July 25, 1933. D. B. HARRIS ET AL 1,919,719

TRANSMISSION SYSTEM FOR SOUND CARRYING CURRENTS

Filed June 13, 1930 3 Sheets-Sheet 1

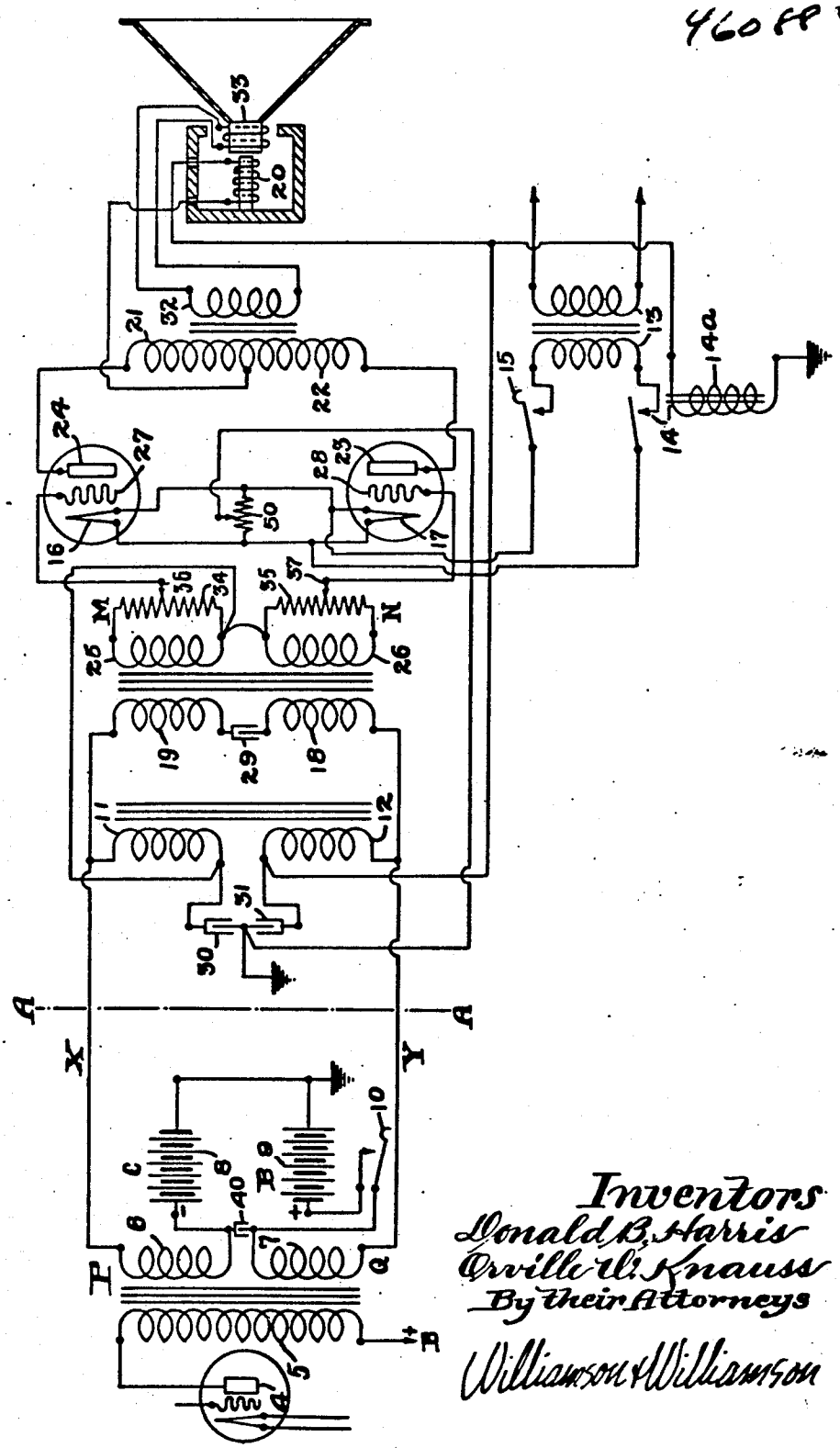


Fig. 1

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TRANSMISSION SYSTEM FOR SOUND CARRYING CURRENTS

Filed June 13, 1930 3 Sheets-Sheet 2

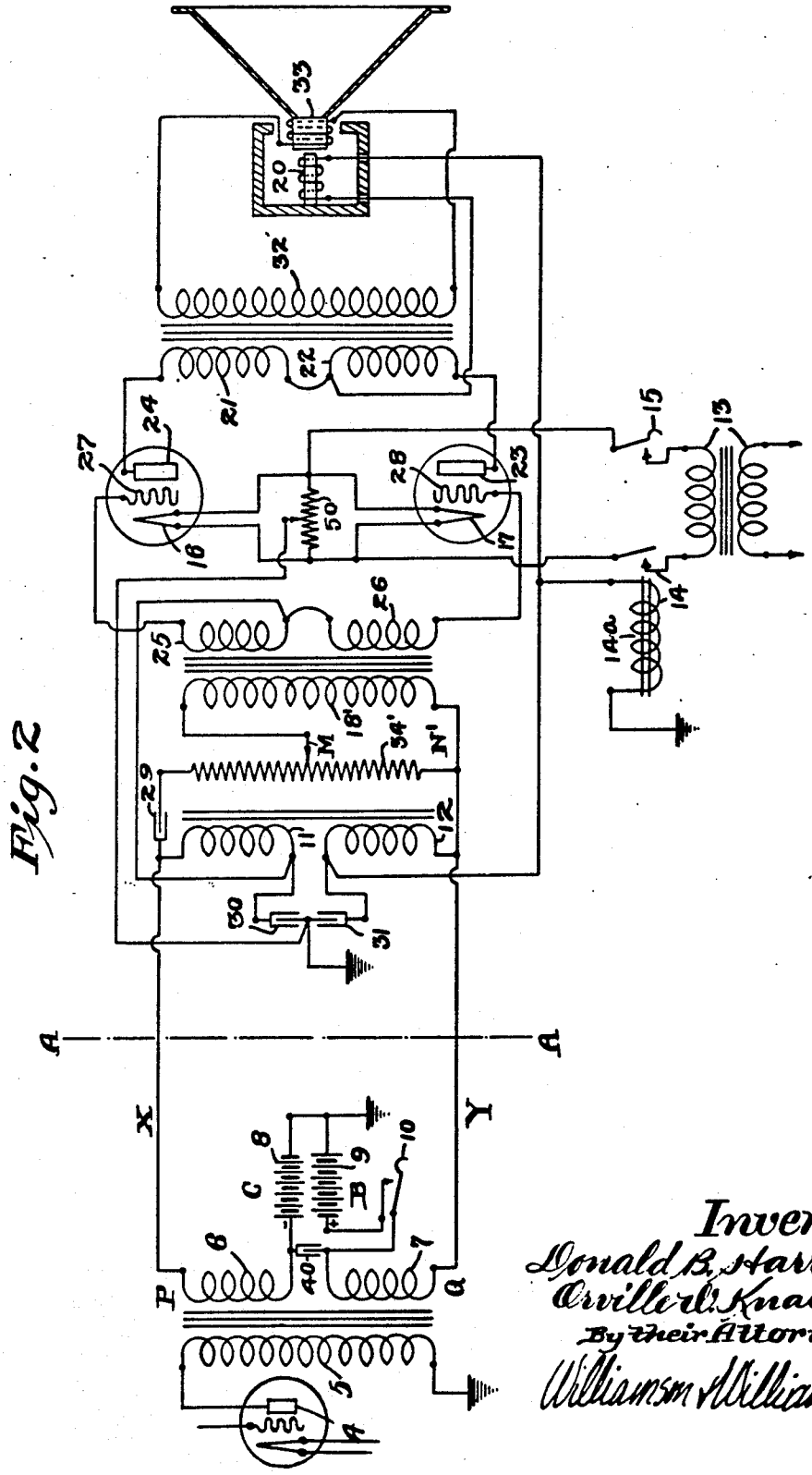


Fig. 2

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TRANSMISSION SYSTEM FOR SOUND CARRYING CURRENTS

Filed June 13, 1930 3 Sheets-Sheet 3

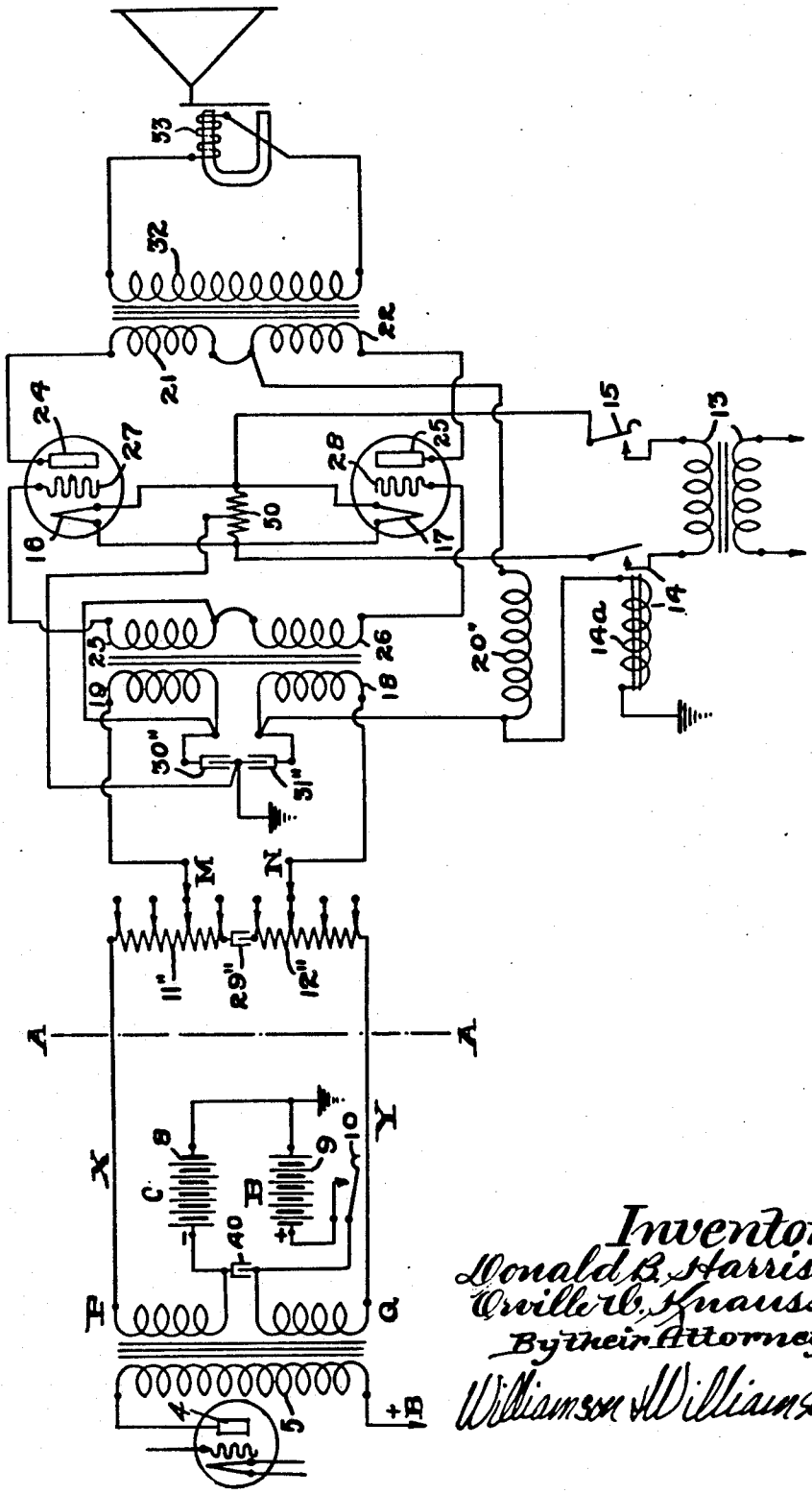


Fig. 3

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Patented July 25, 1933 1,919,719

UNITED STATES PATENT OFFICE

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TRANSMISSION SYSTEM FOR SOUND CARRYING CURRENTS

Application filed June 13, 1930. Serial No. 460,882.

This invention relates to systems for transmitting sound-carrying and image-carrying currents from a central station to a number of distantly located stations through the medium of conductors and is an improvement upon the invention disclosed in our U. S. Letters Patent No. 1,733,194, issued October 29th, 1929. In said patent an operative system was disclosed especially adapted for program service work where programs, such as music, addresses and other sound entertainment, are