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D. K. GANNETT

REGULATION OF TRANSMISSION

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2 Sheets-Sheet 1

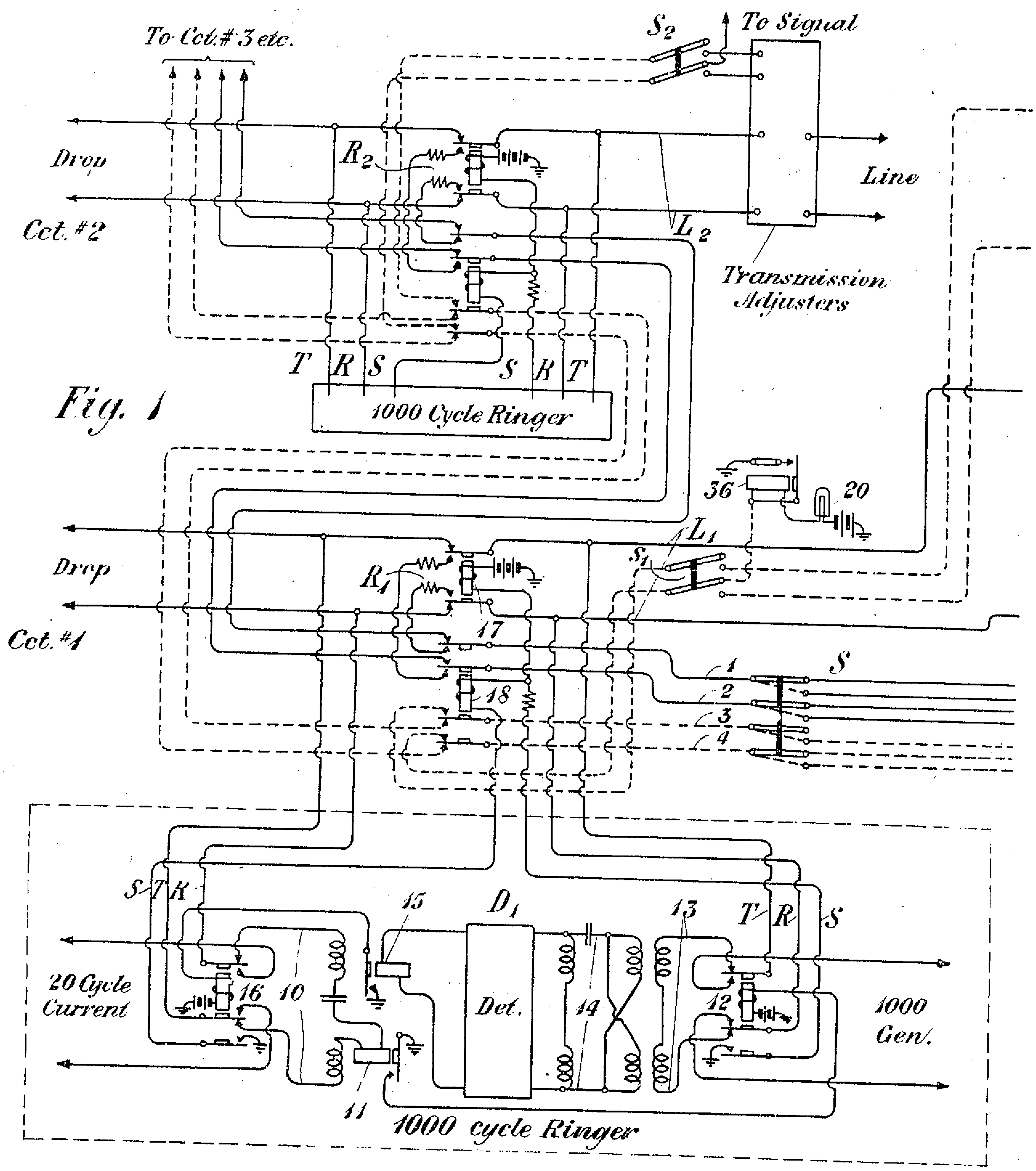
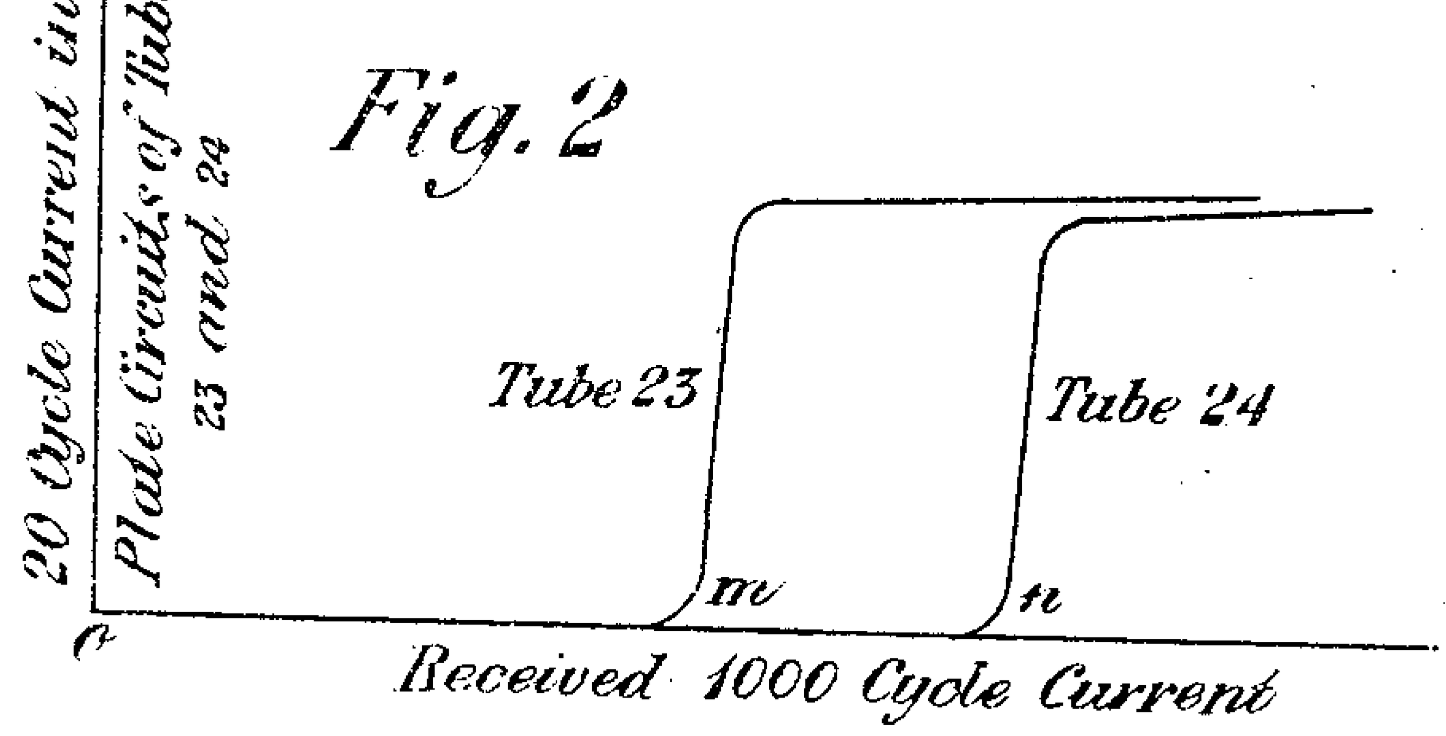


