Aug. 15, 1933. O. ORTNER ET AL 1,922,711

REMOTE CONTROLLING PLANT

Filed June 26, 1930 5 Sheets-Sheet 1

Fig.1.

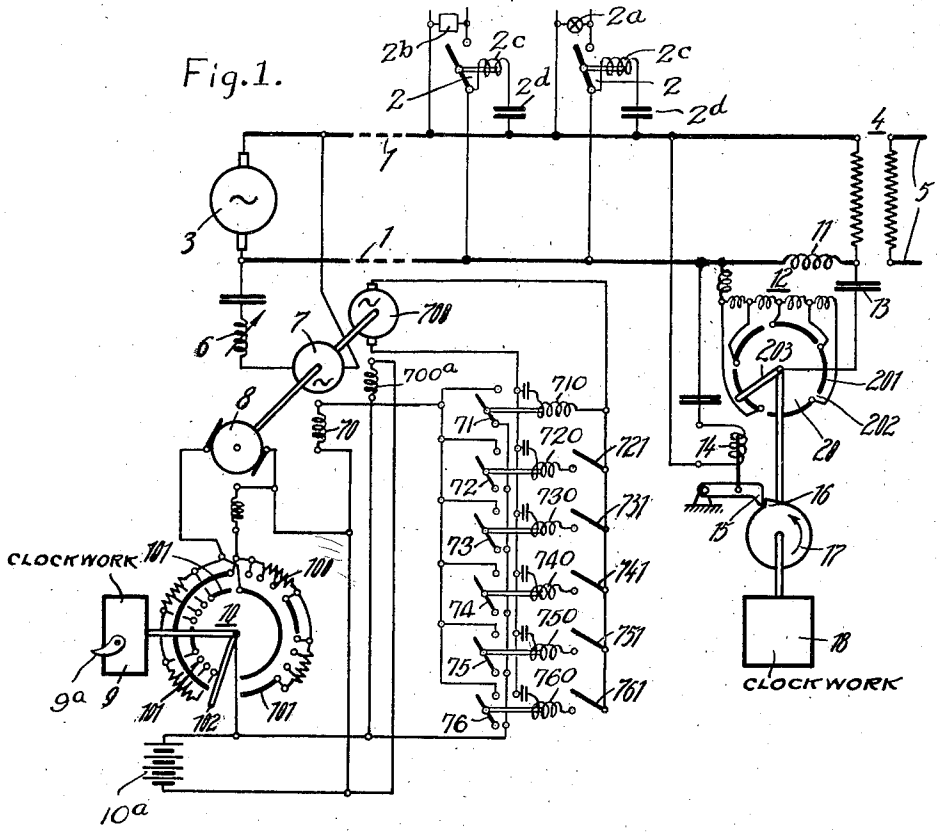
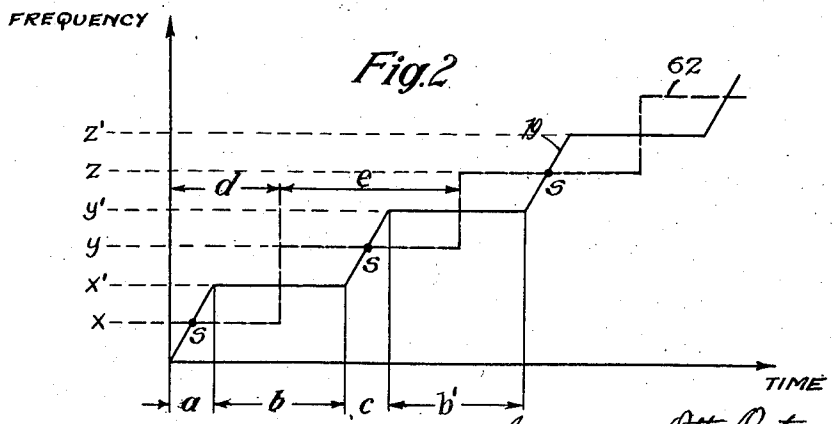


Fig.2



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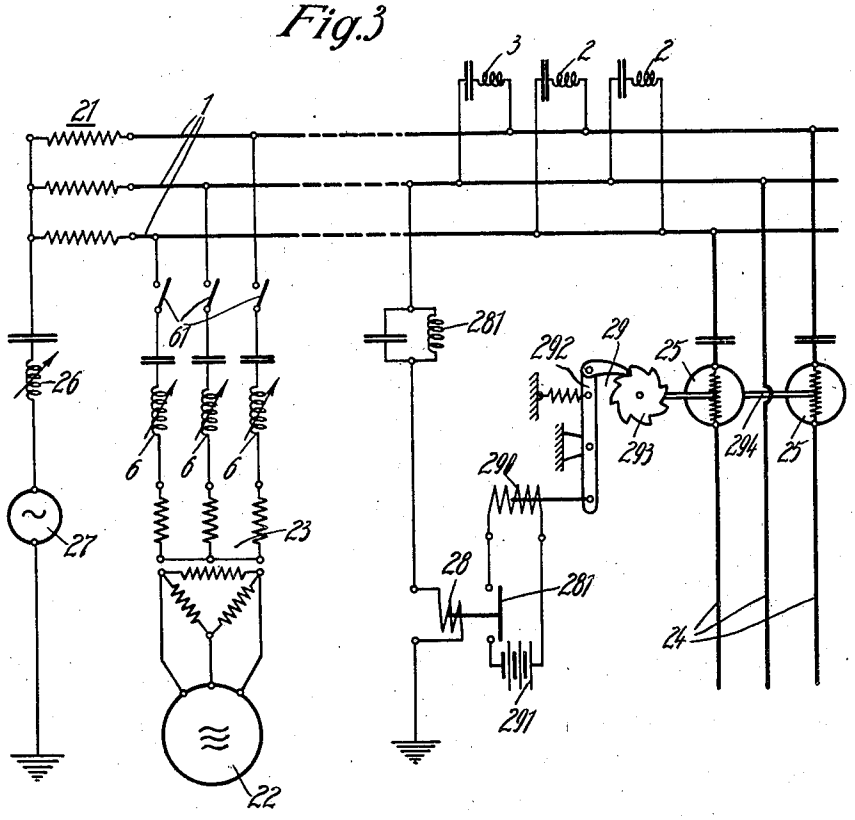
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Aug. 15, 1933. O. ORTNER ET AL 1,922,711

REMOTE CONTROLLING PLANT

Filed June 26, 1930 5 Sheets-Sheet 2

Fig.3



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Aug. 15, 1933. O. ORTNER ET AL 1,922,711