transmitted from a central station to a number of distant stations, such as subscribers' homes, and wherein conductors in conventional communication systems could be conveniently utilized to transmit not only the sound-carrying currents, but in conjunction with ground to transmit other electro-motive forces for operating amplifiers located at the distant stations.

As pointed out in said patent, one of the important advantages of the original system was to eliminate interference caused by capacitative induction of energy into other conductors neighboring or in the same cable with the conductors utilized in our system, which capacitative induction is often referred to as "cross-talk".

While the said original system was found to be operative after extensive use and to be reasonably successful, we have found certain objections thereto which the present invention overcomes.

Even though an efficient transformer system was utilized in connection with the circuits, we found that cross talk or capacitative induction from neighboring conductors or other wires in the same cable to conductors utilized in our system was not entirely overcome due to the fact that the line conductors of our system were not balanced with respect to ground. This unbalance to ground furthermore caused cross talk or capacitative induction from our said line conductors to neighboring conductors used for telephone and other communication purposes.

The original system included provision for volume control at the distant station, but this volume control was not entirely satisfactory since it depended for its operation upon a regulation of filament current and consequently of filament emission, resulting in an undesirable change in the plate impedance which of course caused some distortion.

Furthermore, the old system made no provision whereby the filament circuits of remotely located amplifiers could be disconnected by the operators at the central office. It has been found that the subscribers, where they are paying for program service, often keep the filament circuits of their amplifiers constantly connected. It is found desirable to remotely disconnect, from the central office, the said filament circuits of the distant amplifiers for effecting economy in amplifier tube replacement and for economizing upon the use of amplifier supply currents.

Another objection to the old system was that a small amount of low frequency regeneration resulted in the system due to a feed back from the plate circuit to the grid circuit and through the medium of a potential generated along the plate circuit side of the line.