Fig. 1

Fig. 2



INVENTOR
D. K. Gannett

BY

ATTORNEY

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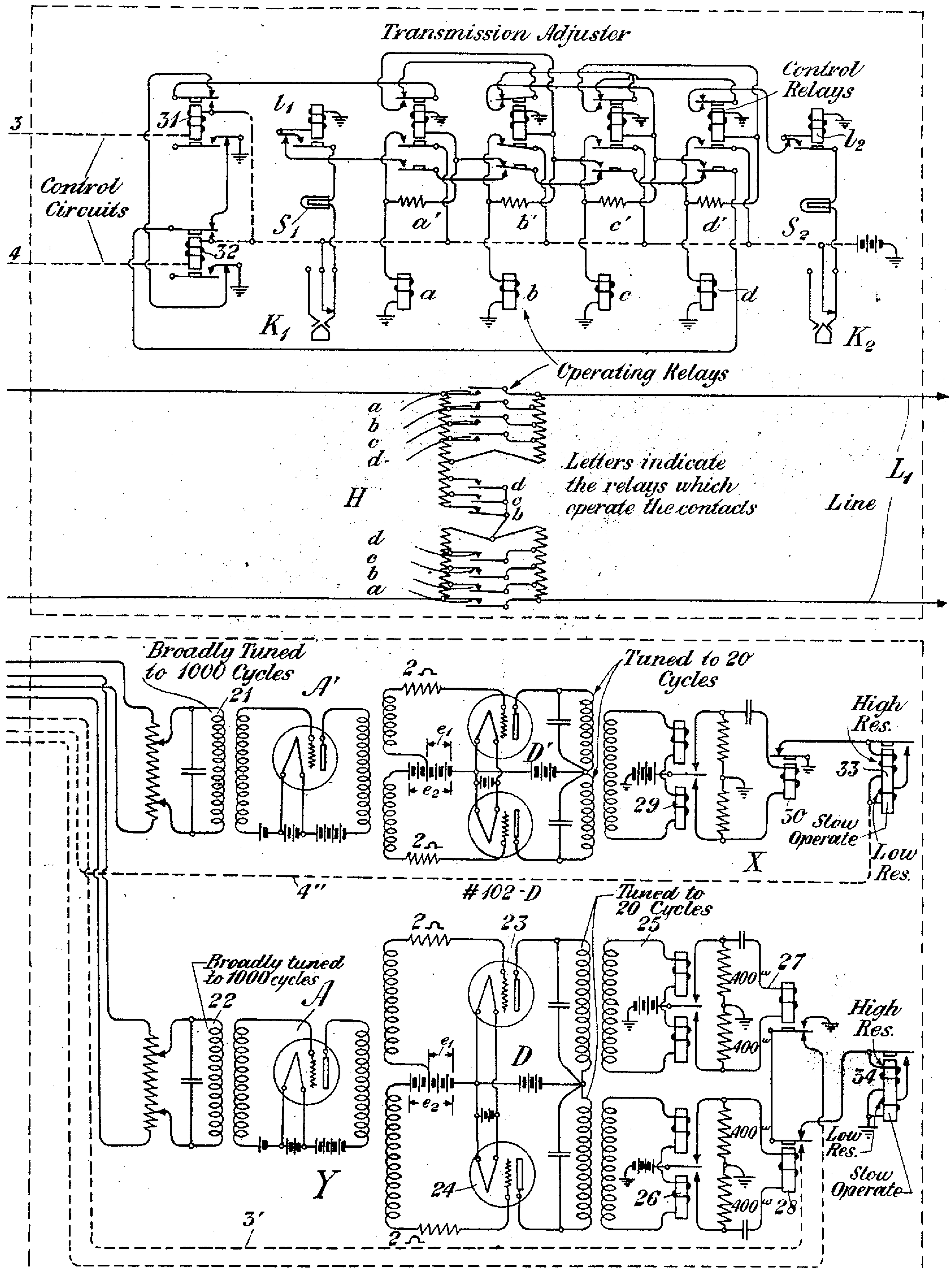

Fig 1(a)

INVENTOR
D.K.Gannett
BY
ATTORNEY

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UNITED STATES PATENT OFFICE.

DANFORTH K. GANNETT, OF JACKSON HEIGHTS, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

REGULATION OF TRANSMISSION.

Application filed November 24, 1923. Serial No. 676,836.

To all whom it may concern:

Be it known that I, DANFORTH K. GANNETT, residing at Jackson Heights, in the county of Queens and State of New York, have invented certain Improvements in Regulation of Transmission, of which the following is a specification.

This invention relates to transmission circuits and more particularly to arrangements for maintaining the transmission constant over long signaling circuits.

In long distance transmission circuits used for telephonic or other signaling purposes the transmission characteristics change from time to time, due to various causes, so that a circuit which would give good transmission at one time might give an indifferent or even a very poor volume of transmission at another time unless some arrangements were provided to maintain the transmission substantially constant.

