Nov. 8, 1949 A. LESTI 2,487,455

TELEPHONE CIRCUIT

Filed Jan. 29, 1945 2 Sheets-Sheet 1

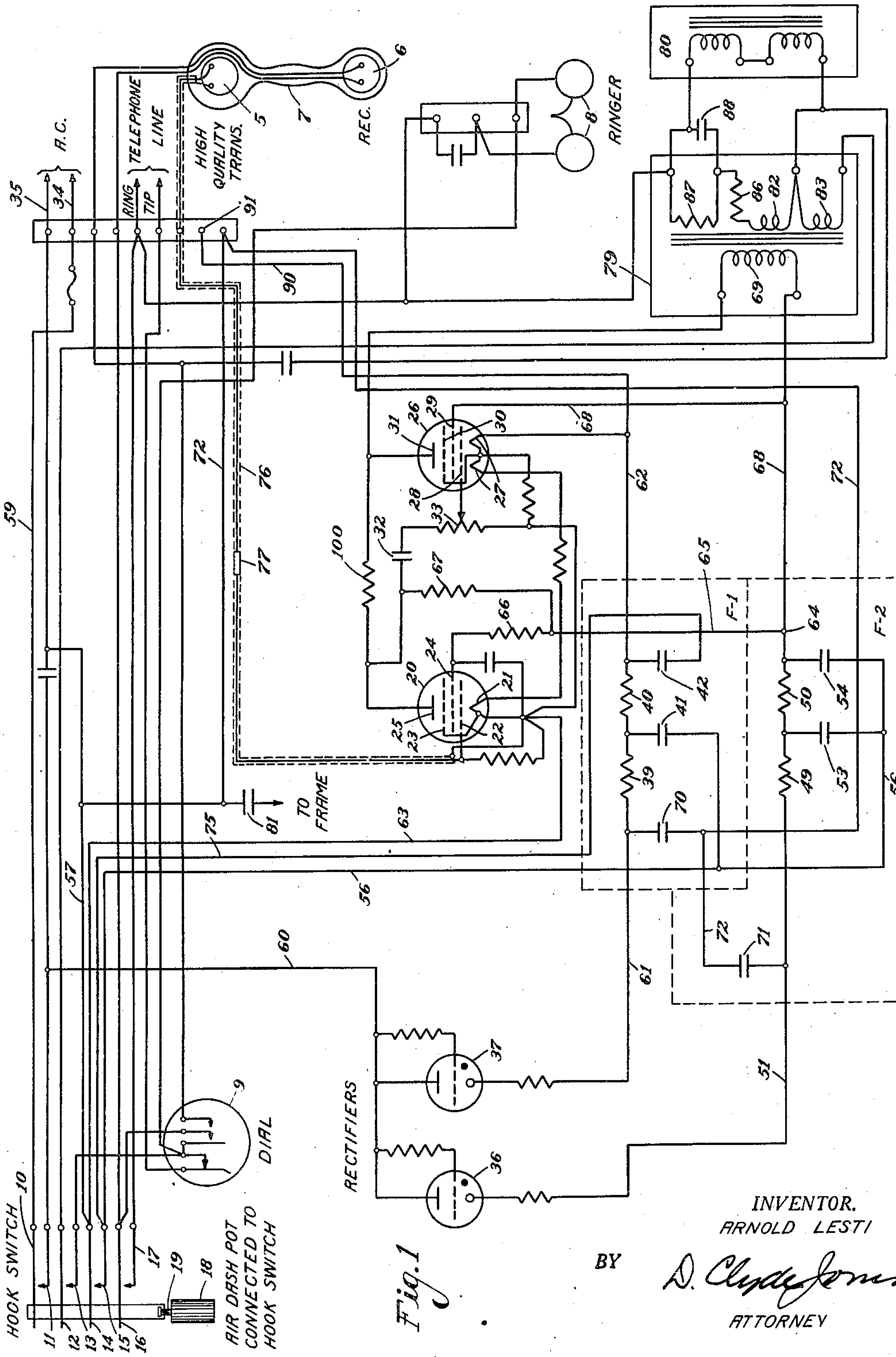