REMOTE CONTROLLING PLANT

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Fig. 4

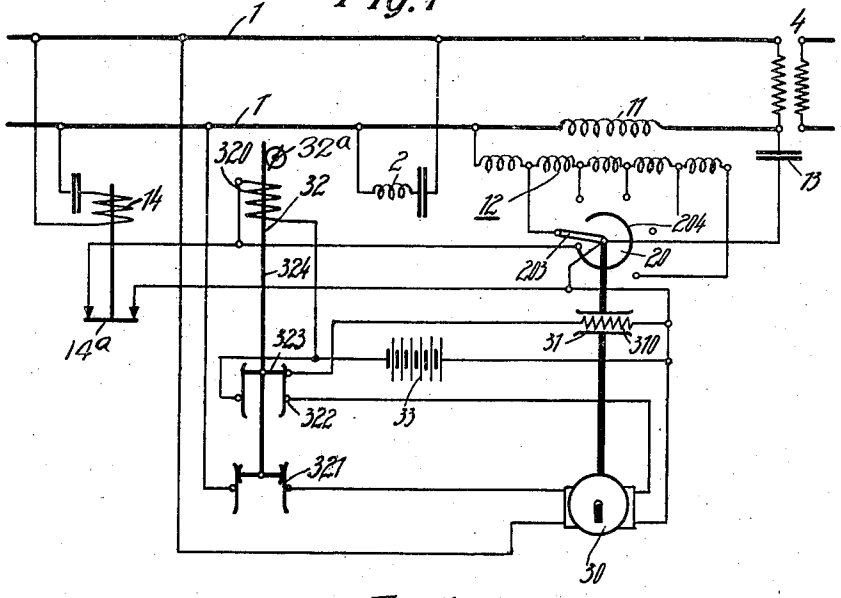
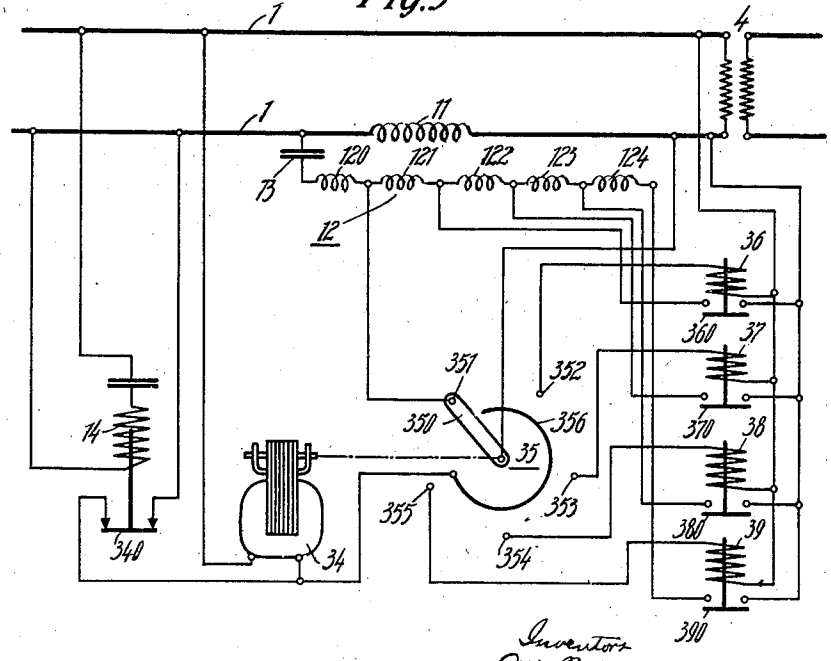


Fig. 5



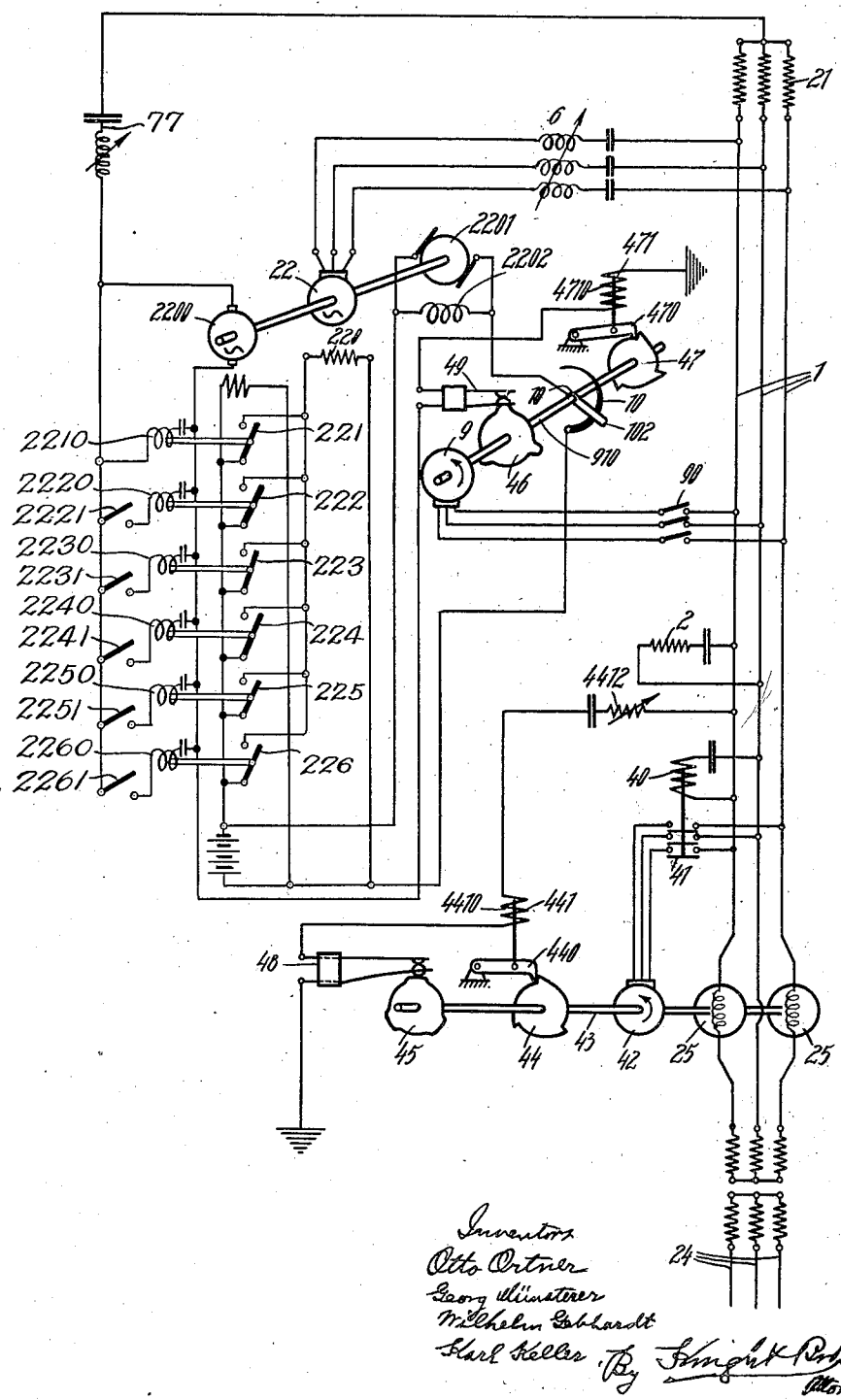
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REMOTE CONTROLLING PLANT