It is one of the objects of the present invention to provide an arrangement which may be associated with the terminal of the transmission circuit and which will operate under certain conditions in response to a change in the transmission conditions of the line to actuate a signal indicating abnormal transmission conditions or to automatically operate an adjusting arrangement associated with the line to adjust the transmission to its normal value.

Another object of the invention is to provide a regulating arrangement of the type referred to which may be common to a plurality of lines and will operate under certain circuit conditions to cause an adjustment of the transmission of any one of a large group of lines.

Another object of the invention is to provide a transmission regulator common to a large group of lines which will function to control the adjustment of the transmission of any given line whenever a voice frequency ringing current is transmitted over the line.

These objects, as well as other objects of the invention, are attained by means of the arrangements set forth in the following description and illustrated in the accompanying drawing. Figures 1 and 1ª of which, when placed side to side, disclose a circuit arrangement embodying the invention and Fig. 2 of which shows curves for elucidating the principles underlying the transmission regulator apparatus.

Referring to Figs. 1 and 1ª of the drawing, the ringing and other apparatus associated with a plurality of transmission lines is shown in Fig. 1. Transmission regulating arrangements common to a plurality of lines are illustrated in the lower part of Fig. 1ª while the upper part of Fig. 1ª illustrates the transmission adjusting means associated with and individual to a single line.

L_1 and L_2 designate two long distance transmission lines entering an exchange and terminating in the usual drop arrangements (not illustrated). A voice frequency ringing arrangement is associated with each line but since this feature is the same for all of the lines involved it is only illustrated in detail in connection with the line L_1 and will therefore only be described in connection with said line. Since it is customary to provide low frequency ringing apparatus at the drops the ringer is arranged to translate the low frequency ringing current transmitted from the drop to some voice frequency as, for example, 1,000 cycles, for transmission over the line itself. Conversely, the 1,000 cycle ringing current received from the line is translated into 20 cycle current for operating the drop. A circuit 10, bridged across the drop side of the line, is tuned to the frequency of 20 cycles and includes a relay 11 operating in response to ringing current from the drop to complete a circuit for a switching relay 12 associated with the bridge 13 across the line side of the circuit. The relay 12, when operated, disconnects the bridge 13 from the line and applies a ringing frequency of 1,000 cycles to the line, said ringing frequency being transmitted at a group frequency of 20 cycles per second.

The circuit 13 has associated therewith a tuned circuit 14, said tuned circuit being resonant at the ringing frequency of 1,000 cycles so that the incoming ringing frequency from the line will be transmitted to a detector D_1, schematically illustrated in the drawing. This detector may be of any well-known type, such as a vacuum tube detector, and functions to translate the received ringing current having a frequency of 1,000 cycles and transmitted at a group frequency of 20 cycles per second into a pulsating current of the latter frequency. The pulsating current operates a relay 15 in the output circuit of the detector to control the circuit of a switching relay 16, said switching relay functioning to disconnect the tuned circuit from the drop side of the line and apply 20 cycle ringing current to the drop.

The ringing arrangements above described are merely typical of the general type of circuit arrangement employed in connection with voice frequency ringing and are not to be understood as showing the best practice in this connection, the details of this portion of the circuit constituting no part of the present invention.

Two relays, 17 and 18, are associated with the line 1 and are operated over sleeve connections from the ringer arrangement. The relay 17 is operated whenever 20 cycle ringing current is transmitted from the drop or 1,000 cycle ringing current is received from the line to disconnect the line from the drop. The relay 18 is operated over a sleeve connection from the ringer only in response to ringing current of 1,000 cycles received from the line. Under the latter conditions relays 17 and 18 are both actuated to establish a connection through resistance R_1, to conductors 1 and 2. By means of a suitable switching arrangement S, conductors 1 and 2 may be connected to either of two regulating arragements X and Y. These regulating arrangments are common to all of the lines of a large group, of which lines L_1 and L_2 are typical. The arrangement X is used when the transmission regulator is only intended to actuate a signal indicating an abnormal transmission condition. The arrangement shown at Y, on the other hand, is used when it is desired to automatically adjust the transmission of any given line.

By means of the switch S, already referred to, control conductors 3′ and 4′ associated with the transmission regulator Y may be connected to conductors 3 and 4. These conductors 3 and 4 are extended successively over contacts controlled by relays similar to relay 18, associated with all of the lines of the group, and when any relay corresponding to 18 is operated said relay functions to connect the conductors 3 and 4 to the automatic transmission adjusting device associated with that line, as will be described hereinafter. This operation takes place at the same time that the transmission regulator is associated with the line over conductors 1 and 2. The switch S may also be so adjusted as to connect the control conductor 4″ of the transmission regulator X to the conductor 4. When the arrangement X is to be used the switch S_1 associated with the line will be thrown to connect the conductor 4 to the signal lamp 20 associated with the line, the switch S_1 at the same time disconnecting the conductors 3 and 4 from the transmission adjusting arrangement, to be described hereinafter. The conductors 1 and 2 leading to the transmission regulator X or Y, as the case may be, are also connected serially over the contacts of relays similar to the relay 18 associated with each of the lines so that any line may be connected by its relay 18 to the transmission regulator whenever a voice frequency ringing signal is received by that line, provided a line whose relay contacts are included in the connection nearer the transmission regulator is not at the same time receiving a ringing signal.

Coming now to the transmission regulator itself, which may be common to a plurality of lines and may be connected to any line of the group when a ringing signal is received over said line, it will be seen that the regulators X and Y are somewhat similar. Each regulator includes an incoming circuit as illustrated at 21 and 22, tuned to the ringing frequency of 1,000 cycles. Each regulator also includes an amplifier, as shown at A and A′, as well as a duplex detector arrangement illustrated at D and D′.

The circuit arrangement of the detector is a vital feature of the regulator and will be described in some detail. A description of the detector arrangement D will be sufficient for this purpose. This detector comprises two vacuum tubes 23 and 24, of the usual type. The input circuit of each tube contains a very large resistance, for example, a resistance of two megohms. A "C" battery common to the input circuits of the two tubes is provided and the connections are such that the normal grid potentials of the two tubes are different, the grid of the tube 23 being connected to a point on the C battery which is negative by an amount e_1 with respect to the filament while the circuit of the grid of the tube 24 is connected to a point which is negative by an amount e_2 with respect to the filament. The voltages e_1 and e_2 are both large compared with the grid voltage required to reduce the space currents in the two tubes approximately to zero. The two input circuits are connected to the output circuit of the amplifier A through separate windings of a common transformer and the output circuit of each of the detector tubes is tuned to the group frequency of 20 cycles.