It is an object of our present invention to provide an economical and highly efficient system for use in program service work for transmitting sound-carrying currents, such as audio-frequency and carrier-frequency currents or for image-carrying currents, such as are used in television, said currents being transmitted from a central to a multiplicity of distant stations through conductors, such as, for example, the conductors or pairs in a conventional communication cable and wherein provision is made for overcoming the objections to said original system which are hereinbefore referred to.

It is a further object to provide a system of the class described; wherein conductors, such as, for example, pairs in a telephone cable, may be utilized for transmitting sound and image-carrying currents; wherein the same conductors may also be utilized in conjunction with ground for transmitting electromotive forces for maintaining the elements of the distant amplifiers at operative potentials; wherein capacitative induction or cross

talk between conductors in our system and neighboring conductors or other conductors in the same cable will be entirely eliminated; or more specifically wherein the line conductors extending between the central station and the distant stations will be perfectly balanced in respect to ground at all times for the purpose of preventing further interference.

Another object is to provide a system of the class described wherein the signal currents will be amplified at the distant station to values whereby loud speakers or other reproducers may be operated to capacity; wherein the amplitude of signals delivered to the reproducers may be regulated without producing distortion; wherein the connection or disconnection of the filament circuits of the amplifiers at the distant stations may be controlled from the central office, and wherein means are provided for preventing a transfer of energy from the plate circuit to the grid circuit thereby removing any chance for low frequency generation.

These and other objects of the invention will be apparent from the following description made in connection with the accompanying drawings wherein three forms of the invention are schematically shown and wherein:—

Fig. 1 is a diagram of my preferred system, and

Figs. 2 and 3 are diagrams of modified systems.

Referring to the preferred form of the invention illustrated in Fig. 1, the elements and apparatus located at the left of the heavy broken line A—A are located at the central station while the apparatus and elements at the right of said line are located at one of the distant stations, such as the home of a subscriber to the program service.

At the central station a source of sound or image-carrying current is available from the output of a suitable amplifier and in the drawings the plate of the last audion tube is indicated by the numeral 4. Batteries 8 and 9 or other sources of direct current supply are also located at the central station and a step-down transformer is located at the central station, the secondary windings 6 and 7 thereof being separated by a condenser 40 and connected with a pair of conductors X and Y, which, if desired, may be a pair of wires in a conventional communication cable, said conductors extending from the central to the distant station. The primary 5 of the step-down transformer at the central station is directly connected to the plate 4 and the secondary comprising sections 6 and 7 is divided as indicated in the drawings. B and C potentials are applied to the conductors X and Y of the line through windings 6 and 7 from batteries 8 and 9 respectively. A key 10 is located at the central office for the purpose of operating a remotely located relay at the receiving amplifiers at the distant stations, the contacts of said key opening and closing the filament circuit of the distant amplifier. An amplifier and loud speaker are located at the distant station. The push-pull circuit is preferably employed in the amplifier. This circuit affords a greater power output for the same plate and grid potentials. The push-pull circuit moreover reduces distortion to some extent by eliminating certain harmonics of the fundamental frequencies generated in the tubes.

In particular the structure of the amplifier at the distant station embodies, choke coils 11 and 12 and condensers 30 and 31 for the purpose of segregating the supply circuit from the program circuit; an input transformer comprising windings 18, 19, 25 and 26, the primary windings of which are separated by a condenser 29; a potentiometer comprising windings 34 and 35 and having two movable arms 36 and 37; two thermionic vacuum tubes connected in "push-pull" of which elements 27 and 28 are the grids of the tubes, elements 16 and 17 are the filaments and elements 23 and 24 are the plates; an output transformer with the windings 21, 22 and 32, of which windings 21 and 22 are the primary, and winding 32 is the secondary; a dynamic speaker including a voice coil 33 and a field coil 20, which is also employed as a choke in the plate circuit for the purpose of further segregating the supply and program circuits; a relay including a spring assembly 14 and a winding 14*a*; a power transformer 13 and a key 15; a resistance balance 50.

In describing our system, the apparatus and elements utilized will be described in conjunction with the several circuits between the central station and the subscriber's home.

Filament circuit

The filament circuit for the thermionic tubes of the amplifying set at the distant station may be conveniently supplied from the household source of alternating current. The filament circuit includes the secondary winding of transformer 13, the contacts of relay 14 and the filaments 16 and 17 of the two tubes and key 15 connected with the other side of the secondary winding of transformer 13. This circuit is closed and supplies current to the filaments of the tubes as long as both the contacts of relay 14 and the contacts of key 15 are closed. Key 15 is available to the use of the subscriber enabling the subscriber to turn the amplifier on or off at will, while relay 14 is energized by currents transmitted from the central station, thereby making it possible for the operators at the central station to energize or de-energize the filament circuits of the distantly located amplifiers as may seem desirable.

The operation of relay 14 will be further treated in the explanation of the control circuit.

