the generator associated with the channel III is illustrated as transmitting oscillations in the neighborhood of 30,000 cycles, which will combine with the oscillations from the source G to produce sum frequencies in the neighborhood of 720,000 cycles.

The band filter BF is arranged to select the upper side frequencies in each instance and its cut-off points may, therefore, be so chosen as to be just below 700,000 cycles and just above 720,000 cycles. It will be seen that the frequencies radiated by the antenna from the several channels will be the same as those in Fig. 1, and the station will, therefore, co-operate with the receiving apparatus of Fig. 2, and its operation in such connection will be obvious without further description.

Figs. 5 and 6 illustrate respectively transmitting and receiving apparatus for radio telephonic communication and auxiliary apparatus for transmitting a ringing signal. At the transmitting station, a modulator M is provided, having a switch SS in its input circuit, whereby the modulator may be connected either to the circuit of a telephone transmitter TT or to the circuit of a ringing transmitter RR. The modulator M is provided with carrier oscillations from a suitable source G and includes an amplifier A in its output circuit. The apparatus RR, for transmitting a ringing signal, comprises a generator and variometer similar to those of the channel II of Fig. 1. The generator of the apparatus RR is preferably arranged to generate a frequency within the audible limit, as, for example, a frequency in the neighborhood of 1,000 cycles. At the receiving station, a detector D is provided for detecting from the received high frequency oscillations either the low frequency telephonic signals or the frequency in the neighborhood of 1,000 cycles from the sending station. An amplifier may be associated with the output circuit of the detector and a filter BF provided for the purpose of selecting low frequency signaling currents, either telephonic or ringing, to the exclusion of high frequency currents. A switch SS′ is associated with the output circuit of the filter for connecting it to either the receiving telephone apparatus TT′ or the receiving ringing or signaling apparatus RR′. The signaling apparatus comprises a detector, a low pass filter and a slow-acting relay for controlling the ringer or other form of signal as described in connection with channel II′ of Fig. 2. The detector has associated with its input circuit a source generating a frequency in the neighborhood of the frequency employed for transmitting ringing signals. In the case given, this frequency may be 1,000 cycles.

If the operator at the station of Fig. 5 desires to telephone to the operator at the station of Fig. 6, the switch SS will first be thrown to its lower position connecting the ringing apparatus to the input circuit of the modulator M. By throwing the key associated with the generator, a frequency in the neighborhood of 1,000 cycles will be generated. This frequency will be cyclically varied by the variometer and impressed on the modulator M with the frequency from the generator G. The carrier frequency from the generator G is accordingly modulated with the signaling frequency and after being amplified is transmitted to the receiving station, where the detector D detects the varying frequency corresponding to that generated by the generator at the transmitting station. This frequency is amplified by the amplifier A′, passed through the filter BF′ and over the switch SS′ (which will normally be in its lower position) to the receiving signaling apparatus. The cyclically varying frequency in the neighborhood of 1,000 cycles will beat with the locally generated frequency of 1,000 cycles to produce low frequency beats which will operate the receiving relay to in turn actuate the ringer or other responsive device. The operator at the station at Fig. 6, upon perceiving the signal, will throw the switch SS′ to its upper position to connect the telephone receiver to the detector circuit and the operator at the sending station, after having transmitted the ringing signal, will throw the switch SS′ to its upper position to connect the telephone transmiter to the modulator. The operator, in speaking into the transmitter, will cause the carrier frequency generated by the generator G to be modulated in accordance with telephonic currents, which will be transmitted to the receiving station and detected by the detector D. The telephone waves, after being detected, will be amplified and passed through the filter BF′ to the receiver TT′.

Figs. 7 and 8 illustrate respectively transmitting and receiving radio telephone sets provided with ringing or signaling devices arranged for code signaling. The code signaling apparatus will be similar to that previously described and no further description of the apparatus is, therefore, deemed necessary. In operating, the operator will throw the switch SS to its lower position, the switch SS′ at the receiving station being normally in its lower position. The code signaling apparatus is then operated to transmit a code signal in a manner practically identical to that described in connection with the channel III of Fig. 1, and the signal will be received by the receiving signal apparatus at the station of Fig. 8 in a manner similar to that described in connection with the channel III′ of Fig. 2. After the signal has been transmitted, the switches SS and SS′ will be thrown to their upper positions and telephone variations may be transmitted by modulating the carrier frequency supplied to the modulator M from the generator G. The receiving operation will be the same as that of Fig. 6.