The operating characteristics of the tubes are illustrated by the curves of Fig. 2. As has already been stated, the ringing current which is received from the line and impressed upon the detector of the transmission regulator consists of current having a frequency of 1,000 cycles and interrupted at a group frequency of 20 cycles per second. The output of the detector tubes, therefore, is a pulsating current having a frequency of 20 cycles per second and is used to operate the relay arrangements of the regulator, to be described hereinafter. The characteristic curves of the two tubes, therefore, show the 20 cycle output of the detector tube plotted against a received 1,000 cycle ringing current from the line. The shape of these curves, it will be noted, is very nearly rectangular. The extreme sharpness of the curves is due to the fact that the range of the applied grid voltage is large compared with the operating range of the tube. For all small values of A. C. potentials applied to the grids of the tubes, which potentials are not large enough in magnitude to reduce the negative grid potential at any point in the wave to a value sufficient to permit space current to flow in the plate circuit of the tube, it is obvious that no 20 cycle output current will flow. For A. C. voltages whose peak values exceed the negative C potential e_1 or e_2 of the grid battery so that the grid potential tends to become positive, it is obvious that the grid to filament impedance of the tube 23 or 24 will become quite small compared with the two megohm resistance connected in series with the grid, during portions of the cycle. Therefore, the grid potential is effectively prevented from becoming appreciably positive even for very large values of applied A. C. voltage. The effect of this is to cause the curve to drop off sharply and become flat so that this part of the curve is almost horizontal, as shown. In other words, the C potential being so adjusted that no current flows in the output circuit, normally, the A. C. current applied to the input of the tube causes no current to flow in the output circuit until the amplitude is increased to a limiting value, depending upon the normal C potential. When this point is reached and the amplitude is further increased an output current begins to flow, this output reaching a maximum for a very small further increase in amplitude, and no substantial increase in the output current occurs for still further increase in the output amplitude.

Since the two tubes are provided with different grid potentials the critical values of received current at which they give sufficient 20 cycle output to operate relays or other devices in their respective circuits are different. In the case of the transmission regulator Y, each detector tube has a separate polar relay associated with its output circuit; for example, a polar relay 25 is associated with the output circuit of the detector 23 and a polar relay 26 is associated with the output circuit of the detector 24, each of these polar relays being responsive to 20 cycle current. When the value of the received 1,000 cycle current lies between zero and m (see Fig. 2) neither polar relay 25 nor 26 is operated. When the value lies between m and n, however, the polar relay 25 will vibrate its armature at a frequency of 20 cycles while the polar relay 26 will still fail to operate. When the value of the received current is greater than n, both polar relays operate.

The vibration of the armatures of these relays is made to control the operation of alternating current relays 27 and 28 by switching connections from a battery so that current flows through the relay winding first in one direction and then the other, as the armature vibrates. The contacts controlled by the relays 27 and 28 are so arranged that if both relays operate a ground is connected to the control circuit 3′. If neither relay operates a ground is connected to the control circuit 4′. If but one relay operates, or, in other words, if only the relay 27 operates, ground is connected to neither of the control conductors. This last mentioned condition corresponds to the condition wherein the received 1,000 cycle ringing current has an amplitude lying between the points m and n in Fig. 2.

The connections of the control circuits 3′ and 4′ to the transmission adjusting arrangement, to be described hereinafter, are such that when the received ringing current is within the limits m and n, no adjustment of the transmission is made. If the amplitude drops below m, however, or goes above n, the transmission of the circuit will be adjusted in the manner hereinafter to be described to bring the transmission back within the normal limits.

The arrangement controlled by the detector D′ of the regulating arrangement X is similar to that described in connection with the regulating arrangement Y except that in this case a single polar relay 29 is differentially connected to the output circuits of the two detector tubes and operates a single A. C. relay 30, which determines whether or not ground will be applied to the control circuit 4″. The vibrating polar relay 29 does not operate when the received 1,000 cycle current has an amplitude less than m or greater than n, for in the former case the amplitude is too small to produce any output current in either tube while in the latter case the output currents are of substantially the same amplitude and oppose each other. When the received ringing current has an amplitude lying between the limits m and n, however, a detected current of 20 cycles appears in the output circuit of the upper tube while no detected current appears in the lower. Consequently, the polar relay 29 vibrates its armature at 20 cycles per second and operates the A. C.

relay 30. The latter disconnects ground from the control circuit 4″, thereby preventing the operation of the signal lamp, such as 20, associated with the transmission line. When the received transmission is either above or below the limits m and n, the relay 30 is not operated and the conductor 4″ is grounded so that the signal lamp is actuated.

At the upper part of Fig. 1ª is illustrated the transmission adjusting arrangement associated with the line L_1 when the automatic transmission regulator Y is to be used instead of the signal controlling regulator X. It will be understood that a similar transmission adjuster will be associated with each line of the group. As already stated, the automatic regulator connects ground to either one or the other of the control circuits 3′ or 4′ if the circuit equivalent of the line at the time of the transmission of ringing current is outside the specified limits. These two control circuits are associated with the transmission adjuster and the latter is arranged to change the equivalent of the circuit by a given amount, each time the regulator operates. The equivalent is increased or decreased, depending upon whether the control circuit 3′ or 4′ is grounded.

The transmission adjuster consists of a group of relays called control relays which may be of any number to produce the desired number of steps of adjustment. These relays are shown as four in number and designated a', b', c' and d' and another group of relays called operating relays and designated a, b, c and d. The operating relays are controlled by the control relays and the operation of the control relays is in turn determined by relays 31 and 32, included in the control circuits 3′ and 4′ respectively.