Grid supply circuit

Grid circuit potentials are transmitted to both grids 27 and 28 respectively, of the thermionic tubes by line conductor X through a circuit from the negative terminal of the C battery 8 at the central office through winding 6 of the step-down transformer through conductor X and choke coil 11, through windings 25 and 26 of the input transformer and potentiometer windings 34 and 35. These potentials are prevented from affecting the input transformer windings 18 and 19 by means of condenser 29.

Signal circuit

Alternating signal potentials are generated by the amplifier 4 and are impressed upon primary winding 5 of the central office output step-down transformer causing current to flow through winding 5 and inducing a similar potential across windings 6 and 7. This potential causes alternating current to flow in the line from a point P on the drawings through conductor X, transformer winding 19, condenser 29, winding 18 and back to the central station through conductor Y to the point Q. This current induces a potential into windings 25 and 26, said potential impressing an alternating voltage on points M and N. This alternating voltage causes current to flow from M to N through potentiometer windings 34 and 35, setting up a corresponding alternating voltage between the potentiometer taps 36 and 37 and accordingly producing an alternating voltage between grids 27 and 28 of the two tubes. The alternating polarity of the grid 27 is always opposite to that of grid 28. Due to the normal operation of a vacuum tube used as an amplifier, a corresponding alternating voltage of greater amplitude is generated in the plate circuits of the two tubes impressing an alternating voltage between plate 24 and plate 23, the alternating potentials of said plates being of course always opposite. Due to said potential, a further current is caused to flow through windings 21 and 22 of the output transformer of the amplifier. The secondary coil 32 of the output transformer is connected with the voice coil winding 33 of the dynamic speaker and an induced current and voltage is generated in said secondary and delivered to the loud speaker. At the distant station it will be noticed that a choke coil 20 is provided, one of the terminals thereof being connected with a central tap on windings 21 and 22 of the output transformer and the other terminal of which is connected with one terminal of condenser 31 which, with condenser 30, is interposed between the choke coils 11 and 12. The function of the choke 20 is to prevent passage of any signal currents which may be generated in the supply circuit due to an unbalance in windings 21 and 22 of the primary of the output transformer or due to a difference in the amplifying properties of the tubes. If such currents were allowed to traverse the supply circuit they would flow from the central tap of windings 21 and 22 through choke 20 and through condenser 31 to the filament and due to the finite impedance of condenser 31, would set up a potential across this condenser which in turn would cause a current through windings 18 and 19 and which would induce a potential on grids 27 and 28 of the tubes causing the effect known as low frequency regeneration or "motor boating".

The further purpose of choke 20 may be to supply or energize the field coil of the dynamic speaker. In such a case the field is employed as the choke for the above described purpose.

The combination comprising choke coils 11 and 12 and condensers 30 and 31 embodies a conventional electrical filter. This filter is placed across the line conductors primarily for the purpose of segregating the signal currents on the conductors from the currents generated in the plate circuit of the tube. Although in a circuit of the push-pull type, signal currents in the supply circuit of the amplifier are small and are limited to those generated due to unbalances in the tubes or in the output transformer, these currents are of sufficient magnitude to cause undesirable regeneration effects if they are allowed to return to the grid circuit of the amplifier. In this invention signal currents of small magnitude may be created in the circuit from the center tap of windings 21 and 22 through choke coil 20 to condenser 31. They are, however, prevented from returning to line conductor Y by the combination of condenser 31 and choke coil 12. Condenser 31 offers a very low impedance path for the return of these currents to the filament, while choke coil 12 offers a path of extremely high impedance. As a result practically no signal current is returned to the line conductors and the input transformer, and regeneration is avoided. At the same time a path of relatively low impedance is supplied by choke coil 12 for the transmission of direct currents to the plate circuits of the tubes, while condenser 31, has, of course, an infinite impedance for currents of this type and accordingly does not provide a path to the filament of the tubes.

Choke coil 11 and condenser 30 are inserted primarily for the purpose of balancing the line conductors in respect to ground. The impedance of this combination is exactly equal to the impedance of condenser 31 and choke coil 12 so that impedance from conductor X to ground is always maintained equal

to the impedance from conductor Y to ground.

A further object of the filter is to prevent the passage of signal currents on the conductors from conductor X to conductor Y. This object is accomplished by the extremely high impedance of choke coils 11 and 12.

Condenser 29 is interposed between the primary windings 19 and 18 of the receiving input transformer and has for its purpose to prevent a direct current short circuit across the line through said transformer windings 18 and 19 while allowing the passage of signal currents through the transformer for setting up alternating potentials for operation of the grid circuit.

Plate supply circuit

Both plates are supplied from potentials transmitted over line conductor Y, to a circuit from positive B battery 9 at the central office, key 10, winding 7, conductor Y, choke coil 12, choke coil 20, windings 21 and 22 and plates 23 and 24. As explained in the description of the signal circuit, these plate supply potentials have no effect on the input transformer of the amplifier due to the use of condenser 29.