Fig. 1

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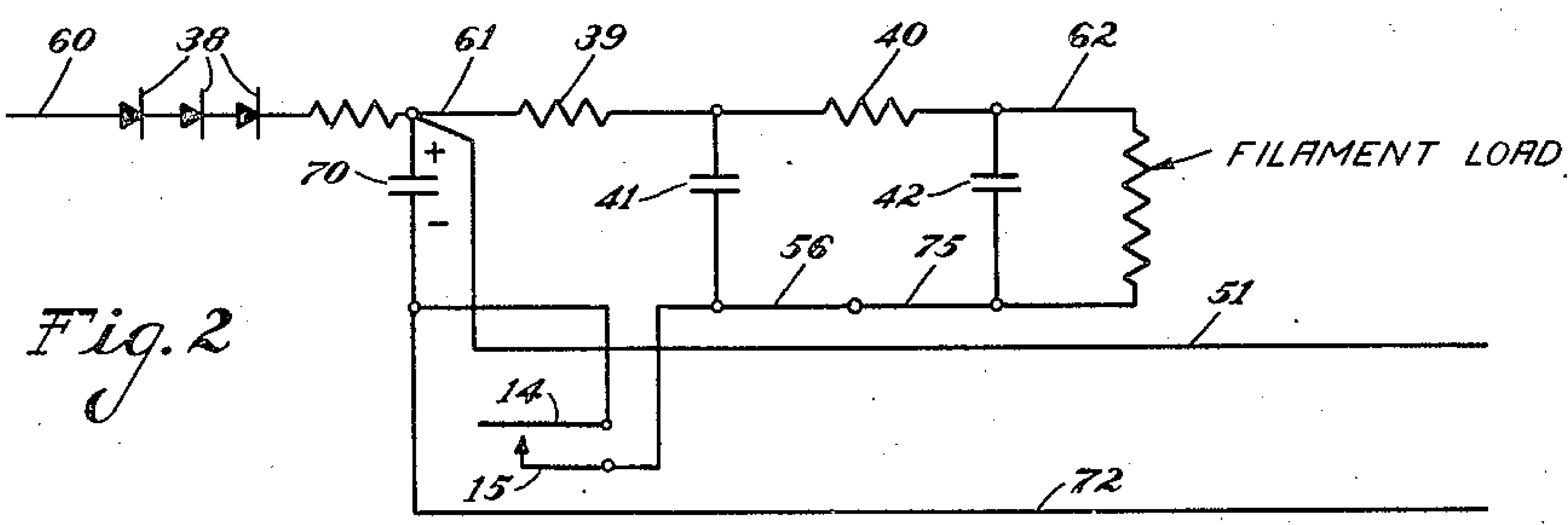