It will 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. The method of distant control which consists in transmitting high frequency energy from the transmitting station, receiving said high frequency energy at a receiving station, beating the received energy with a locally supplied frequency to produce a difference frequency, and periodically varying at a sub-audible rate one of said frequencies over a range such that the two frequencies will coincide at periodic intervals.

2. The method of distant control which consists in generating at a transmitting station energy varying periodically at a sub-audible frequency, transmitting said energy of said periodically varying frequency to a receiving station, receiving said energy at a receiving station, and beating it at the receiving station with a locally supplied frequency to produce a periodically varying difference frequency whose variations extend over a very narrow range.

3. The method of distant control, which consists in transmitting high frequency energy from a transmitting station, receiving said high frequency energy at a receiving station, beating said received energy with a locally supplied frequency to produce a difference frequency, periodically varying one of said frequencies at a sub-audible rate over a range such that the two frequencies will periodically coincide, whereby the difference frequency will vary from zero to a low maximum frequency, selecting a narrow band from said difference frequencies including the zero difference frequency, and impressing said narrow band upon a translating device.

4. The method of distant control which consists in generating at a transmitting station energy of periodically varying frequency, transmitting said energy of periodically varying frequency to a receiving station, receiving said energy at said receiving station, beating said energy at the receiving station with a locally supplied energy to produce a periodically varying difference frequency varying from zero to a low maximum frequency, selecting a narrow band from said difference frequencies including the zero difference frequency, and impressing said narrow band upon a translating device.

5. The method of distant control which consists in transmitting high frequency energy from a transmitting station, receiving said energy at a receiving station, successively beating the received energy with locally supplied frequencies, periodically varying one of the frequencies at a sub-audible rate whereby the difference frequencies finally produced will periodically vary over a narrow range from zero to a low maximum frequency.

6. The method of distant control which consists in transmitting high frequency energy from a transmitting station, receiving said energy at a receiving station, successively beating the received energy with locally supplied frequencies, periodically varying one of the frequencies at a sub-audible rate, whereby the difference frequencies finally produced will periodically vary over a narrow range from zero to a low maximum frequency, selecting a narrow band from said final difference frequencies including the zero difference frequency, and impressing said narrow band upon a translating device.

7. The method of distant control which consists in generating at a transmitting station energy of periodically varying frequency, transmitting said energy of periodically varying frequency to a receiving station, receiving said energy at said receiving station, successively beating the received energy at the receiving station with a locally supplied frequency to produce a final difference frequency which periodically varies over a narrow range extending from zero to a low maximum frequency.

8. The method of distant control which consists in generating at a transmitting station energy of periodically varying frequency, transmitting said energy of periodically varying frequency to a receiving station, receiving said energy at said receiving station, successively beating the received energy at the receiving station with a locally supplied frequency to produce a final difference frequency which periodically varies over a narrow range extending from zero to a low maximum frequency, selecting a narrow band from said difference frequencies including the zero frequency, and impressing said narrow band upon a translating device.

9. The method of distant control which consists in generating high frequency energy at a transmitting station, controlling said high frequency energy in accordance with a predetermined code combination, transmitting said energy to a receiving station in accordance with said code combination, subjecting the received energy to a beating action with at least one locally supplied frequency, periodically varying one of said frequencies at a sub-audible rate over a range such that a final difference frequency will be produced which periodically varies over a narrow range extending from zero to a low maximum frequency, said difference frequencies having impressed thereon the predetermined code combination, and reproducing from the narrow band of difference frequencies the code combination.

10. The method of distant control which consists in generating at a transmitting sta-

tion energy periodically varying at a sub-audible frequency, controlling the said periodically varying energy in accordance with a predetermined code combination, transmitting said controlled periodically varying frequency energy to a receiving station, subjecting said energy at the receiving station to a beating action with at least one locally supplied frequency to produce final periodically varying difference frequencies whose variations extend over a very narrow range from zero to a low maximum frequency, said final band of difference frequencies having said code combination superposed thereon, and reproducing from the narrow band of difference frequencies the code combination.

11. The method of distant control which consists in generating energy periodically varying at a sub-audible frequency within the audible range at a transmitting station, controlling the said periodically varying frequency energy in accordance with signals, modulating carrier frequency energy in accordance with said periodically varying frequency energy, transmitting the modulated carrier frequency energy to a receiving station, stepping-down the received frequency at said receiving station to a point within the voice range, and beating the stepped-down periodically varying frequency with a locally supplied frequency energy lying within the limits of said periodic variations, and reproducing from the resultant difference frequencies the signals imposed upon the periodically varying frequency at the transmitting station.