Control relay circuit

The control relay is energized by currents transmitted from central office battery 9 through the contact of key 10 through winding 7, line conductor Y, choke coil 12, winding 14*a* of relay 14 to ground. By operating key 10 relay 14 may be energized or de-energized, thereby opening or closing the filament circuit.

Volume control operation

As discussed briefly in the description of the signal circuit the potential set up between points M and N causes current to flow through potentiometer windings 34 and 35 and sets up a corresponding potential between the potentiometer taps. The magnitude of the potential between the taps is directly proportional to the resistance included between them. The potentiometer is so constructed that as the arms of the potentiometer are moved a similar resistance change is produced between each tap and the center tap of the transformer. A similar change in potential is correspondingly produced between each grid and the filament of the same tube. It will be noted that the manipulation of the volume control has no effect on the supply constants of the tubes.

Referring to the modified form of the invention illustrated in Fig. 2, the apparatus included in this form is similar to that described in connection with the preferred form and the individual elements are disposed similarly in respect to each other with the exception that an input transformer with a single primary winding is employed and that the potentiometer used for volume control is placed on the line side of the input transformer and consists of a single winding. The primary of input transformer is numbered 18′ and the two secondary windings are numbered 25 and 26 in the drawing. The potentiometer winding is numbered 34′ in the drawing. With these exceptions the elements of the circuit are designated by the same numbers in the drawing as were employed in the case of the preferred form.

In describing this modified form only such circuits will be treated in detail as deviate from the corresponding circuits outlined in the description of the preferred form.

Filament circuit

This circuit is similar to the preferred form.

Grid supply circuit

This circuit is exactly similar to the grid supply circuit described for the preferred form with the exception that grid potentials do not traverse the potentiometer windings in conjunction with the secondary windings 25 and 26 of the input transformer.

Signal circuit

In this circuit alternating signal potentials are transmitted from the central station to the remote station in a manner exactly similar to that employed in the case of the preferred form. At the remote station the signal potentials received from the line cause a signal current to flow through condenser 29′ and potentiometer winding 34′ setting up a potential between points M′ and N′ indicated on the drawing. This potential causes current to flow through winding 18′ of the input transformer inducing a secondary potential across windings 25 and 26 of the input transformer. This potential is applied directly to the grids 27 and 28 of the amplifying tubes. The remainder of the operation of the signal circuit is similar to the operation of the preferred form.

Plate supply circuit

This circuit is similar to the preferred form.

Control relay circuit

This circuit is similar to the preferred form.

Volume control operation

As explained in the description of the signal circuit, signal currents are caused to traverse the winding 34′ of the potentiometer. These currents cause potentials to be set up between any given point on the length of the potentiometer winding and any other

point on the winding. These potentials are in all cases exactly proportional to the resistance included between the two points. In this case a permanent connection is made to one end of the potentiometer. As the movable arm of the potentiometer is moved along the length of the winding, the resistance between its point of contact and the end of the winding is changed causing a corresponding change in the potential applied to winding 18' and resulting in a similar change in the signal current flowing through winding 18'. It will be apparent that as the volume control is manipulated no change is produced in the grid, filament or plate potentials of the tube.

Referring to the modified form of the invention disclosed in Fig. 3, this form of the invention is similar to the preferred form except that the filter combination 11, 30, 31 and 12 is omitted and is replaced by the potentiometer combination 11'', 29'' and 12''. This potentiometer performs a dual purpose in regulating the volume and in maintaining the line balance. The type of loud speaker shown is of the magnetic type, as compared with the dynamic speaker shown in the preferred form. The connections on the primary of the input transformer are also somewhat differently made. This deviation will be discussed in explaining the operation of the various circuits.

In describing this modified form, a complete explanation will be given only in the cases of circuits where marked deviations from the preferred form occur.

Filament circuit

This circuit is similar to the preferred form.

Grid supply circuit

Grid circuit potentials are supplied from the negative terminal of C battery 8 through winding 6 of the central office output transformer, conductor X, potentiometer winding 11'', transformer winding 19, transformer windings 25 and 26 to the grids 27 and 28.

Signal circuit

Alternating signal potentials are impressed between conductors X and Y at points P and Q as in the preferred form of the invention. These potentials cause current to flow from point P through line conductor X, potentiometer winding 11'', condenser 29''. potentiometer winding 12'', line conductor Y to point Q. This current sets up a corresponding potential between the potentiometer taps M and N which in turn causes current to flow through winding 19, condenser 30'', condenser 31'' and winding 18. By induction a corresponding potential is created across windings 25 and 26 and is impressed on the grid. These potentials are amplified and delivered to the loud speaker winding as described in the explanation of the preferred form. Small unbalanced currents generated in the plate supply circuit are prevented from returning to the grid circuit by choke coil 20'', which, in this case does not form a part of the dynamic speaker, by condenser 31'' which presents a low impedance for the return of signal frequencies to the filament and by transformer winding 18, which presents a high impedance to signal currents and performs the function of a retardation coil in addition to its purpose as a transformer.