The contacts of the operating relays are arranged to adjust by steps an **H** type of artificial line or pad, H, in the line L_1. This artificial line comprises series resistances in each line wire and a shunt resistance connected to the midpoints of the series resistances. The contacts are arranged to adjust by steps the series resistance elements on each side of the midpoint and to simultaneously adjust the shunt resistance, thereby changing the transmission loss but not the impedance characteristics of the line. The control relays are so arranged that when a given relay with its corresponding operating relay is operated and the artificial line H given a particular adjustment, a ground placed upon the wire 3 will operate the control relay to the right of the control relay then operated and when the ground is removed at the end of the ringing signal the preceding relay will be released. On the other hand, if ground is placed on the wire 4 the relay to the left will be operated and when the ground is removed at the end of the ringing signal the original relay will be released. Each ringing signal serves to adjust the network H one step, if any adjustment is required. When the limit of adjustment is exceeded in either direction the relay l_1 or l_2 will be operated to close a circuit of the signal lamp s_1 or s_2, which will be locked up until the abnormal condition is overcome, when the relay l_1 or l_2 controlling the lamp may be released by means of a suitable key, K_1 or K_2.

Further details of the apparatus will be clear from a description of the operation which is as follows: If 20 cycle ringing current is transmitted from the drop terminal of the line L_1, for example, the ringing current will flow into the tuned bridge 10 and operate the relay 11, which in turn closes a circuit of relay 12. The relay 12 opens the tuned bridge 13 and applies 1,000 cycle ringing current, interrupted at a group frequency of 20 cycles per second, to the tip and ring conductors of the line L_1. The operation of the relay 12 also applies ground to the sleeve conductor of the ringer so that a circuit is completed through a resistance and through the winding of the relay 17. The relay 17 is actuated to disconnect the conductors of the line L_1 from the drop terminals during the ringing operation but as the relay 18 is not actuated the transmission regulator does not come into play.

When 1,000 cycle ringing current, interrupted at a group frequency of 20 per second, is received from the line L_1, however, the ringing current is transmitted through the bridge 13 to the tuned circuit 14. The detector D_1 detects the ringing current producing a pulsating frequency of 20 cycles per second, which actuates the relay 15 to close the circuit of the relay 16. The relay 16 opens the tuned circuit 10 and connects 20 cycle ringing current to the tip and ring conductors of the drop terminals. At the same time the relay 16 connects ground to the left-hand sleeve conductor of the ringing arrangement, thereby completing a circuit through the windings of relays 18 and 17 in series. Relay 17, as before, disconnects the drop terminals from the line conductors of the line L_1 and connects the line L_1 through the resistances R_1 and over the make contacts of the relay 18 to the conductors 1 and 2.

Assume now, that the switch S is in the position shown in the drawing, so that the conductors 1 and 2 are connected to the transmission regulator X and that the switch S_1 of the line L_1 is in its upper position so that the signal lamp 20 will be employed rather than the transmission adjuster. The ringing current incoming from the line L_1 will be transmitted over the conductors 1 and 2 to the tuned circuit 21 and will be amplified by the amplifier A_1 and impressed upon the detector arrangement D_1. If the transmission equivalent of the line L_1 is normal so that the amplitude of the received ringing current lies within the range m—n (see Fig. 2) substantially no 20 cycle current will be detected in the output circuit of the lower tube of the detector D′. The upper tube, on the other hand, will detect a 20 cycle current which will be transmitted to the vibrating relay 29 to cause its armature to vibrate. The vibration of the armature of the relay 29 will operate the alternating current relay 30 to disconnect ground from the conductor 4″. Consequently, no circuit will be completed for the lamp 20.

If, however, the transmission condition of the line L is abnormal—either too high or too low—so that the amplitude of the received 1,000 cycle current lies above n or below m, the relay 29 will not be actuated. In the former case this will be because the detected current in the output circuits of the two tubes will be substantially equal and will balance each other while in the latter case substantially no current will be detected in the output circuit of either tube. As a consequence, the relay 30 will not be operated and ground will be applied to the conductor 4″. Current will now flow through the high resistance winding of relay 33. By reason of the high resistance of the winding of the relay 33 the current flowing over the conductor 4″ and the conductor 4 is insufficient to energize the relay 36 and the signal lamp 20. After an instant, however, the slow operating relay 33 attracts its armature and shunts its high resistance winding by a low resistance winding, thereby increasing the current flow over the conductors 4″ and 4. The current flowing over the circuit is now sufficient to cause the lamp 20 to glow and to energize the relay 36, which closes a locking circuit through its winding and through the lamp 20 to hold the lamp 20 energized after the circuit 4 has been opened by the release of the relay 18 at the end of the ringing signal. The lamp indicates to an attendant that the transmission is abnormal and the attendant can then adjust the transmission to a desired value in any well known manner.

If 1,000 cycle ringing current should be received from the line L_2 the relays associated with said line corresponding to the relays 17 and 18 of the line L_1 will be actuated to connect the conductors 1 and 2 to the line L_2 and to connect the conductor 4 to the signal associated with the line L_2, provided, of course, that a ringing signal is not received by the line L_1 simultaneously with that received by the line L_2. If signals are received on two or more lines simultaneously the line nearest the transmission regulator obtains precedence and will have its transmission adjustment signal operated.

If, when the ringing current was received from the line L_1 and its relays 17 and 18 were operated, the switch S should be in its alternative position, indicated in dotted lines, and the switches S_1 and S_2 associated with the individual lines in their lower positions, the transmission regulator Y will come into play and the automatic transmission adjuster will be operated. In this case the 1,000 cycle interrupted ringing current received from the line will be transmitted over the contacts of the relay 17 through the resistances R_1 and over the upper contacts of relay 18 and conductors 1 and 2 to the tuned circuit 22. The ringing current will then be amplified by the amplifier A and impressed upon the detector D.

If the transmission is normal, so that the amplitude of the received ringing current lies within the limits m and n of the curve of Fig. 2, 20 cycle current will be produced in the output circuit of the tube 23 but no detected current will appear in the output circuit of the tube 24. Consequently, the vibrating relay 25 will be energized so that its armature will vibrate and actuate the alternating current relay 27. The relay 27 will attract its armature to disconnect the ground normally connected through the high resistance winding of the relay 34 to the conductor 4′. This produces no effect upon the transmission adjuster, shown in the upper part of Fig. 1ᵃ and the line circuit L_1 is permitted to remain in the condition of adjustment which then obtains.