Filed June 26, 1930 5 Sheets-Sheet 4

Fig.6



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REMOTE CONTROLLING PLANT

Filed June 26, 1930 5 Sheets-Sheet 5

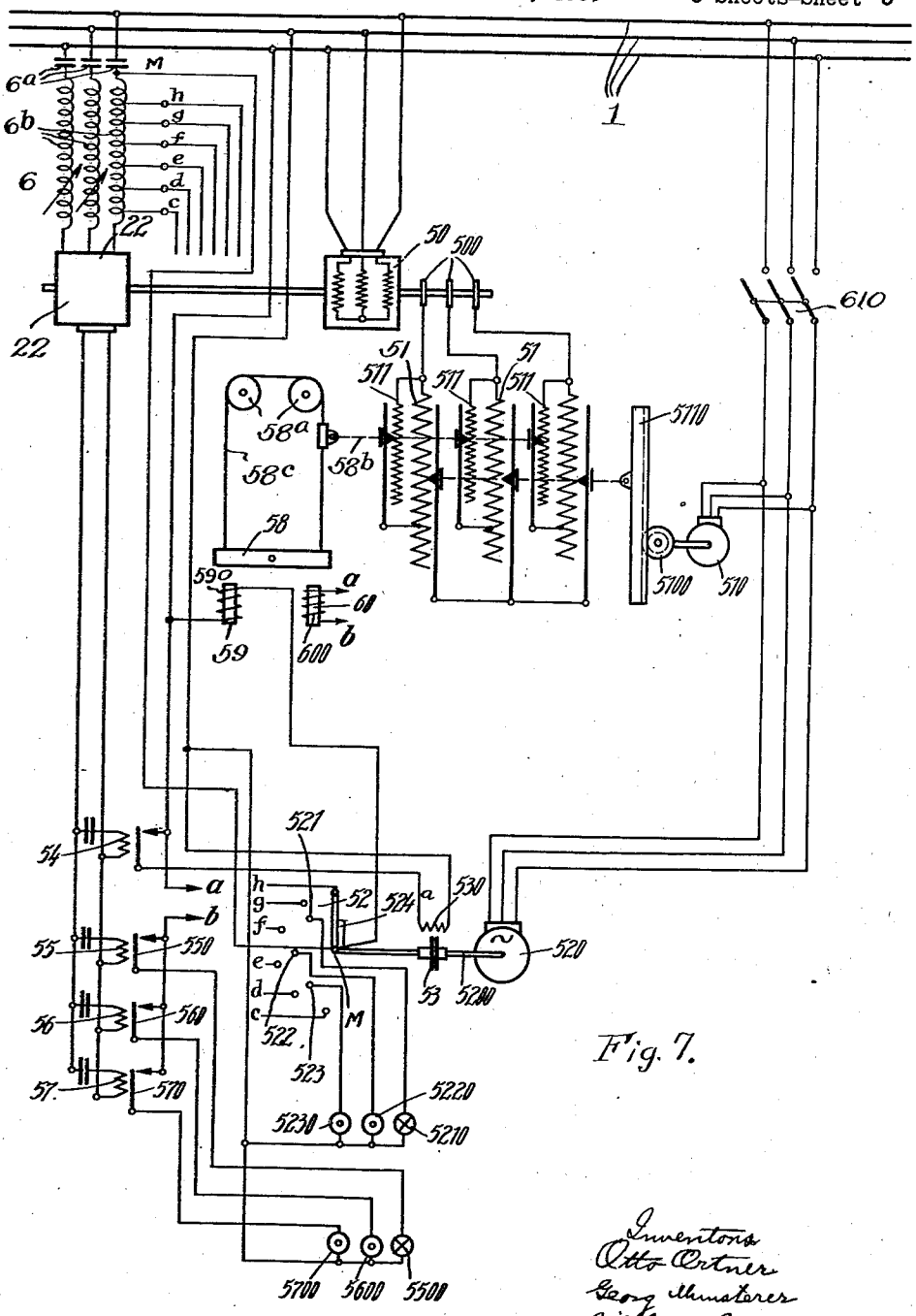


Fig. 7.

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Patented Aug. 15, 1933

1,922,711

UNITED STATES PATENT OFFICE

1,922,711

REMOTE CONTROLLING PLANT

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Application June 26, 1930, Serial No. 464,018, and in Germany July 5, 1929

12 Claims. (Cl. 171—97)

Our invention relates to remote control systems for the remote control of switches, rate meters, clocks or the like from a central point by way of existing line conductors through which from such central point electric power of any form is supplied for other purposes. In systems of this character control currents of a certain selected frequency—different from the frequency of the power current flowing in the line—are superposed upon the line and thereby conducted to correspondingly tuned receiving devices which by way of switching devices or other means known in the art actuate the devices to be controlled.

In particular the invention relates to remote control systems in which control current of audible frequencies are superposed upon the conductors of a heavy current distributing system, and in which the correspondingly tuned receiving devices are connected directly to the line conductors.

In such remote control systems it frequently becomes necessary to block certain sections of the power current system against the passage of the control currents, maybe in order to avoid unnecessary losses of control energy, maybe in order to separate these blocked line sections in order not to disturb the function of other control currents superposed upon the blocked section or sections from other control centrals. For blocking such line sections it has been proposed to use so-called blocking or absorption circuits which consist of a fixed inductance connected into the power line at the blocking point, and of a condenser connected in parallel to the inductance. Such a circuit has, however, a blocking effect only for currents of the frequency to which it is tuned.

It is usually necessary in such control systems to use a number of different control frequencies, for instance for turning on and off street lighting systems, or lighting systems for whole buildings, or for changing the rate of current meters for day and night use, and other objects subject to control in such systems.

One object of the invention is to provide an arrangement by which also in case of a number of different control frequencies a complete blocking of the line section to be isolated is attained.

Another object of the invention is to provide a blocking arrangement which, while effective for a number of different frequencies, will not cause an unduly high voltage drop of the service current in addition to its natural voltage drop.

It is possible to use, for blocking a line section or district, a single blocking or absorption circuit which before the superposition of a specific control frequency is tuned to this particular frequency. Difficulty has been encountered heretofore in such cases to tune the blocking circuit to the prevailing control frequency at the right moment, in particular in cases where the line conductor itself has been used for conveying the control energy to the tuning device for the blocking or absorption circuit, for instance in the manner of providing a relay at the blocking point tuned to that particular frequency, which relay will, on transmission of this particular frequency over the line, tune the blocking circuit to this frequency. It frequently happens in such arrangements that the first control impulse sent in this manner will affect a differently tuned blocking circuit and is apt to flow through it into the blocked line section. Only after the tuned control relay has completed the tuning of the blocking circuit to the particular control frequency to be sent, will the blocking be completed. In the meantime, however, the control impulse which had accidentally escaped into the blocked line section might have already caused disturbances in that section.

It is the principal object of the invention to provide an arrangement according to which the blocking element, while it is connected into one or several of the many line conductors at the blocking point, is free from the last-mentioned defects. The particular object of the invention is to avoid in such cases a separate conductor for controlling the tuning device for the blocking circuit.

The invention is illustrated in the accompanying drawings in which a number of modifications are illustrated, in diagrammatic fashion, and the manner in which our invention may be reduced to practice.

In these drawings:

Fig. 1 shows a remote control system in which controlling currents are superimposed upon an electric power transmission system and in which a part of the power system is blocked by means of a resonant circuit, tunable from the sending station and connected in series with the wire of the power system at the blocking point.

Fig. 2 represents a graph, illustrating the frequency-time characteristic of a device for regulating the frequency of the sender and the device for regulating the blocking circuit.

Fig. 3 shows a system provided with a separate circuit for the currents serving to control the blocking circuits.

Figs. 4 and 5 represent blocking arrangements

in which the regulation of the blocking circuits begins only after all the driving machines for the regulation begin to run in perfect synchronism.

Fig. 6 shows an arrangement in which the frequency regulator at the sending point and the tuning device at the blocking point are each provided with a stopping device in order to equalize any difference which may occur between the tuning of the blocking circuit and the frequency of the sender, and

Fig. 7 shows an arrangement which continuously or in steps supervises, by means of the frequencies produced by the sender, the tuning of the blocking elements to these frequencies.

Referring to Fig. 1, the service current line conductors are supplied with service current by the power generator 3. In this particular case the service line may be composed of two sections which are coupled by means of the transformer 4. The conductors of one line section which happens to be directly connected to the generator 3 are denoted with 1, and those of the other section beyond transformer 4 with 5. It is assumed that in section 1 a number of remotely located devices should be controlled from a point at or near the central station at which generator 3 is located. For this purpose at the different control points relays 2 are connected across the line conductors, which relays are assumed to be tuned to different control frequencies. In order to simplify the diagram only two of these actuating relays 2 are shown. As soon as such a relay is traversed by a current of the frequency to which the relay is tuned, it will actuate the switching or other mechanism for which it is designed, for instance it may actuate a switching device for a street lighting system 2^a, or it may change the rate of metering of a current meter 2^b from the day rate to the night rate. Of course, further relays tuned to other control frequencies may be provided for performing any other function within the scope of such installations. In order to block the power current of the line 1 from these relays, condensers 2^d are arranged in series with the coils 2^c of these relays, the electric values of the coils and the condensers being such that the line power current is prevented from flowing through the relay circuits. At a certain point of the power system 1, controlling currents of certain frequencies produced in control generator 7 are superimposed upon it through the tunable circuit 6, generator 7 being driven by the direct current motor 8 from local source 10^a. This tunable circuit need not be extremely critical, and may in fact be quite broad with respect to the band of control frequencies. Its main purpose is to keep the power line current frequency away from generator 7. The driving motor 8 is controlled by a speed regulator 10, driven by a clockwork 9 and operating in such a manner that when the regulator is put into motion the motor is first started and its speed is then increased through a certain range, whereupon it is finally switched off again. For each period of transmission of control frequencies the regulator 10 makes one revolution. The control generator 7 runs thus through a certain range of frequencies but it produces normally no pressure, its field winding 70 being normally de-energized. The latter may be cut in by closing one of the selector switches 71 to 76. When one of these switches is closed, the control generator 7 impresses, through the tuning circuit 6 which in the meantime has been adjusted for the desired frequency, its voltage at that frequency upon the power system 1.