The combination 19, 30'', 31'' and 18 performs the same function as the filter 11, 30, 31 and 12 disclosed in the drawing of the preferred form. By means of this filter a low impedance path is provided for direct potentials transmitted to the grids and plates of the tubes, but a high impedance path is presented between the line and the plate circuit to potentials originating either in the line or in the plate circuit. By this means attenuation of the line signal currents is prevented and currents generated in the plate circuits of the tubes are not allowed to return to the input circuit thereby preventing undesirable regeneration effects. Windings 18 and 19 and condensers 30'' and 31'' are also balanced in such a way that the impedance from conductor X to ground is equal to the impedance from conductor Y to ground thereby maintaining the line conductors in perfect balance and further preventing or lessening undesirable interference effects.

Plate supply circuit

Plate supply potentials are transmitted from positive B battery 9 at the central office through the contacts of key 10, winding 7, line conductor Y, potentiometer winding 12'', transformer winding 18, choke coil 20'', windings 21 and 22 to the plates of the tubes. These potentials are prevented from traversing the potentiometer windings 11'' and 12'' by the use of condenser 29''.

Control relay circuit

Control relay is energized by currents transmitted from central office B battery 9 through the contacts of key 10, winding 7, line conductor Y, potentiometer winding 12'', winding 18, relay coil 14*a* to ground. By operating key 10, relay 14 may be energized or de-energized opening and closing the filament circuit of the remotely located amplifier.

From the foregoing description it will be seen that the three embodiments of the invention disclosed successfully fulfill the objects set forth. Of the three forms disclosed, the form shown in Fig. 1 presents certain advantages in relation to the modified forms, but each of the modified forms possesses

lesser points of advantage in certain respects.

Referring to the preferred form, the employment of the volume control in the grid circuit of the tubes is advantageous in that no current flows through the volume control, effecting substantial economy in the manufacture of the windings. In order to make this advantage available it has been necessary, in Fig. 1, to employ the separate segregating filter 11, 30, 31 and 12, as the use of the potentiometer across the secondary reduces the primary impedance of the input transformer to a point where it would no longer be effective as a segregating unit, particularly in view of the fact that an extremely high ratio input transformer must be employed in this case. A further advantage of the employment of said segregating filter is that no direct current is allowed to traverse the transformer windings 18 and 19 thereby preventing saturation effects which might result.

The form of the invention disclosed in Fig. 2 has the same advantages as disclosed above in reference to the preferred form and has the additional advantage that the form of potentiometer employed is of a simpler design resulting in economy of manufacture. This advantage, however, is thought to be outweighed by the fact that the form disclosed in Fig. 2 does not present as perfect a line balance as the preferred form.

The form disclosed in Fig. 3 presents an advantage in that a separate filter combination is not employed, the windings of the transformer also performing the function of the filter. In order to keep the transformer windings at as high an impedance as possible, the potentiometer is placed on the line side of the transformer. In this respect the preferred form is preferable to the form disclosed in Fig. 3 in that no current traverses the potentiometer windings in the preferred form and consequently an economy in manufacture is effected.

Figs. 1 and 2 show the use of the field coil of the dynamic speaker as a choke coil for impeding the passage of unbalance currents from the plate circuit to the supply circuit. This is an economical feature and should result in a lower cost of manufacture.

In the three embodiments of the invention heretofore disclosed, it is to be understood that the winding 5 of the central office output transformer is so related to windings 6 and 7 in respect to turns ratio that potentials impressed on conductors X and Y will be sufficiently low in our system, where the line is perfectly balanced with respect to ground, that interference through capacitative induction or cross talk between conductors X and Y and other neighboring conductors or conductors in the same communication cable will be entirely eliminated, it being remembered that our system is especially adapted for use in program service supplied by telephone companies, and whereby conductors in the conventional communication cables may be utilized for transmitting sound or image-carrying currents, as well as electro-motive forces for maintaining the grid and plate elements of the amplifier tubes at operative potentials. The use of a line potential of this small magnitude is made possible by so terminating the line at the central office that the impedance of the termination is equal to the line impedance. Under these conditions the transmission of a maximum energy level can be accomplished with a corresponding minimum voltage level and transmission of said alternating current from the central station to the distant station will be accomplished with maximum efficiency.

It will, of course, be understood that various changes may be made in the form, details and particular types of apparatus used and that while the push-pull amplifier circuit is illustrated, any other type of amplifier circuit may be utilized with our system, all within the scope of our invention.

In the appended claims the term "alternating currents" is of course meant to include all currents described in the foregoing specification as sound-carrying, image-carrying or signal currents.

It is further to be understood that in this application and the claims thereof, wherever the word "ground" is to be used, it shall include earth or a common conductor of any nature, such as the sheath of a conventional communication cable, or a third conductor in a cable.