If the amplitude of the received 1,000 cycle current should be lower than the point m of Fig. 2, 20 cycle current will be detected in the output circuits of neither tube and neither of the relays 27 nor 28 will be operated. Consequently, a circuit is completed from ground through the high resistance winding of the relay 34, over the back contacts of relays 28 and 27, over conductor 4′, over conductor 4, lower make contact of relay 18, lower bar of the switch S_1 and through the winding of the relay 32 to battery. Owing to the high resistance of the relay 34 this current is not sufficient to operate the relay 32 but when the relay 34, after an instant, attracts its armature and shunts its high resistance winding by its low resistance winding, the current is sufficiently increased to energize the relay 32.

Assume, now, that the circuit of the transmission adjuster is in the condition shown, with the relays b' and b actuated. The energization of the relay 32 will complete a circuit from battery, over the upper front contact of said relay, lower back contacts of relays d' and c', lower front of relay b' and through the winding of the relay a'

to ground. The relay a' is accordingly energized and is locked up over its inner lower front contact to battery. A circuit is also completed over its inner lower front contact for the winding of the operating relay a, which by closing the a contacts of the network H, short circuits the entire network and produces the maximum transmission adjustment for the line L_1.

At the end of the ringing signal the relays 17 and 18 will be released and the circuit over the conductor 4 to the relay 32 will be opened. When the relay 32 releases its armatures its lower contacts close to connect ground, over the upper back contact of relay 31, upper front contact of relay a' to the winding of the relay b', thereby short-circuiting the winding of said relay and causing it to release its armatures. The opening of the inner contacts of relay b' disconnects the battery from the operating relay b releasing it. The relays a' and a will now remain energized, with the transmission adjusted as indicated, until a subsequent ringing signal is received.

In case the amplitude of the received ringing current from the line L_1 had exceeded n of the curve of Fig. 2, 20 cycle current would have been detected in the output circuits of the tubes 23 and 24 so that both relays 27 and 28 would be energized. A circuit would then be completed from ground, over the front contacts of relays 27 and 28, over conductor 3′, over conductor 3, inner front contact of relay 18, upper bar of switch S_1 and through the winding of relay 31 to battery. Assuming that the circuit of the transmission adjuster is at this time in the condition shown in the drawing, with relays b' and b energized, a circuit will be completed from battery, over the upper front contact of relay 31, upper back contact of relay a' and over the upper front contact of relay b', through the winding of relay c' to ground. Relay c', upon being energized, is locked up and completes a circuit over its inner front contact for the operating relay c. Relay c closes the contacts designated c in the network H, thereby increasing the series resistance elements of the network and decreasing the shunt resistance elements. This produces a corresponding increase of the transmission loss of the line L_1.

At the end of the ringing signal the relays 27 and 28 will release their armatures and the relays 17 and 18 will be released so that the circuit over conductor 3 will be opened and the relay 31 deenergized. When the armature of said relay falls off its lower contact is closed to connect ground, over the upper back contact of relay 32, over the lower back contact of relay d' and over the lower front contact of the relay c' to the winding of relay b'. The winding of the relay b' is accordingly short circuited and the relay is deenergized and restored to normal, thereby opening the circuit of the relay b, which is likewise deenergized. The network H now remains in the condition of adjustment to which it is set by the operation of the relay c until a subsequent ringing signal is received.

It will be observed that under the conditions in which neither relay 27 nor 28 was operated the high resistance winding of the relay 34 was momentarily connected in circuit with the relay 32, thereby slightly delaying the operation of the latter relay. This was for the purpose of preventing a false operation of the transmission adjuster in case there should be a slight delay in the energization of either the relay 27 or 28 or both. The relay 33, it will be recalled, was also included in circuit with the conductor 4″ for a similar reason, viz, that too slight a delay in the operation of the relay 30 might result in energizing and locking up the lamp 20, even though the transmission conditions be normal.

If, when a ringing signal is received, the transmission adjuster is set for the condition of maximum transmission with relays a' and a actuated, and the amplitude of the ringing current should be lower than m of Fig. 2, the conductor 4′ will be grounded in the manner already described, thereby causing the relay 32 to be energized. Battery will then be connected over the upper front contact of the relay 32 and over the lower back contacts of relays d', c' and b' and thence over the lower front contact of relay a' to the winding of relay l_1. The latter relay will then be energized and locked up over its lower front contact, completing a circuit through the signal lamp s_1, which indicates that the transmission conditions of the circuit are so abnormal as to exceed the limits of the transmission adjuster. The relay l_1 is provided with no upper contact and consequently when the relay 32 falls off at the end of the ringing signal no momentary impulse is transmitted to short circuit the relay a' and the latter relay still remains operated. When the attendant has made a suitable change in the transmission of the line circuit the key K_1 may be actuated to release the relay l_1 and the lamp s_1. The transmission adjuster will, however, remain with the relays a' and a energized after the key K_1 has been actuated.

If, on the other hand, the transmission adjuster had been so set that the relays d' and d were actuated, and the amplitude of the received ringing current should be greater than n, so that both relays 27 and 28 are energized, the conductor 3′ will be grounded to complete a circuit for the relay 31. Battery would then be connected over the upper front contact of relay 31, upper back contacts of relays a', b' and c' and upper front contact of relay d' to the winding of the relay l_2. The relay l_2 would then be energized and locked up over a circuit including the signal lamp s_2 so that an abnormal adjustment of the circuit would be indicated. In this instance, also, the relay d' would not be short circuited at the end of the ringing signal and after the attendant has made suitable transmission changes the relay l_2 could be released by means of the key K_2, leaving the transmission adjuster set with the relays d' and d energized.

It will be observed from the circuit arrangement shown in Fig. 1 that a single transmission regulator Y or X, as the case may be, will serve a large group of lines, the regulator being automatically connected to any given line whenever a ring is received on that line, provided always that a ring is not being simultaneously received on another line nearer the regulator. It is apparent from the arrangement of the circuits that the line L_1, which is the line nearest the regulator, will receive the most frequent regulation and a line further away from the regulator will receive regulation only when lines between it and the regulator are not signaling. However, in practice it is found that only about one per cent of the time of a circuit is occupied by signaling, even at the busy hour. Consequently it follows from the law of probability that if the group served by the regulator contained 100 circuits the circuit furthest from the regulator would still receive regulation on the average about one time out of three. If the group contained only 10 circuits the circuit furthest from the regulator would receive regulation 90 per cent of the time. It is apparent, therefore, that the group of lines served by a single regulator may be made quite large.