The selector switches 71 to 76 are, however, only closed each at the occurrence of a certain frequency. The closing is cared for by the corresponding relays 710 to 760, which are tuned each to one of these several frequencies. According to requirement, these relays may, by means of the respective hand switches 721 to 761, be connected to an auxiliary alternating current generator 700 permanently excited by winding 700^a from source 10^a, and also coupled with motor 8, and which produces pressure as soon as it starts running. Only relay 710, which is tuned to a certain suitable preliminary frequency, which as will appear from the following, must of course be lower than all other control frequencies used, is without such a switch. This preliminary control frequency, by which the different devices of the system are prepared, preliminary to receiving the desired control frequency impulse, is termed hereinafter and in the claims shortly "preliminary frequency", as distinguished from the control frequencies by which the actual control of the remote objects is brought about. At each switching operation, during which motor 8 performs a run as described, relay 710 therefore responds first, as soon as generator 700 attains this preliminary frequency, and closes by means of switch 71 the circuit of the exciting winding 70 for the control generator 7 which at that time has attained the same frequency. A preliminary-frequency is, therefore, always first superimposed upon the power system 1 by control generator 7 and an impulse of a different, higher frequency is only superimposed afterward, the value of the frequency depending upon which of the switches 721 to 761 the operator has closed. To this preliminary frequency is normally tuned—i. e. during the intermission between the sending of the actual control frequencies—a tunable absorption circuit, by which the passage of control current of preliminary frequency into the line conductor section 5 behind transformer 4 is blocked. This absorption circuit consists of a fixed inductance 11 connected at the blocking point in series with one of the line conductors, of a tunable inductance 12, and of a condenser 13, coil 12 and condenser 13 being connected to inductance 11, so as to form a tunable absorption circuit. At the blocking point is further connected across the line conductors 1 a relay 14 tuned to the aforementioned preliminary frequency. This relay releases when energized a normally not operating clockwork 18 so that it will start running. For this purpose a cam disk 17 is fixed on shaft 18^a of the clockwork, which normally rests with its cam 16 against pawl 15 which is controlled by relay 14. As soon as the latter is energized by currents of preliminary frequency sent over the line, pawl 15 is raised and releases disk 17 so that the clockwork is free to run. As soon as the preliminary frequency currents stop flowing over the line, which, as will be explained later, may happen immediately after disk 17 has been released, pawl 15 drops back onto the periphery of disk 17, and as soon as cam 16 comes around, it will again abut against pawl 15, and thus the clockwork will be stopped after one revolution of its shaft. With shaft 18^a of the clockwork is coupled a tuning device 20 for coil 12, which device consists of a number of conductive segments 201 insulated from one another and which are connected to the individual sections of coil 12, and of a contact arm

203 fixed on shaft 18a at one end and sliding over segments 201 with its free end. The tuning device is designed so that it tunes the blocking circuit normally—i. e. when the clockwork is at rest—so as to prevent currents of preliminary frequency from flowing into the block section 5. It is further designed so that as soon as relay 14 is actuated by preliminary frequency currents and the clockwork starts to turn arm 203 one revolution, the blocking circuit is tuned successively, at least approximately (say within 10% tolerance), to the different frequencies of the range for which the control system is designed and which generator 7 can send over line 1. At the completion of one revolution the tuning device returns to its normal position in which it is shown in Fig. 1, and in which the absorption or blocking circuit is tuned to the preliminary frequency.

Supposing the operator desires to superimpose a control current of 250 cycles, to which relay 730 may be tuned. He first closes switch 731 for that relay and changes the tuning of circuit 6 from the preliminary frequency to the frequency 250. Then he starts a clockwork 9 by means not shown here in detail, but indicated by a handle 9a, so that regulator 10 will start its one revolution. Thereby motor 8 is started and its speed step by step increased to certain values corresponding to the several different frequencies required in the system, among which would be first the preliminary frequency, and later 250, above referred to. When auxiliary generator 700 has attained the speed at which it generates current at the preliminary frequency, which may be 125 cycles, relay 710 tuned to that frequency first responds and closes switch 71 and, so long as that frequency is maintained, energizes winding 70 of control frequency generator 7, which now sends currents of preliminary frequency over the power line 1 with the effect described before. As regulator 10 is advanced by the clockwork to adjust the motor for the next frequency (which may be 200), relay 710 ceases to respond and opens its switch 71, so that while generator 7 runs at that frequency, it sends no current over the line. Since switch 721 is not closed by the operator, relay 720 which may otherwise respond to the frequency of 200 when auxiliary generator 700 generates current of that frequency, cannot respond, and nothing happens. As now regulator 10 proceeds to the next step, at which motor 8 drives the two generators at a speed for 250 cycles, at which in the present example the operator desires to send control current over the line, the current of that frequency generated by generator 700 finds the 250 cycle relay hand switch 731 closed, and now relay 730 is energized, and closes switch 73 whereby generator 7, also running at that frequency, is energized and now sends 250 cycle current over the line as desired. This current will find the blocking circuit 11, 12, 13 at the blocking point adjusted in the meantime by tuner 20 to absorb currents of that frequency, so that these currents cannot flow beyond that point into the undesired line section 5. Flowing through line section 1, however, they may for instance operate one of the distant relays 2 which may be tuned to that frequency and in responding may for instance switch in lamp 2a. If the speeds of the driving machines such as clockworks 9 and 18 are not exactly the same, it may easily happen that the tuner 20 of the blocking device leads or lags so much with respect to the speed regulator 10 at the sending station that the blocking device is not tuned soon enough or too early to the frequency impressed upon the system. In that case the superimposed controlling energy penetrates into the parts of the power system to be blocked, for instance into part 5 which may be superimposed from other controlling stations, and causes disturbances. If these other parts of the system are not superimposed with control energy from a different station, at least undesirable losses of control energy result in the part to be controlled. To eliminate these difficulties, the control generator 7 is operated with increasing frequency only for a limited length of time when connections are made to the power system, and then operated for a certain length of time at a constant frequency intermediate in value between two control frequencies, and then again for another limited period at increasing frequency (which includes the next control frequency), and so forth. The variable blocking circuits are controlled during these periods also periodically but in opposite sequence, i. e. in the present example during the first period of rising generator frequency, during which it passes through the preliminary frequency, the tuning of the blocking circuit remains constant, namely for blocking the preliminary frequency 125. During the following period of a constant generator frequency, which is of an intermediate value between two control frequencies, and to which none of the relays 710–760 responds, the tuning of the blocking circuit is varied, to block the possibly transmitted next higher control frequency 200. During the next period of rising generator frequency, during which it passes through 200, the tuning of the blocking circuit remains constant at 200, and so forth, the tuning of the blocking circuit always running ahead of the generation of the pertaining generator frequency, until the cycles of the two devices are completed for a signalling period.

In Figure 2 the frequencies of the control generator and of the blocking circuit are jointly plotted against the times during which they are varied and during which they remain constant.