What is claimed is:

1. In transmission systems for alternating current, a central station, a source of alternating current and a source of direct current at said central station, a distantly located station, a thermionic amplifier at said distant station having a grid element, a filament element and a plate element, a pair of conductors connected to transmit alternating current from said source to said amplifier, a circuit including said pair of conductors and ground for supplying electro-motive forces from said source of direct current to said amplifier whereby said grid and plate are maintained at operative potentials in respect to said filament and a combined transformer and impedance system having a unit at said central station connected to said pair of conductors and to ground and having a unit at said central station interposed between said conductors and said source of alternating current and connected to ground and having a unit at said distant station interposed between said conductors and said amplifier and connected to ground, said transformer and impedance system being adapted to supply a terminating impedance for said line conductors equal to the characteristic impedance of

said conductors inducing a maximum voltage on the grid element of said amplifier and maintaining said conductors in a balanced condition with respect to ground.

2. In transmission systems for alternating current, a central station, a source of alternating current and a source of direct current available at said central station, a distantly located station, a thermionic amplifier at said distant station having a grid element, a filament element and a plate element, a pair of conductors connected to transmit alternating current from said source to said amplifier, a transformer system including a transformer at one of said stations, windings of which constitute an electrical filter and having a unit at said central station connected to said source of alternating current and to said conductors and having a unit at said distantly located station connected to said amplifier and to said conductors and a cooperating impedance system connected to said conductors and to ground, said impedance system having a unit at said central station and a unit at said distant station, one of said impedance units including the transformer windings which constitute said electrical filter, said impedance system, in conjunction with ground and said conductors, supplying electro-motive forces to said amplifier whereby said grid and plate elements will be maintained at operative potentials with respect to said filament element and maintaining said conductors in a balanced condition with respect to ground.

3. In a transmission system for alternating current, a central station having available a source of alternating current, a source of direct current, a distantly located station, a thermionic amplifier at said distant station having grid, filament and plate elements, a pair of conductors connected to said source of alternating current and to said source of direct current, at said central station and connected to said amplifier at said distant station, said conductors transmitting alternating current from said source to said amplifier, means for maintaining said grid and plate at operative potentials in respect to said fi'ament, a filament circuit for maintaining said filament at a temperature adequate for proper operation, a controlling element at said distant station including an electro magnet and a pair of contacts inserted in said filament circuit, said contacts being actuated by said electro magnet, and a control circuit for actuating said control element including said electro magnet and including a circuit breaking element at said central station connected to one of said conductors and to said source of direct current.

4. In a transmission system for alternating current, a central station having a source of alternating current, a source of direct current, a distantly located thermionic amplifier having a grid, filament and plate, a filament circuit for maintaining said filament at a temperature adequate for proper operation, a controlling relay at said distant station having a pair of contacts inserted in said filament circuit and including an electro magnet, a pair of conductors extending between said central station and said distantly located amplifier, said pair of conductors being connected to said source of alternating current, to said amplifier and to said source of direct current for transmitting electro motive forces to said amplifier whereby said grid and plate will be maintained at operative potentials in respect to said filament and one of said conductors being connected to said electro magnet and a circuit breaking element at said central station interposed between said source of direct current and one of said conductors for controlling currents transmitted to said electro magnet.

5. In transmission systems for alternating current, a central station having available a source of direct potential, a source of direct current and a source of alternating current, a distantly located station, a thermionic amplifier at said distant station having plate, grid and filament elements, a pair of conductors extending between said sources and said amplifier and connected thereto, a circuit for said alternating current including said conductors, grid and plate supply circuits also including said conductors and including said source of direct potential and said source of direct current for maintaining said grid and plate elements at operative potentials in respect to said filament element and means for maintaining said pair of conductors in a balanced condition with respect to ground.

6. In transmission systems for alternating current, a central station having available a source of direct potential, a source of direct current and a source of alternating current, a distantly located station, a thermionic amplifier at said distant station having grid, plate and filament elements, a connection to ground at said central station and at said distant station, a pair of conductors extending between said sources and said amplifier and connected thereto, a circuit for said alternating current including said conductors, a plate supply circuit also including at least one of said conductors, including said direct current source and including said connections to ground, a conductive path connected to said grid element including at least one of said conductors including said connections to ground and including said source of direct potential adapted to maintain said grid element at an operative potential in respect to said filament element and means for maintaining said pair of conductors in a balanced condition with respect to ground.

7. In transmission systems for alternating current, a central station having available a source of direct potential, a source of direct current and a source of alternating current, a distantly located station, a thermionic amplifier at said distant station having grid, plate and filament elements, a pair of conductors extending between said sources and said amplifier and connected thereto, a circuit for said alternating current including said conductors, a plate supply circuit also including at least one of said conductors and including said direct current source, a conductive path connected to said grid element and including at least one of said conductors and including said source of operative potential adapted to maintain said grid element at an operative potential in respect to said filament element and means for maintaining said pair of conductors in a balanced condition with respect to ground.

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