Fig. 2

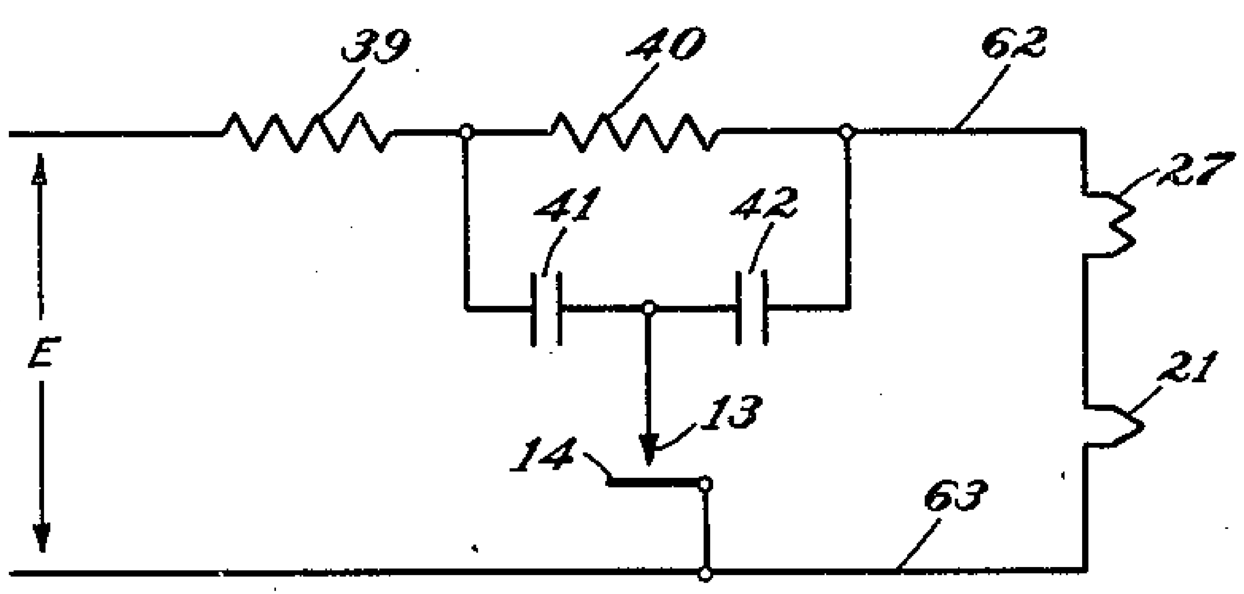

Fig. 3

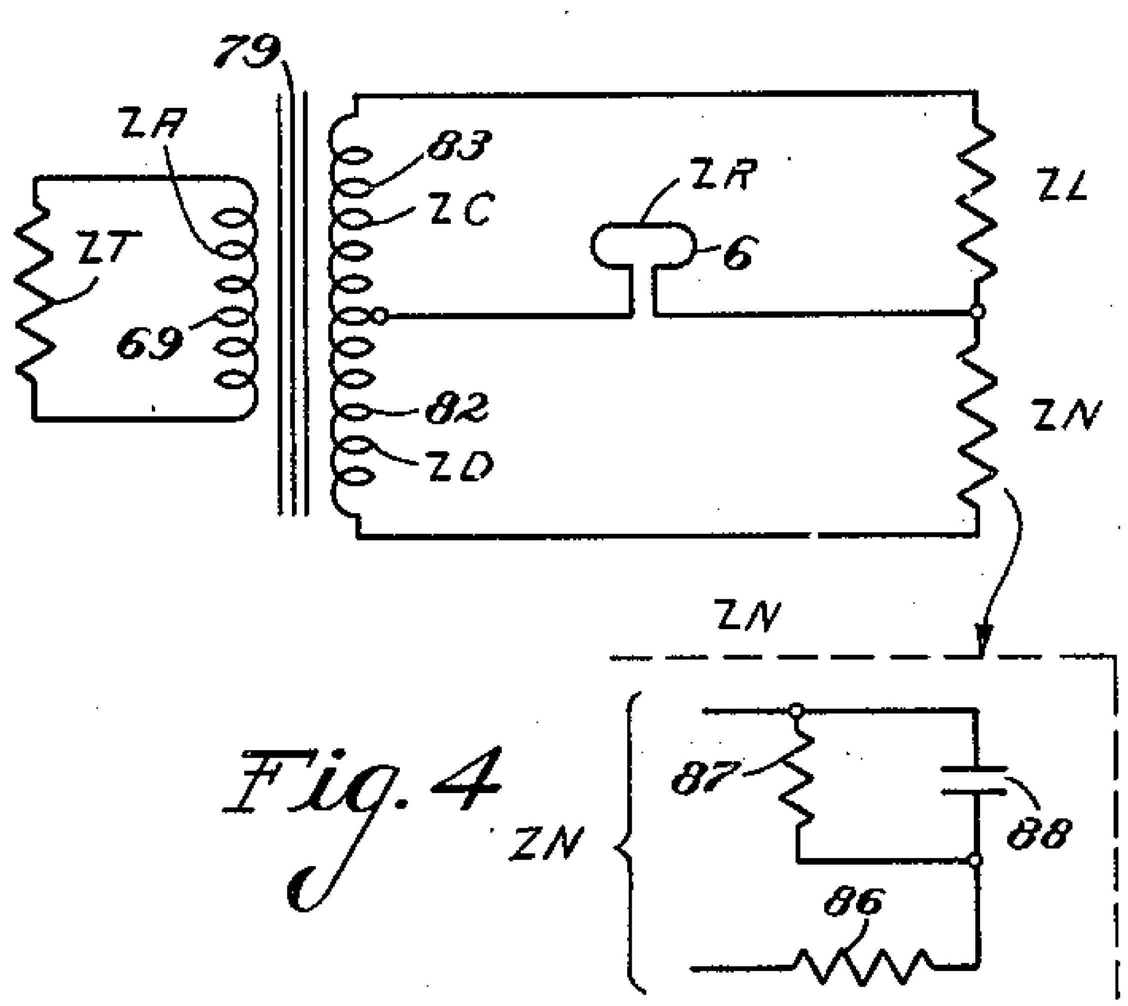

Fig. 4

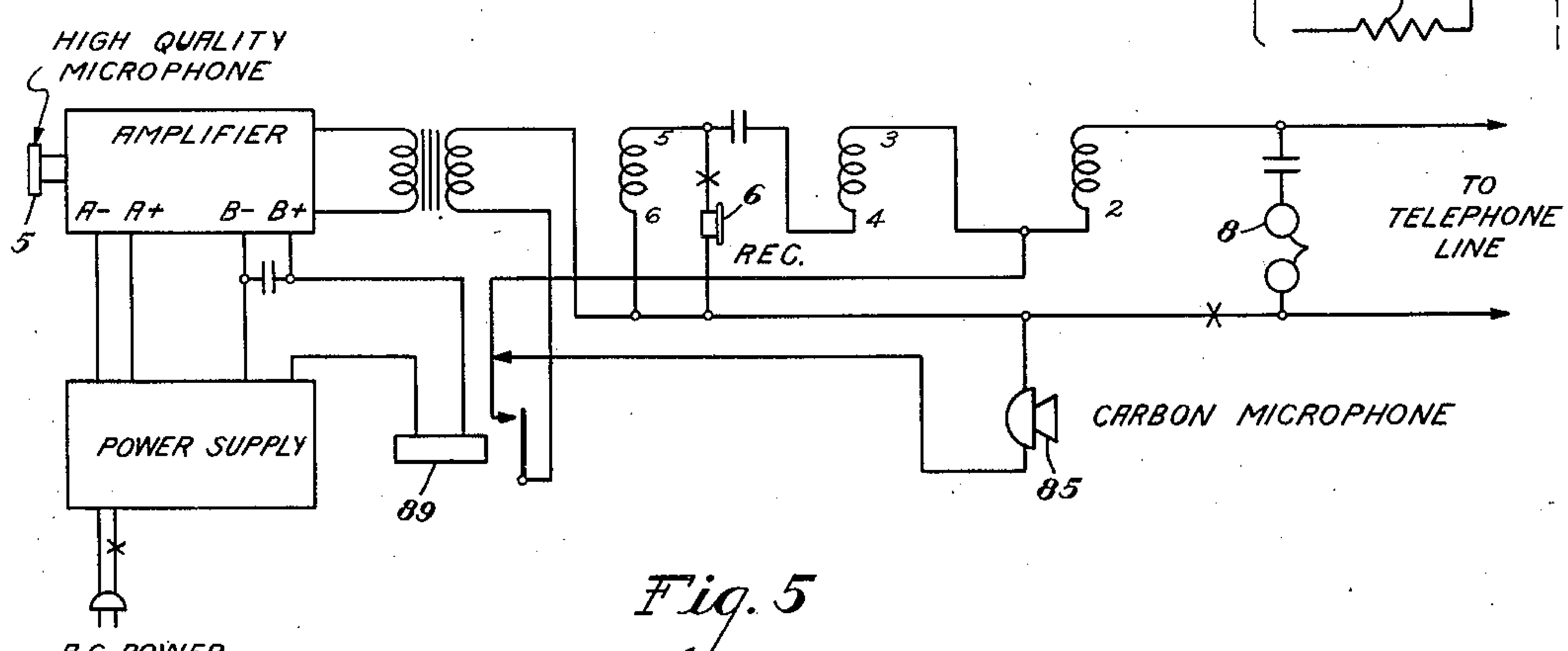

Fig. 5

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2,487,455

TELEPHONE CIRCUIT

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9 Claims. (Cl. 179—1)

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This invention relates to telephone circuits for a microphone and a receiver such as are utilized at subscribers' telephone substations and the like.