An important advantage of the invention resides in the fact that the functioning of the detector arrangement of the regulator is very nearly independent of the characteristics of the tubes but is determined principally by the adjustment of the grid potentials e_1 and e_2. It is, therefore, necessary only to maintain the adjustments of the grid batteries within fairly close limits. It is not necessary that the batteries supplying the filament and plate currents should be carefully adjusted. It will, of course, be necessary for proper operation of the arrangement to maintain the voltage of the 1,000 cycle ringing generator which supplies the ringing current at the transmitting end of the circuit within rather narrow limits. This may readily be done, however, by various arrangements well-known in the art.

Another important feature of the invention is the use of the resistances, such as R_1 and R_2, in the connection between any given line and the transmission regulator. The group of lines with which the transmission regulator is associated may consist of lines which, because they are of different lengths or for other reasons, are operated at different normal transmission equivalents. In order to make possible the use of a single transmission regulator having one adjustment with all the lines of the group, it is necessary to equalize the losses of the lines to the regulator by inserting additional losses in series between the lines and the regulator, these additional losses being larger for the lines of lowest loss, and smaller for the lines of greatest loss. The resistances R_1 and R_2, etc., serve as these additional equalizing losses.

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. In a signaling system, a plurality of transmission lines, a transmission responsive device common to said lines and responsive to changes in the transmission equivalent of a line when connected thereto, means to connect said device with any one of said lines and means associated with said transmission responsive device for producing an indication in response to an abnormal transmission condition of a line to which the transmission responsive device is connected.

2. In a signaling system, a plurality of transmission lines, a transmission responsive device common to said lines and responsive to changes in the transmission equivalent of a line when connected thereto, means to connect said transmission responsive device to any one of said lines in response to the transmission of a signal over said line and means controlled by said transmission responsive device to produce an indication in response to an abnormal transmission condition of a line to which the transmission responsive device is connected.

3. In a signaling system, a plurality of transmission lines, a transmission responsive device common to said lines, means to connect said transmission responsive device to any one of said lines upon the transmission of ringing current over said line and means controlled by said transmission responsive device for producing an indication in response to an abnormal transmission condition of the line to which said transmission responsive device is connected.

4. In a signaling system, a plurality of transmission lines, a transmission responsive device common thereto, means to connect said transmission responsive device to any one of said lines in response to a voice frequency ringing current transmitted over said

line and means controlled by said transmission responsive device for producing an indication in response to an abnormal transmission condition of the line to which said transmission responsive device is connected.

5. In a signaling system, a plurality of transmission lines, a transmission adjuster for each line, a transmission responsive device common to said lines, means to connect said transmission responsive device to any one of said lines and means controlled by said transmission responsive device in response to an abnormal transmission condition of a line to which said transmission responsive device is connected to operate the transmission adjuster for said line.

6. In a signaling system, a plurality of transmission lines, a transmission adjuster for each line, a transmission responsive device common to said lines, means to connect said signal responsive device to any one of the lines in response to a signal transmitted over said line and means controlled by said transmission responsive device in response to an abnormal transmission condition of a line to which said transmission responsive device is connected to operate the transmission adjuster for said line.

7. In a signaling system, a plurality of transmission lines, a transmission adjuster for each line, a transmission responsive device common to said lines, means to connect said transmission responsive device to any one of said lines in response to ringing current transmitted over said line and means controlled by said transmission responsive device in response to an abnormal transmission condition of a line to which said transmission responsive device is connected to operate the transmission adjuster for said line.

8. In a signaling system, a plurality of transmission lines, a transmission adjuster for each line, a transmission responsive device common to said lines, means to connect said transmission responsive device to any one of said lines upon the transmission of a voice frequency ringing current over said line and means controlled by said transmission responsive device in response to an abnormal transmission condition of a line to which said transmission responsive device is connected to operate the transmission adjuster for said line.

9. In a signaling system, a plurality of transmission lines, a transmission responsive device common to said lines, means to connect said transmission responsive device to any one of said lines in response to the transmission of signaling current over said line, means to impress said signaling current upon said transmission responsive device and means controlled by said transmission responsive device to produce an indication when said signaling current arrives at said transmission responsive device with abnormal amplitude.

10. In a signaling system, a plurality of transmission lines, a transmission adjuster for each line, a transmission responsive device common to said lines, means to connect said transmission responsive device to any one of said lines upon the transmission of a signaling current over said line, means to impress said signaling current upon said transmission responsive device and means controlled by said transmission responsive device to operate the transmission adjuster for the line when said signaling current arrives at said transmission responsive device with abnormal amplitude.

11. In a signaling system, a plurality of transmission lines, and a transmission adjuster for each line, said transmission adjuster comprising a variable impedance element associated with the line and a series of counting relays for controlling the setting of said impedance element, a transmission responsive device common to said lines, means to connect said device to any one of said lines in response to the transmission of a signaling current thereover and means controlled by said transmission responsive device when the transmission condition of the line to which it is connected is abormal to operate the counting relay adjacent a previously operated counting relay of the transmission adjuster associated with said line, thereby producing a different setting of said impedance element.

12. In a signaling system, a plurality of transmission lines, a transmission adjuster for each line, said transmission adjuster comprising a variable impedance device associated with the line, a plurality of counting relays for controlling the setting of said impedance device, said counting relays being so arranged that when a given relay is operated it will set and maintain the setting of said impedance device until another counting relay is operated, a transmission responsive device common to said lines, means to connect said transmission responsive device to any one of said lines in response to the transmission of a signaling current thereover and means controlled by said transmission responsive device when said device is connected to a given transmission line to produce no effect upon said transmission adjuster when the signaling current arrives at said transmission responsive device with normal amplitude, said means operating when the amplitude of the signaling current exceeds the normal limit to operate a counting relay on one side of the counting relay then operated to increase the loss of said impedance device and said means operating when the amplitude of the signaling current is below normal to actuate the relay on the other side of the counting

relay then actuated to decrease the impedance of said impedance device.

13. In a signaling system, a plurality of transmission lines, a transmission adjuster associated with each line, said transmission adjuster comprising a variable impedance device associated with said line and means to vary the loss of said device by steps, signaling means associated with said last mentioned means adapted to be operated when said last mentioned means is adjusted above or below the limits of said impedance device, a transmission responsive device common to each of said lines, means to connect said transmission responsive device to any one of said lines upon the transmission of a signaling current thereover and means controlled by said transmission responsive device to operate the transmission adjuster of the line with which it is associated whenever a signaling current arrives at the transmission responsive device with abnormal amplitude.