In this figure the heavy line curve 19 is the frequency characteristic of the control generator 7, and curve 62 drawn in dash lines is the frequency characteristic of the blocking circuit. The control generator 7 runs during the time *a* with increasing speed from zero through the preliminary frequency up to an intermediate frequency *x'*. During the time *b*, it maintains that intermediate frequency constant, and during the time *c* it again gradually increases its frequency through the next control frequency *y* to the next intermediate frequency *y'* where it again remains during the next period *b'*, and so forth. This alternate succession of the different operations repeats itself until the end of the entire running time. The blocking circuit is from the beginning and during the time *d* tuned to the preliminary frequency *x*. At the end of this period, and in the middle of period *b* it is tuned by tuner 20 to the first control frequency *y* and remains during the time *e* in this tuned position. In the same manner as the changing over of the blocking circuit tuning from the preliminary frequency *x* to the first control frequency *y* takes place after the period *d*, so also does the changing over to the next higher frequency *z* take place at the end of the period *e* and during the period *b'*. The successive tuning of the blocking circuit is, therefore, like that of the control generator,

performed in steps, but in such tine relation to the generated frequencies, that if both characteristics are plotted to the same scale over one another, the horizontal parts of curve 62 cross the rising parts of curve 19 at about the middle. At the times corresponding to these points S of intersection, the control generator 7 is connected to the power net, and the corresponding control frequency is superimposed on the net. As may be seen from Fig. 2, the blocking circuits are at these times already tuned to the pertaining superimposed frequencies, so that even if there should be an appreciable difference in speed between the driving motor 9 of the frequency regulator 10 at the sending station and the driving motor 18 of the tuning device 20 at the blocking point, the control frequency sent over the line will find the blocking circuit in proper condition to prevent that frequency from passing over into section 5. These oppositely phased characteristics according to the curves 19 and 62 are, for example, obtained by always arranging in the speed regulator or rheostat 10 at the sending station a longer contact 101 at which no change in resistance occurs, to follow a number of short contacts 100 at each of which the resistance varies, and by making at the blocking point in the blocking circuit tuner 20 for coil 12, the length of a contact 201 several times greater than that of the insulation lying between two contacts. Of course, as pointed out hereinbefore, a tolerance, for instance about 10% in the broadness of tuning of all responding devices is provided, alone for the reason that responding relays or the like are hard to manufacture in quantity production so that they would respond exactly to one single frequency only. Thus the intersection points S of the curves in Fig. 2 should not be taken as mathematically instantaneous time values, but as relatively short time values within the admitted tolerance, which would give all devices concerned the required time to act, and which would bring the blocking circuit into effect as soon as the control frequency current arriving at the tuned blocking point comes within the frequency range of the tolerance.

In the example according to Fig. 3, the successive tuning of the blocking circuit is performed by means of a relay connected to an auxiliary circuit.

In this circuit, during the intervals between sending of two control frequencies, a current impulse is sent from the superimposing station, which current impulse puts into action the relay serving to tune the blocking circuits. As an auxiliary controlling current, single-phase alternating current is most suitable. Since the inductive resistances in the conductors of cables and overhead lines are greater with single-phase currents than with polyphase currents, the controlling frequencies may with single-phase current be kept within lower ranges in order to operate under about equally favorable conditions.

In Fig. 3 the net 1, across the wires of which the tuned receiving relays 2 are connected, is fed from the power transformer 21, connected in star. In this figure as well as in the remaining figures the details for throwing the tuned relays into and out of circuit, such as shown in Fig. 1, are not repeated. 22 is a three-phase superimposing control frequency generator, driven from a suitable source such as motor 8 in Fig. 1, this generator being connected to the power system 1 through the impressing transformer 23, the tuning circuit 6 and the switch 61. 24 is a branch circuit of the power system, which is to be blocked against the controlling energy supplied by the generator 22 by means of the blocking circuit 25. The tuning chokes of the blocking circuit 25 consist of coils movable with respect to one another. The neutral point of the transformer 21 is connected to ground, through a tuned connection 26 and which contains the single-phase generator 27, driven in a manner similar to the drive of generator 700 in Fig. 1. At the blocking point 25, the relay 28 and the blocking circuit 281 tuned to the frequency of the power system, are connected between a phase of the system 1 and ground. If the power system has a neutral wire, then the generator 27 and the relay 28 may be connected to the neutral wire instead of to ground. The relay 28 opens and closes a switch 280, which is connected to the local source of current 291 through the winding 290 of the electro-magnetically operated pawl and ratchet device 29. Instead of being connected to an auxiliary source of current, the winding 290 may also be connected to the power system—which latter connection is not shown, being an obvious equivalent. In connection with the movable core of the solenoid 290 is operated through a lever 292, a pawl 29 which engages the teeth of the ratchet wheel 293. Through shaft 294 on which this wheel is mounted the tuning device 25 of the blocking circuit is operated.

The arrangement operates as follows: Simultaneously with superimposing generator 22, the auxiliary generator 27 is put into motion. It is advisable to run the auxiliary generator at a constant frequency. Its excitation is switched in each time the main generator 22 has a certain speed, lying between two control frequencies. The cutting in of the exciting winding of the auxiliary generator 27 may, for example, be performed by means of one of the set of frequency selectors as shown at 721—761 in Fig. 1 for cutting in the exciting winding 70 of the control generator 7. Every time the exciting winding of the generator 27 is cut in, a controlling current is sent into the system through the ground. The controlling current puts the relay 28 into action, which in turn varies the tuning of the blocking circuits 25 one step by means of the ratchet and pawl device 29. The current impulse may be made use of in the same manner for a series of blocking points. The last impulse switches the blocking device back into the original position in which it is tuned to the normal frequency, and cuts off the generator 27, the devices operating similar to the corresponding devices 20 and 10 in Fig. 1.

Instead of using an auxiliary generator, such as 27 in Fig. 3, a phase of the superimposing control frequency generator 22 may be connected between ground and the neutral point, which substitution is an obvious expedient and therefore not illustrated.

In order to bring in the arrangement according to Fig. 1, the driving motors 9 and 18 of the frequency regulator 10 at the sending station and of the tuning device 20 at the blocking point as much as possible to the same speed at the beginning of the sending period, an electro-magnetic coupling, as shown in Fig. 4, may be inserted between the tuning device of the blocking circuit and its driving motor, which electromagnetic coupling is only energized after the driving motors for these devices run in perfect synchronism.

As driving motors, synchronous motors starting as asynchronous motors may be employed, which are switched in and out by a relay tuned to a preliminary frequency. But asynchronous motors of the same construction may also be employed for driving these frequency controlling devices.

In the present example 30 represents a synchronous motor with asynchronous starting of a design well known in the art. In order not to unnecessary complicate the diagram the interior wiring arrangement of this motor has been omitted.

The motor operates, by way of the magnetic coupling 31, the tuner 20 of the variable inductance 12 of the blocking circuit. The primary actuating relay 14 of Fig. 1 which is tuned to the preliminary frequency connects by means of its switch 14^a the winding 320 of a relay switch 32 to a local direct current source 33, by which source also the synchronous winding of motor 30 and the winding 310 of the electromagnetic coupling 31 is supplied with current. Switch gear 32 successively closes switches 321, 322 and 323. By means of switch 321 motor 30 is started asynchronously. After a certain time, determined by the dash pot 32^a control switch 32, motor 30 is changed over to synchronous operation. By means of switches 322 and 323 successively the synchronous winding of the motor and the winding 310 of electromagnetic coupling 31 are connected to the auxiliary current source 31.

The arrangement operates in the following manner: The same as in the modification Fig. 1, the central control point sends by means of the generator, such as 7 in Fig. 1, a preliminary frequency current over the line, to which tuned relay 14 responds. The absorption circuit is normally, i. e. in the position of arm 203 shown, tuned to this preliminary frequency. When relay 14 responds, and while the preliminary frequency currents flow over the line, it connects by way of its switch 14^a the winding 320 of switch gear 324 to battery 33. Switch gear 324 commences its retarded operation and first closes switch 321. This will start motor 30. In the meantime the switch gear 324 has been gradually raised into the position shown, in which the contact bridge of switch 321 has been moved into the uppermost position, so that motor 30 has been switched over for synchronous operation by closing first switch 322, and then as soon as switch 23 is closed, also coupling 31 has been energized. The motor 30 is now coupled to the tuning device 20 of the tuning choke 12. At the sending station (Fig. 1) a synchronous motor would also be used as a driving motor in place of clockwork 9, so that during the actual sending period only very small deviations in the speeds, caused by variations in the friction, produced by heating, or the like are possible. The regulator arm 203 makes one revolution during the sending period. The core of the relay switch 32 is during this time held in the attracted position due to its winding 320 now being connected to the source of e. m. f. 33 through the regulator arm 203 and the contact ring 204. At the end of a sending period the regulator arm 203 moves away from the contact ring 204. The relay switch 32 drops its core and bar 324 and opens the switches 323 and 321.

Instead of a synchronous motor with a winding for starting asynchronously, small synchronous motors (synchronous motors for clocks) which fall into step after a fraction of a second, as shown in Fig. 5, may be used with advantage. The successive switching of the blocking circuit may then be performed by means of relay switches.