The carbon microphone or transmitter has been almost universally used in subscribers' telephone sets because, in addition to modulating current in accordance with sound, it also possesses the unique property of acting as an amplifier. However, the carbon microphone is subject to highly undesirable defects, such as carbon noise, packing, deterioration with age, positional defects, non-linear distortion, and distortion which results in modulation products when two frequencies are impressed thereon. Extensive research on the carbon type of microphone has failed to overcome these defects. It is therefore the purpose of the present invention to eliminate the carbon microphone in substation circuits and to substitute therefor a high quality microphone which may be any one of several kinds, commonly designated electro-magnetic, moving coil, crystal, condenser or velocity types. However, such high quality microphones have no inherent amplification and consequently do not deliver sufficient output to actuate to the desired level, the receiver at a distant station. It therefore becomes necessary to associate an amplifier with the microphone, preferably at the substation, so that the amplified output of the microphone will be at the desired level. However, the use of such an amplifier introduces the problem of providing a power supply source without disturbing hum. Furthermore, substation circuits of the type under consideration are preferably arranged to have anti-side-tone characteristics and it therefore becomes a real problem to provide an anti-side-tone network into which the output of the amplifier can be efficiently introduced.

Where an amplifier is provided at a subscriber's substation, it is highly desirable that the vacuum tube or tubes in the amplifier be operated only when this substation is in use. However, vacuum tubes whose cathodes are heated from a rectified and filtered alternating current source require a substantial interval of time before their cathodes are heated to the degree where there is ample electron emission therefrom to render these tubes operative. The required heating interval necessary to render the cathodes of such vacuum tubes effective, is longer than the time interval between the start of the lifting of the handset from the desk-stand and the placing of the transmitter up to the mouth. Consequently, if conventional vacuum tube amplifiers are used, it is possible for the subscriber to speak into the

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transmitter before the amplifier is operative, with the result that a portion of the conversation can be lost.

The main feature of the present invention therefore relates to a novel arrangement for effecting high speed heating of the cathode or cathodes of the vacuum tube or tubes in an amplifier, so that the amplifier can be used at a subscriber's substation, and will be operative before the subscriber starts talking.

A further feature of the invention relates to an arrangement for deriving the power for a telephone substation from the commercial lighting circuit available at the substation.

An additional feature of the invention relates to a telephone substation including a high quality microphone and an amplifier therefor powered from the commercial lighting circuit, together with a normally ineffective standby carbon microphone automatically rendered effective and powered over the telephone line from the central exchange, whenever the lighting source fails.

Other features and advantages of the invention will appear from the detailed description and claims when taken with the drawings in which:

Fig. 1 is a diagrammatic showing of a novel substation circuit arrangement in accordance with the present invention;

Fig. 2 is a diagrammatic showing of a modified form of rectifier which can be substituted for the gas tube rectifiers in Fig. 1;

Fig. 3 is a simplified diagram of a portion of the filter network of Fig. 1;

Fig. 4 is a diagram useful in describing the connection of the amplifier into the anti-side-tone circuit arrangement of Fig. 1; and

Fig. 5 illustrates a simplified showing of a circuit wherein a high quality microphone and amplifier are powered from the commercial lighting current source at the substation and wherein there is provided a carbon microphone in standby relation ready to be cut into service and to be powered over the telephone line from the battery at the exchange when the commercial lighting current source fails.