14. In a signaling system, a transmission line, a transmission responsive device to which alternating signaling currents may be transmitted over said line, said transmission responsive device comprising a pair of translating elements, both translating elements being substantially unaffected by received alternating currents of small amplitude, one of said translating elements becoming responsive to alternating signaling currents above one amplitude and the other being responsive to alternating signaling currents above another amplitude.

15. In a signaling system, a transmission line, a transmission responsive device to which signaling currents may be transmitted over said line, said transmission responsive device comprising a pair of translating elements, both translating elements being substantially unaffected by received currents of small amplitude, one of said translating elements becoming responsive to signaling currents above one amplitude and the other being responsive to signaling currents above another amplitude, and means associated with said translating elements for producing an indication when neither of said elements responds, said means producing no indication when only one of said elements responds and said means producing an indication when both of said elements respond.

16. In a signaling system, a transmission line, a transmission responsive device associated with said line, said device comprising a pair of vacuum tubes having input and output circuits, means to apply normal potentials to the grids of said tubes such that one of said tubes is unresponsive to currents having an amplitude below a given limit and responsive to currents having amplitudes greater than said limit, the other tube being unresponsive to currents having amplitudes below a higher limit and being responsive to currents having an amplitude greater than said higher limit.

17. In a signaling system, a transmission line, a transmission device associated with said line, said device comprising a pair of vacuum tubes having input and output circuits, said tubes being so adjusted that their operating range is small as compared with the amplitude of signaling currents transmitted over said line, means to apply normal potentials to the grids of said tubes such that one of said tubes is unresponsive to currents having an amplitude below a given limit and responsive to currents having amplitudes greater than said limit, the other tube being unresponsive to currents having amplitudes below a higher limit and being responsive to currents having an amplitude greater than said higher limit, and means controlled by said tube, said means producing an indication when neither of said tubes is responsive to signaling currents, said means producing no indication when but one of said tubes is responsive and said means producing an indication when both of said tubes are responsive.

18. In a signaling system, a plurality of transmission lines, a transmission responsive device common to said lines, means to connect said transmission responsive device to any one of said lines upon the transmission of signaling current thereover, said transmission responsive device comprising a pair of translating elements, both translating elements being substantially unaffected by received currents of small amplitude, one of said translating elements becoming responsive to signaling currents above one amplitude and the other being responsive to signaling currents above another amplitude.

19. In a signaling system, a plurality of transmission lines, a transmission responsive device common to said lines, means to connect said transmission responsive device to any one of said lines upon the transmission of signaling current thereover, said transmission responsive device comprising a pair of translating elements, both translating elements being substantially unaffected by received currents of small amplitude, one of said translating elements becoming responsive to signaling currents above one amplitude and the other being responsive to signaling currents above a certain amplitude and means associated with said translating elements for producing an indication when neither of said elements is affected, said means producing no indication when only one of said elements is affected and said means producing an indication when both of said elements respond.

20. In a signaling system, a plurality of transmission lines, a transmission responsive

device common to said lines, means to connect said transmission responsive device to any one of said lines upon the transmission of signaling currents thereover, said device comprising a pair of vacuum tubes having input and output circuits, said tubes being so adjusted that their operating range is small as compared with the amplitude of signaling currents transmitted over said line, means to apply normal potentials to the grids of said tubes such that one of said tubes is unresponsive to currents having an amplitude below a given limit and responsive to currents having amplitudes greater than said limit, the other tube being unresponsive to currents having amplitudes below a higher limit and being responsive to currents having an amplitude greater than said higher limit.

21. In a signaling system, a plurality of transmission lines, a transmission responsive device common to said lines, means to connect said transmission responsive device to any one of said lines upon the transmission of signaling currents thereover, said device comprising a pair of vacuum tubes having input and output circuits, said tubes being so adjusted that their operating range is small as compared with the amplitude of signaling currents transmitted over said line, means to apply normal potentials to the grids of said tubes such that one of said tubes is unresponsive to currents having an amplitude below a given limit and responsive to currents having amplitudes greater than said limit, the other tube being unresponsive to currents having amplitudes below a higher limit and being responsive to currents having an amplitude greater than said higher limit, and means controlled by said tube, said means producing an indication when neither of said tubes is responsive to signaling currents, said means producing no indication when but one of said tubes is responsive and said means producing an indication when both of said tubes are responsive.

22. In a signaling system, a plurality of transmission lines, a transmission adjuster for each line, a transmission responsive device common to said lines, means to connect said device with any one of said lines upon the transmission of signaling currents thereover, said device comprising a pair of translating elements, both translating elements being substantially unaffected by received currents of small amplitude, one of said translating elements becoming responsive to signaling currents above one amplitude and the other being responsive to signaling currents above another amplitude, and means controlled by said elements whereby when neither of said elements responds said transmission adjuster will be operated in one direction, whereby when both of said elements respond said transmission adjuster will be operated in the other direction and whereby when but one of said elements responds no effect will be produced upon said transmission adjuster.

23. In a signaling system, a plurality of transmission lines, a transmission adjuster for each line, a transmission responsive device common to said lines, means to connect said device to any one of said lines upon the transmission of signaling currents thereover, said device comprising a pair of vacuum tubes having input and output circuits, said tubes being so adjusted that their operating range is small as compared with the amplitude of signaling currents transmitted over said line, means to apply normal potentials to the grids of said tubes such that one of said tubes is unresponsive to currents having an amplitude below a given limit and responsive to currents having amplitudes greater than said limit, the other tube being unresponsive to currents having amplitudes below a higher limit and being responsive to currents having an amplitude greater than said higher limit, and means controlled by said tubes, said means operating when neither tube responds to adjust in one direction the transmission adjuster of the line connected to said transmission responsive device, said means operating when both of said tubes respond to adjust the said transmission adjuster of the line in the opposite direction and said means producing no adjustment of said transmission adjuster when only one tube responds.

In testimony whereof, I have signed my name to this specification this 21st day of November, 1923.

DANFORTH K. GANNETT.