12. In a signaling system, a transmitting station, a receiving station, means for generating high frequency energy at said transmitting station, means for transmitting said high frequency energy to the receiving station, means to beat the received energy with at least one locally supplied frequency at the receiving station, means for periodically varying one of the frequencies at a sub-audible rate, thereby producing a final difference frequency which periodically varies over a narrow range from zero to a low maximum frequency, a responsive device at the receiving station, and a selecting apparatus to prevent the transmission to said responsive apparatus of final difference frequencies exceeding a predetermined low maximum frequency.

13. In a signaling system, a transmitting station, a receiving station, means to generate energy of periodically varying high frequency at the transmitting station, means to transmit said energy of periodically varying frequency to the receiving station, means at the receiving station to beat the energy of periodically varying received frequency with at least one locally supplied frequency to produce a periodically varying difference frequency extending over a range from zero to a low maximum frequency, a responsive device at the receiving station, and selective means to prevent the transmission to said responsive device of final difference frequencies higher than a pre-assigned low maximum frequency.

14. In a signaling system, a transmitting station, a receiving station, means at said transmitting station for generating high frequency energy, means for controlling the said high frequency energy in accordance with a code combination, means for transmitting said high frequency energy to the receiving station, means at said receiving station for beating the received energy with at least one locally supplied frequency, means to periodically vary one of said frequencies at a sub-audible rate whereby the final difference frequencies will periodically vary over a narrow range from zero to a low maximum frequency, a responsive device for reproducing from said final difference frequencies the code combination originally transmitted at the sending station, and selective means for preventing the transmission to said responsive device of final difference frequencies higher than a pre-assigned low maximum frequency.

15. In a signaling system, a transmitting station, a receiving station, means for generating high frequency energy periodically varying at a low frequency rate at said transmitting station, means for controlling the said periodically varying energy in accordance with a code combination, means for transmitting said energy to the receiving station, means at said receiving station to beat the received energy with at least one locally supplied frequency, thereby producing a final difference frequency periodically varying over a narrow range from zero to a low maximum frequency and having superposed thereon the code combination transmitted at the transmitting station, a responsive device at the receiving station for reproducing from the final difference frequencies the code combination superposed thereon, and selective apparatus for preventing the transmission to said responsive device of difference frequencies higher than a pre-assigned low maximum.

16. In a signaling system, a transmitting station, a plurality of receiving stations, means to produce energy of periodically varying frequency at said transmitting station, a plurality of code senders at the transmitting station, one corresponding to each receiving station, means whereby the generation of said energy of periodically varying frequency may be controlled by any one of said code senders to superpose code combinations thereon, means to transmit said energy of periodically varying frequency to each receiving station, means at each re-

ceiving station to beat the received energy with at least one locally supplied frequency, thereby producing final difference frequencies which periodically vary over a narrow range extending from zero to a low maximum, code selectors at each receiving station, each code selector being responsive to the code combination of a corresponding code transmitter at the receiving station, devices at each receiving station responsive to the final difference frequencies for operating said code selector, and selective means at each receiving station for preventing the transmission to said responsive means of final difference frequencies greater than a pre-assigned low maximum.

17. In a signaling system, a transmitting station, a receiving station, means at said transmitting station to generate energy of periodically varying frequency within the voice range, means to generate voice waves, a modulator supplied with carrier frequency energy, means to transmit to said modulator either said energy of periodically varying frequency or said voice waves, whereby the carrier frequency energy may be modulated in accordance with either the periodically varying frequency energy or the voice waves, means to transmit the modulated carrier frequency energy to the receiving station, means at the receiving station to detect the modulations from said carrier, a telephone receiver, a demodulator, means to apply energy of the detected modulating frequencies to said telephone receiver and to said demodulator, a beating frequency supplied to said modulator, said beating frequency lying within the range of the periodic variations in the audible frequency generated at the transmitting station, a responsive device, and means to prevent the transmission to said responsive device of difference frequencies appearing in the output circuit of said demodulator and lying above a pre-assigned low maximum frequency.

In testimony whereof, we have signed our names to this specification this 12th day of April, 1921.

LLOYD ESPENSCHIED.
RALPH BOWN.