Referring especially to Fig. 1, the substation telephone set therein disclosed includes a microphone 5 of a high quality type such as a crystal microphone, or if coupled to the amplifier in a manner well known to the art an electromagnetic microphone, a moving coil microphone, a condenser microphone or a velocity type microphone may be used instead. The microphone, while it may be of any one of the mentioned types is preferably of the crystal type which is especially suitable because of its small size. The substation set also includes a receiver 6 preferably of the watch case type so that the microphone 5 and the receiver 6 can be mounted in the handle of the usual hand set 7, more commonly referred to as the French type of telephone. The substation set also includes a conventional ringer 8 and is equipped with or without a dial impulse sender 9, as occasion demands. There is also included in the substation set a so-called hook-switch actuated to its alternate positions in the conventional manner by the removal from and the replacement respectively, of the hand set 7 on the cradle of the telephone stand (not shown). The hook-switch comprises sets of contact springs 10—11, 12—13, 14—15 and 16—17. The operation of traveling contact springs of each set is delayed by an air dash-pot comprising a fixed cylinder 18 and a plunger 19 movable therein under the influence of these traveling springs. Contacts 10—11 close first to complete an alternating current power circuit which, in combination with a suitable rectifier unit to be described, conducts pulsating rectified current through the filaments of the amplifier tubes to be referred to, and this heats up these tubes quickly. The air dash-pot increases the time from the closure of spring contacts 10—11 to the closure of spring contacts 14—15 of the hook-switch. During this interval the rectified alternating current has ample time to heat up the filaments of the tubes. When contacts 14—15 close, they thereby connect certain capacitors across all filter circuits for hum elimination as will be described. This occurs faster than the time required to remove the hand set from the hook-switch and place the receiver to the ear. Contacts 12—13 close slightly before contacts 14—15 while contacts 16—17 close slightly thereafter. The latter prevent noise in the receiver when the operator is flashed by opening the receiver circuit, until all other circuits are closed. The closing of contacts 12—13 at nearly the time of closure of contacts 14—15, minimizes the duration of momentary noise on the line.

Since the present substation arrangement is intended to be used where a high signal output is desired, it is essential that the response of the microphone 5 be amplified. This is effected by a two-stage amplifier comprising the electron tubes 20 and 26, which are of the directly heated pentode type, and may be of the type now commonly sold under the code numbers 1L4 and 3Q4, respectively. The tube 20 is provided with electrodes including a filamentary cathode 21, a control grid 22, a screen grid 24, a suppressor grid 23 and an anode or plate 25. Likewise, the tube 26 is provided with corresponding electrodes designated 27, 28, 29, 30 and 31. The amplifier tubes 20 and 26 are resistance-coupled by the capacitor 32 and the resistors 67 and 33 the last-named of which is connected potentiometer fashion to the control grid 28 to serve as a volume control. These amplifier tubes are powered by rectified and filtered current derived from the alternating current leads 34 and 35 of the commercial source of electric lighting current available at the telephone subscriber's residence where the substation set is located.