In Fig. 5 the connection of clock motor 34 to the a. c. supply is controlled through a switch 340 actuated by the resonant relay 14, which is tuned to the preliminary frequency. Motor 34 drives the switching drum 35, (in the drawings the drive is only diagrammatically shown), through which the relays 36 to 39 are successively energized and de-energized. These relays control respectively the switches 360 to 390. The switching drum 35 makes one revolution during the sending period. In the position drawn, the blocking circuit 11, 12, 13 is tuned to the preliminary frequency. It is connected through the contact 351 and the switch arm 350. When the preliminary frequency is transmitted from the superimposing station, the relay 14 attracts its core, switch 340 is closed and the motor 34 starts running. During the further course of the sending period, the motor remains connected to the power system through the switching drum. While the first control frequency is impressed upon the power system, the contact arm 350 has reached the contact 352. Now relay 36 is energized, attracts its core and closes the switch 360. Thereby the portion 121 of tuning coil 12 is added to 120 as a part of the blocking circuit. While the second control frequency is sent the contact arm 350 has reached the contact 353. The relay 36 has in the meantime become de-energized and has opened its switch 360. In its place the relay 37 is now connected to the power system. It closes its switch 370 and connects into the blocking circuit portions 120, 121, 122 of coil 12. In the same manner, the contacts 354 and 355 are, in accordance with the increasing frequency of the sending generator at the sending station, successively reached by the regulator arm 350 and the portions 123, 124 of coil 12 are thereby inserted into the blocking circuit for tuning purposes. At the end of the sending period the contact arm 350 has completed one whole revolution and returned to the contact 351 on which the blocking circuit is tuned to the preliminary frequency. Arm 350 has at the same time left the contact ring 356, whereby the circuit through motor 34 is interrupted so that it stops running, and arm 350 remains on contact 351. The entire system is now set for a new cycle of operations. Of course, the point at which arm 350 leaves ring 356 is located in reality sufficiently close to the arm position on contact 351, that the momentum of the de-energized motor suffices to move the arm onto the contact.

In the course of operation, it is however possible, owing to the variations in the friction and in the load, for the speeds of the regulator driving motors to vary to such a degree that the positions of the regulating device at the sending station and at the blocking point differ considerably from one another. To avoid these difficulties it is rendered possible, as shown in Fig. 6, to stop the frequency regulator at the sending station and the tuning device at the blocking point at different points of their switching paths, corresponding to certain intermediate frequencies between the actual sending frequencies, until the two regulator levers have re-attained similar positions. The time for a complete cycle of the frequency regulator at the sending station and of the tuning device at the blocking point is, therefore, sub-divided into shorter periods. Thus

the speed of each regulator is repeatedly reduced to zero at uniform intervals. Within these short periods, practically only negligible differences are possible between the regulator positions, so that the frequency impressed upon the power system always finds at the blocking point a resonant circuit tuned to the same frequency.

The same as in the example according to Fig. 3, the power system, across the wires of which the receiving relays 2 are connected, is fed in Fig. 6 by the transformer 21 connected in star. 22 is the three-phase control carrier frequency generator, which is connected through the resonant circuits 6 to the power system 1. 24 is the part of system to be blocked off. The control generator 22 is driven by the electric motor 2201, which has, as in the example according to Fig. 1, a regulator 10 driven by a suitably geared motor 9 and designed similar to Fig. 1 in such a manner that when the regulator is put into motion, the motor 2201 controlled by it is first started and its speed intermittently increased through a predetermined range, whereupon it is switched off again. These details of regulator 10 are omitted in Fig. 6, since they are fully illustrated in Fig. 1. The control frequency generator 22 delivers the desired energy to the power system in the previously described manner when its exciting winding 220 is energized by means of any one of the differently tuned frequency selector relays 2210 to 2260 which control respectively the energizing switches 221 to 226. The individual selectors are controlled by the switches 2221–2261.

The blocking circuit 25 is tuned normally to the preliminary frequency. The starting relay 40 is tuned for that frequency and closes, when responding, the switch 41, whereby a three-phase motor 42 is connected to the power system. Motor 42 is suitably geared (not shown in detail) to a shaft 43 which operates the tuning device of the blocking elements 25. On shaft 43 are also fixed the ratchet disk 44 and cam disk 45. Shaft 910, which is geared to driving motor 9 at a ratio similar to that of shaft 43 to motor 42, carries arm 102 of the frequency regulator 10 at the sending station, and also carries the cam disk 46 and ratchet 47. The teeth of disk 44 on shaft 43, and 47 on shaft 910 engage respectively the pawls 440 and 470, which can be lifted by their pertaining relay 441 and 471. The cams of disks 45 and 46 open and close respectively the contacts 48 and 49. On each of the shafts 43 and 910 the angular or timed relation between a ratchet tooth and a cam is such that a cam will close its pertaining contact first, and immediately thereafter, on slightly further rotation of the shaft, a ratchet tooth will engage the pertaining pawl, unless the latter is lifted. One pole of the auxiliary generator 2200 is, through the tuning device 77, connected to the star-point of the transformer 21; this tuning device is mainly for the purpose of keeping the power current of the line away from generator 2200, its tuning being broad enough however to allow all higher control frequencies to pass. The other pole of generator 2200 is grounded through the contacts 49 and the winding 4710 of relay 471. One end of winding 4410 of relay 441 is, through the blocking circuit 4412 and contacts 48, connected to one lead of the power system 1, and the other end of this winding is connected to ground. Blocking device 4412 likewise allows all control frequencies to pass, but blocks the power current frequency.

The relays for releasing the pawls 440 and 470 are, therefore, fed in series with single-phase current, which, as in the example according to Fig. 3, flows through the wires carrying power current and returns through the ground. To avoid that, owing to unequal voltage drops in the several phases of the system, the single-phase current circulates through the current consumers across the wires of the power system, blocking elements should be inserted in the system, which are tuned to the frequencies of the single-phase current.

As soon as the operator closes switch 90 which starts motor 9 to begin a sending period, preliminary frequency currents are first sent over section 1, to which relay 40 responds by closing switch 41, and now also motor 42 begins to run. The cams of the discs 45 and 46 are arranged in such manner that the contacts 48 and 49 are always closed at the moment when the auxiliary generator 2200 attains a frequency, lying between two sending frequencies. Each of the motors 9 and 42 is, however, arrested by its pertaining pawl 440 or 470 respectively, should one of the cams of its cam disk arrive at the pertaining contact ahead of the time when a cam on the disk driven by the other motor arrives at its pertaining contact. The reason for this is that the two relay coils 441 and 471 and contacts 48 and 49 are connected in series, and unless both contacts are closed simultaneously, the motor whose contact is closed ahead of time is arrested by the pertaining pawl, since no relay current can flow which could lift that pawl. This arrested condition persists until the other motor has caught up and closed, by means of one of the cams on its cam disk, its own contact. Now both contacts are closed and current can flow through both relays, and now both pawls are lifted, the arrested motor is released by its pawl, the other motor which had caught up merely continues running. If both motors are in synchronism, no arresting action at all occurs, because in that case both contacts are closed at the same time, both pawls are lifted at the same time before they can arrest their motor, and both motors continue running. In this manner it is achieved that, when differences occur in the speeds of the regulators at the blocking point and at the sending station, it is impossible for the differences in the tuning to accumulate and to become so great that the blocking circuits are not at least approximately tuned to the frequencies impressed at the moment upon the power system.

It may happen that in remote control systems of the character described, owing to frictional losses, or electrical resistance losses, or load changes, the speed of the driving motors of the system, especially the motor for the generator which furnishes the control currents of different frequency varies within a sending period. In such cases the resonance frequencies as adjusted in the absorption circuit would not fully agree with the frequencies superposed upon the line, so that to a certain extent the absorption circuit loses its blocking effect. According to a further development of this invention, these difficulties are overcome by providing an arrangement which will either continuously or in steps supervise the tuning of the blocking circuits by means of the frequencies emanating from the control station. For this purpose the control element for at least one of the tunable resonance circuits is provided with a number of auxiliary contacts by way of which are connected the signal or indicating devices by which the differences or the agreement in tuning between the circuits and the frequencies generated can be ascertained.

For this purpose we provide a number of auxiliary contacts for the tuned circuits corresponding to the number of differently tuned resonance relays employed at the distant points of the power circuit. There are further provided a number of correspondingly tuned local relays, the resonances of which correspond to the frequencies which the auxiliary contacts adjust at the tuned circuits. These local relays are energized by the different frequency currents produced by the sending or auxiliary generator and release signal devices corresponding to the signal devices connected to the auxiliary contacts. If signal devices of the same kind respond simultaneously, synchronism obtains. If differences occur between the frequency of the generator and the frequency of the resonant circuit, the two auxiliary circuits may be employed for increasing or decreasing the speed of the sending generator.

An arrangement involving these features is shown in Fig. 7. In this figure 22 is the control frequency current generator which is connected to the transmission line 1 by way of the tuned circuits 6. Generator 22 is connected to line 1 in order to send the desired frequency at the proper time in the manner illustrated in Figs. 1 to 6, so that these details are omitted in Fig. 7. In this case generator 22 is driven by means of a three-phase alternating current motor whose speed is regulated through the desired range of frequencies (the same as motor 8 in Fig. 1) by means of a variable resistance 51 connected into its rotor circuit by means of the slip rings 500. Resistance 51 is varied over the desired range during a sending period by means of asynchronous motor 510 which is geared at a suitable ratio (not shown here) by means of pinion 5100 and rack bar 5110 to this resistance, such that generator 22 will assume the different speeds in accordance with the frequencies which it is desired to superpose on the transmission line. The tuned circuits 6 which are located between generator 22 and the transmission line consist for each phase of a condenser 6^a and the inductances 6^b. In this particular modification these resonance circuits 6 do not serve the purpose of preventing the entering of control energy of the desired frequency into the transmission line 1, but the purpose of preventing the line current from entering the windings of the control generator 22. They must thus be tuned during each sending period to the different frequencies to be superposed in such manner that as soon as generator 22 furnishes current into the transmission line the control current of the desired frequency can enter the line unimpeded, and that its value and its phase remain the same for each frequency. For this purpose each of the three tuning coils 6 is provided with a motor operated tuning device whose contacts are connected with corresponding taps provided on the inductances 6. Of course, in case of a three-phase system such as is shown in Fig. 7 each of the tuning circuits 6 is provided with taps, and the taps for each phase lead to an individual contact device. In order not to complicate the wiring in this figure, the taps and the tuning device for only one phase are shown. The contact device is designated with 52 and is driven by motor 520, a suitable gearing being interposed between the motor and the device 52 (not shown) by which the speed of the motor is reduced so that the device 52 performs one revolution within the sending period. The contacts *c* to *h* are connected with the corresponding taps *c* to *h* of tuning coil 6. The connecting lines are only indicated at the tuning coil so as not to complicate the drawing. An electric coupling 53 is provided for tuning device 52 and motor 520. Further, contacts are provided on tuning device 52 which are numbered 521, 522 and 523 which contacts are connected by way of different colored lamps 5210, 5220 and 5230 to one of the transmission line conductors. The contact arm which is driven by motor 520 consists of two superposed elements, a longer one 524 and a shorter one 524^a, separated from one another by an insulating layer. In Fig. 7 these arms are shown side by side. The inner end of arm 524 designated with M is connected by way of a conductor to the point M of the connecting line between the pertaining tuned circuit 6 and the transmission line conductor. The inner end of the shorter arm 524^a, which arm cooperates with auxiliary contacts 521 to 5230 is connected by way of electromagnet winding 590 of magnet 59 to one of the transmission line conductors. A special supply line of single phase alternating current extends from generator 22 to relays 54 to 57 which correspond in number and are tuned to the several frequencies to be sent out by generator 22. The relay 54 is tuned to the preliminary frequency. It closes, when energized, a circuit by which pressure is applied to the magnet winding 530 of the electric coupling 53. Relay 55 is tuned to a frequency, to which the superimposing circuit is tuned by means of one of the contacts *c*—*h*, as soon as the shorter regulator arm 524^a of the tuning device 52 has reached the auxiliary contact 521. In the same manner the relays 56 and 57 are coordinated with the auxiliary contacts 522 and 523 of the tuning device 52. The relays 55, 56, 57 operate the switches 550, 560 and 570, through which the glow lamps 5500, 5600 and 5700 are connected to the net. The glow lamps 5500 and 5210, 5220 and 5660, 5230 and 5700 are pairwise of the same color. In the drawings, crosses, circles and points show the corresponding colors. In parallel to the regulating resistor 51 in the rotor circuit of the driving motor 50 is connected a further fine regulating resistor 511, the resistance of which may be varied by means of the iron armature 58 pivoted midway between its ends. This armature as shown operates, when tilting in one or the other direction, a cord 58^c which is led over two pulleys 58^a. To the cord is attached a bar 58^b which operates resistor 511 in one or the other direction. Opposite one end of the iron armature 58 is the relay 59, and opposite the other end the relay 60. The relay 60 is, at the points marked *a* and *b*, inserted in the common conductor connecting the switches 550, 560, 570 with the net. The preliminary frequency for coupling the regulating motor 520 to the regulating device 52 may also be superimposed upon the power system and taken from the power system for the purposes in question at any desired point.

The arrangement operates in the following manner: The synchronous motors 510 and 520 are started simultaneously by means of a switch 610. The driving motor 50 of the frequency generator 22 gradually increases its speed. As soon as the speed corresponding to the preliminary frequency is reached, relay 54 for the preliminary frequency responds and couples the motor 520 to the regulator arm 524 of the tuning device 52. It is by this means insured that at the

beginning of the regulation the motor 510 and the motor 520 have attained at the start of the period the same speed. As soon as the regulator arm 524a has reached the auxiliary contact 521, the glow lamps 5210 and the relay 59 receive net current. If at this moment the speed of the motor 50 is such that the generator 22 supplies the sending frequency corresponding to the resonant position 521e, relay 55 will respond and close switch 550. Thereby the glow lamps 5500 and the winding 600 of the relay 60 are also connected on to the net. A uniform pull is exerted upon both ends of armature 58, and it therefore does not move. If, for example, the motor 520 has a higher speed than the motor 510, then the regulator arm 524a reaches the auxiliary contact 521 before the relay 55 receives current of the proper frequency to enable it to respond. Therefore, while relay 59 is already energized, tuned relay 55 has not yet closed the energizing circuit through relay 60. Consequently, only relay 59 attracts the left hand end of armature 58 and thereby tilts armature 58 and reduces the fine resistance 511 in the rotor circuit of the driving motor 50. The driving motor 50 is accelerated until the tuning of the superimposed circuit corresponds to the generator frequency. If relay 60 responds before the regulator arm 524a has reached the contact 521, i. e. if the motor 510 leads with respect to the motor 520, then relay 60 is energized before relay 59. Relay 60 attracts the right hand end of armature 58 and, through the rheostat mechanism connected with it, holds back the driving motor 50 until both speeds correspond. The same occurs over again as soon as the regulator arm 524a reaches the contacts 522 and 523. Of course, also the blocking arrangements for the different sections of the power system may be provided with supervising devices such as are shown in Fig. 7 for the sending station of a section. Since, however, the same kind of motors would be used at the blocking station, it is sufficient to provide such devices only at the sending stations.

We claim:

1. In a multi-frequency remote control system the combination of a transmission line, a generator connected to the line at the control transmission point for superposing within a given time period currents of a control frequency, selected out of a number of control frequencies, upon the line, means for controlling said generator to run during said time period through a cycle of different speeds for successively producing the several frequencies, an absorber for said superposed control currents, located at a line point beyond which the control currents are not utilized, a tuning device for said absorber and means for operating said tuning device substantially synchronously with said cyclic generator controlling means for tuning said absorber to the selected control current frequency.