Since the amplifier tubes are lighted only during the time that the subset is in use, these tubes as well as the rectifiers must become effective in a period of about one-quarter of a second which is shorter than the interval between the lifting of the telephone handset from its cradle and the time when the subscriber first speaks into the microphone. The use of indirectly heated cathode tubes is therefore precluded, since they require up to twenty seconds to heat up from a cold start. Instead, directly heated filamentary type tubes are necessary, but this alone is not enough. A circuit with these latter tubes and a resistance capacitor filter adequate to filter the hum, takes about 1.1 seconds to warm up. The long time-constant of the filter, together with some thermal inertia of the filaments slows the action. In accordance with the present invention, there is provided a high speed circuit, which reduces the warming-up time to about $\frac{2}{10}$ second. In this circuit, cold-cathode gas rectifier tubes 36 and 37 are used to insure fast starting. However, a single selenium half wave rectifier 38 may be substituted for the gas rectifier tubes as shown in Fig. 2. Capacitors 70 and 71 merge into one unit, if this substitution is made. Two separate filter networks F—1 and F—2 for the filament and anode supplies respectively, are provided. The filter F—1 includes the resistors 39 and 40 in series in the positive conductors 61 and 62 of the filament circuit to be described. This filter also includes capacitors 41 and 42, capacitor 41 having one terminal thereof connected to the common terminals of resistors 39 and 40. Capacitor 42 has one of its terminals connected to conductor 62. The plate filter F—2 includes the resistors 49 and 50 in series with the plate supply conductor 51 and the capacitors 53 and 54. The capacitors 41, 42 and 53, 54 have their negative leads 56 and 75 connected to the hook-switch contact spring 15 and must be extended through springs 14—15 to complete the circuit to the common negative return lead 57. These capacitors are in an opened circuit when the amplifier is not in use, and also during the interval of time between the closing of contacts 10—11 of the hook-switch and the closing of contacts 14—15, which interval begins substantially when the hand set is lifted by the subscriber. During this interval, the rectifiers 36 and 37 are functioning so that pulsating current flows through the filament circuit to heat up the filaments of the amplifier tubes 20 and 26. This filament circuit may be traced from power lead 34, conductor 59, hook-switch contacts 10—11, conductor 60, through rectifier 37, conductor 61, filter resistors 39 and 40, conductor 62, filaments 27 and 21, conductors 63 and 57, to the power lead 35. The plate supply for the amplifier tubes extends from the power lead 34, conductors 59 and 60 through the rectifier 36, conductor 51, through the resistors 49 and 50 in series, to the junction 64. From this junction, the circuit to amplifier 20 extends over conductor 65 through resistors 66 and 67 to the screen grid 24 and anode 25 respectively of tube 20. From junction 64, the conductor 68 extends to the screen grid of tube 26 and through coil 69, to the anode 31 of tube 26. Condensers 70 and 71 respectively connect the conductors 61 and 51 from the rectifiers 37 and 36 to conductors 72 and 57, leading to the power lead 35, thereby providing a return circuit for the alternating component of the rectified current. Since the filter capacitors 41 and 42 are in an open circuit for an interval of time when the handset is removed from the hook-switch, there is no delay in supply of filament current to tubes 20 and 26 due to the time required to charge them which would otherwise be required. The interval of time between the closing of spring contacts 10—11 and 14—15 of the hook-switch is increased by the air dash-pot connected to the traveling springs, but this "slow" interval is shorter than the longest permissible heating-up time. The slow interval allows enough pulsations, which are separated by 1/60 second, to flow through the filaments of the amplifier tubes to insure their heating-up. Subsequently, when contacts 14—15 of the hook-switch close, the shunting effect of the capacitors 41 and 42 causes a momentary drop in filament current which, because of thermal inertia of the filaments 21 and 27, is insufficient to lower the temperature of these filaments sufficiently to stop electronic emission. Other factors outlined hereinafter, are effective which contribute to an even faster action.

During the interval of spring travel, the capacitor 41 which is connected to the junction of the resistors 39 and 40 is in series with the capacitor 42, as illustrated in Fig. 3. Consequently, during such an interval, the resistor 40 is shunted by a capacitance combination in series 41, 42 and in addition to the current flowing through the resistor 40, there is at first also a current surge through the capacitors 41, 42. These combined currents flow in the filaments of the amplifier tubes, and hence decrease the interval required to raise the temperature of these filaments to the value where electron emission occurs. Moreover, both these filament circuit capacitors 41, 42 and the plate circuit capacitors 53, 54 remain charged after the handset 7 is replaced on the hook-switch, because the common return lead 56 of these capacitors, is open at that time. The stored charge speeds up subsequent starting times even further, for a considerable period after the handset has been used a first time. In the first operation, from a cold uncharged condition, a charge is developed on the capacitors which minimizes the shunting action when contacts 14 and 15 of the hook-switch close. The warming-up of the filaments from a cold first start to a point where the speech is transmitted is about 1/10 second. Repeated on and off operation of the hook-switch to flash the operator charges the capacitors 41, 42 and prevents surges. The filaments are thus protected and the circuit is fool-proof. The surge through the capacitors 41 and 42 also compensates for the lowered starting voltage due to the increased 60 cycle impedance in the rectifier circuit when the capacitors are opened by springs 14—15 of the hook-switch. This increased impedance lowers the starting surge through the rectifier tubes 36, 37 and insures that they will have longer life.