2. In a multi-frequency remote control system the combination of a transmission line, a generator connected to the line at the control transmission point for superposing within a given time period currents of a control frequency, selected out of a number of control frequencies, upon the line, means for controlling said generator to run during said time period through a cycle of different speeds for successively producing the several frequencies, an absorber for said superposed control currents, consisting of at least one capacity and of variable inductances and being located at a line point beyond which the control currents are not utilized, a tuning device for said absorber, and means for operating said tuning device substantially synchronously with said cyclic generator controlling means for tuning said absorber to the selected control current frequency.

3. In a multi-frequency remote control system the combination of a transmission line, a generator connected to the line at the control transmission point for superposing within a given time period currents of a control frequency, selected out of a number of control frequencies, upon the line, means for controlling said generator to run during said time period through a cycle of different speeds for successively producing the several frequencies, an absorber for said superposed control currents, located at a line point beyond which the control currents are not utilized, a tuning device for said absorber, an auxiliary alternating current generator operated synchronously with the first generator, means responsive to the currents of the different corresponding frequencies, produced by said auxiliary generator for controlling the delivery currents of the different corresponding frequencies by the first generator to the line, and means for operating said absorber tuning device substantially synchronously with said generator controlling means for tuning said absorber to the selected control frequency of the generator.

4. In a multi-frequency remote control system the combination of a transmission line, a generator connected to the line at the control transmission point for superposing within a given time period currents of a control frequency, selected out of a number of control frequencies, upon the line, means for controlling said generator to run during said time period through a cycle of different speeds for successively producing the several frequencies, an absorber for said superposed control currents, located at a line point beyond which the control currents are not utilized, a tuning device for said absorber and means for operating said tuning device substantially synchronously with said cyclic generator controlling means for tuning said absorber to the selected control current frequency, said means including a relay connected to the line at the absorption point, and being tuned to at least one of the control frequencies for setting said tuning device in operation.

5. In a multi-frequency remote control system the combination of a transmission line, a generator connected to the line at the control transmission point for superposing within a given time period currents of a control frequency, selected out of a number of control frequencies, upon the line, means for controlling said generator to run during said time period through a cycle of different speeds for successively producing the several frequencies, an absorber for said superposed control currents, located at a line point beyond which the control currents are not utilized, a tuning device for said absorber, an auxiliary alternating current generator operated synchronously with the first generator, means responsive to the currents of the different corresponding frequencies, produced by said auxiliary generator for controlling the delivery of currents of the different corresponding frequencies by the first generator to the line, and means for operating said absorber tuning device substantially synchronously with said generator

controlling means for tuning said absorber to the selected control frequency of the generator, said means including a relay connected to the line at the absorption point and being tuned to at least one of the control frequencies for setting said tuning device in operation.

6. In a multi-frequency remote control system the combination of a transmission line, a generator connected to the line at the control transmission point for superposing within a given time period currents of a control frequency, selected out of a number of control frequencies, upon the line, means for controlling said generator to run during said time period through a cycle of different speeds for successively producing the several frequencies, an absorber for said superposed control currents, located at a line point beyond which the control currents are not utilized, a tuning device for said absorber, an auxiliary alternating current generator operated synchronously with the first generator, relays responsive to the currents of the different corresponding frequencies produced by said auxiliary generator, and means for connecting said relays at will to said generator, switches actuated by said relays for energizing said first generator when it has attained a speed enabling it to deliver into the line currents of the frequency to which the switch actuating relay responds, and means for operating said absorber tuning device substantially synchronously with said generator controlling means for tuning said absorber to the selected control frequency of the generator.

7. In a multi-frequency remote control system the combination of a transmission line, a generator connected to the line at the control transmission point for superposing within a given time period currents of a control frequency, selected out of a number of control frequencies, upon the line, means for controlling said generator to run during said time period through a cycle of different speeds for successively producing the several frequencies, an absorber for said superposed control currents, located at a line point beyond which the control currents are not utilized, a tuning device for said absorber, an auxiliary alternating current generator operated synchronously with the first generator, means responsive to the currents of the different corresponding frequencies, produced by said auxiliary generator for controlling the delivery of currents of the different corresponding frequencies by the first generator to the line, and means for operating said absorber tuning device substantially synchronously with said generator controlling means for tuning said absorber to the selected control frequency of the generator, and means at the absorption point responsive to the several different control frequencies for supervising the synchronous tuning of said absorber in accordance with the prevailing control frequency.

8. In a multi-frequency remote control system the combination of a transmission line, a generator connected to the line at the control transmission point for superposing within a given time period currents of a control frequency, selected out of a number of control frequencies, upon the line, means for controlling said generator to run during said time period through a cycle of different speeds for successively producing the several frequencies, an absorber for said superposed control currents, located at a line point beyond which the control currents are not utilized, a tuning device for said absorber, and a driving motor synchronized with said generator-controlling means for operating said tuning device substantially synchronously with said generator controlling means, for tuning said absorber to the selected generator frequency, a relay connected to the line and being responsive to one of the control frequencies to start said driving motor, and means for stopping said driving motor after the generator has passed through an operating cycle covering the range of frequencies employed in the system.

9. In a multi-frequency remote control system the combination of a transmission line, a generator connected to the line at the control transmission point for superposing within a given time period currents of a control frequency, selected out of a number of control frequencies, upon the line, means for controlling said generator to run during said time period through a cycle of different speeds for successively producing the several frequencies, an absorber for said superposed control currents, located at a line point beyond which the control currents are not utilized, a tuning device for said absorber, and an electric driving motor synchronized with said generator-controlling means for operating said tuning device substantially synchronously with said controlling means for tuning said absorber to the selected generator frequency, a starter for said motor, a relay connected to the line and being responsive to one of the control frequencies and being connected to said starter for starting said driving motor on the response of the relay, and means connected with said starter for stopping said motor after a predetermined period.

10. In a multi-frequency remote control system the combination of a transmission line, a generator connected to the line at the control transmission point for superposing within a given time period currents of a control frequency, selected out of a number of control frequencies, upon the line, means for controlling said generator to run during said time period through a cycle of different speeds for successively producing the several frequencies, an absorber for said superposed control currents, located at a line point beyond which the control currents are not utilized, a tuning device for said absorber and means for operating said tuning device substantially synchronously with said cyclic generator controlling means for tuning said absorber to the selected control current frequency, said means including an auxiliary generator operating at a constant speed and having means for delivering a current impulse of desired frequency into the line between successive frequencies imposed upon the line by said first generator, a relay connected to the line and a local current source controlled by said relay for operating said tuning device one step when said auxiliary generator delivers an impulse into the line, a circuit interposed between said relay and the line and being tuned to the frequency of said auxiliary generator, for tuning said absorber to the frequency of the current next to be delivered by said first generator into the line.

11. In a multi-frequency remote control system the combination of a transmission line, a generator connected to the line at the control transmission point for superposing within a given time period currents of a control frequency, selected out of a number of control frequencies, upon the line, means for controlling said generator to run during said time period through a cycle of different speeds for successively producing the several frequencies, an absorber for

said superposed control currents, located at a line point beyond which the control currents are not utilized, a tuning device for said absorber, said absorber being normally tuned, between control cycles, to a preliminary control frequency produced by said generator, means for controlling said generator to produce and superpose upon the line currents of said preliminary frequency at the beginning of a control cycle, and a relay for said absorber tuned to said preliminary control frequency and adapted when responding to start the operation of said tuning device.

12. In a multi-frequency remote control system the combination of a transmission line, a generator connected to the line at the control transmission point for superposing within a given time period currents of a control frequency, selected out of a number of control frequencies, upon the line, means for controlling said generator to run during said time period through a cycle of different speeds for successively producing the several frequencies, an absorber for said superposed control currents, located at a line point beyond which the control currents are not utilized, a tuning device for said absorber, said absorber being normally tuned, between control cycles, to a preliminary control frequency produced by said generator, means for controlling said generator to produce and superpose upon the line currents of said preliminary frequency at the beginning of a control cycle, and a relay for said absorber tuned to said preliminary control frequency and adapted when responding to start the operation of said tuning device, and means for stopping said tuning device after the completion of a tuning cycle.

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GEORG MÜNSTERER.
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