The above high speed circuit requires special precautions to insure quiet operation of the amplifier. Referring to Fig. 1, the capacitor 42 must filter the filament circuit to the point where no hum can be heard. The return lead of this capacitor is connected by conductor 75 directly to spring 15 of the hook-switch and is separate from the return lead 56 of the other capacitors which is also connected to spring 15. This reduces the common resistance between the quiet capacitor 42 and the other capacitors which are connected to points in the circuit in which the voltage pulsations are high, and hence would induce pulsating voltages in the capacitor 42. The filaments of the tubes are connected in series as previously mentioned and the return conductor 63 of the tube 20 is connected directly to spring 14 of the hook-switch, thus reducing common coupling into the filament circuit. The only part of these circuits that are common is through springs 14 and 15 and their contacts. However, these springs are made of low resistance spring brass, while the contacts thereof are pure silver. It has been found that this reduces the noise to such a low level that it is not noticed or else cannot be heard.

The crystal microphone 5 in the handset 7 is completely shielded and is connected to the voltage amplifier tube 20 by a shielded cable 76 with shielded coupling 77. The shielding on this cable must be closely meshed. The microphone is connected directly to the control grid 22 of the tube 20, with the shielding connected to the cathode 21 thereof, to provide a return path for the microphone current and to insure quietness. The tube 20 is a pentode voltage amplifier and is resistance coupled to the pentode power tube 26 with volume control potentiometer as previously mentioned. A slight amount of inverse feed-back on tube 26 and its input network is provided by the resistor 100. The plate of the tube 26 is connected to the primary winding 69 of the induction coil designated as 79. This coil is analogous to the local battery anti-side-tone coil of conventional substation circuits, but in this case the carbon transmitter thereof is replaced by the tube 26, and the coil impedances are suitably altered as will be described. The secondary windings 82 and 83 as well as the resistors 86 and 87 together with capacitor 88 are the other impedances of the anti-side-tone network hereinafter discussed. In the hook-switch, spring terminals 12—13 close the telephone line circuit through to the induction coil, while the coil designated 80 is a choke which provides a low resistance direct current path for central office supervisory purposes. This latter arrangement, together with the opening of the receiver circuit at springs 16—17 of the hook-switch, and the connections to the dial sender 9 are conventional. Springs 10—11 of the hook-switch control the power circuit as mentioned and close first when the handset is taken from its cradle. The housing (not shown) of the instrument is not connected directly to any point of the circuit, but the .005 mf. capacitor 81 is connected to the return conductor 57 of the power circuit. The housing is safe and no electrical shock can be obtained from it. The capacitor 81 eliminates line noise. Conductor 90 and terminal 91 provide a convenient arrangement for testing the filament voltage.

Amplifier tubes, such as 26, do not necessarily have their output plate load impedance equal to their plate impedance. For example, the tube 26 should work into a load of ten thousand ohms for maximum undistorted power output, but its plate impedance is rated at one hundred twenty thousand ohms. In the conventional anti-side-tone substation, the induction coil used therein is designed in accordance with well-known formulas since the load impedance of the telephone transmitter or microphone is equal to its internal impedance. However, the fact that the plate load of tube 26 is ten thousand ohms while its plate impedance (internal impedance) is one hundred twenty thousand ohms, made it appear impossible to substitute a power amplifier tube, such as 26, for the usual transmitter in the conventional anti-side-tone network and still retain a maximum output network. For desirable operation it is important that the tube **26** should work into its optimum load (10,000 ohms), the subset circuit should be of the anti-side-tone type, and receiver circuit efficiency should be as high as possible. It was only after extended study and experimentation that the present anti-side-tone network (Fig. 1) was discovered. The desirable operation outlined above is achieved in the anti-side-tone network of this invention, as will be seen from the following analysis of the circuit diagram of Fig. 4 which is a simplified showing of the anti-side-tone network of Fig. 1. In this circuit the condition of side-tone balance is achieved in the first conjugacy condition given by the relation.

$$\sqrt{\frac{Z_C}{Z_D}}=\frac{Z_L}{Z_N} \tag{1}$$

The second conjugacy condition ordinarily existing in anti-side-tone circuits, namely, that an E. M. F. acting in Z_L produces no current in Z_N holds approximately when

$$\frac{\sqrt{Z_C Z_D}}{Z_A}=\frac{Z_R}{Z_T} \tag{2}$$

Maximum power is delivered from Z_T when

$$\frac{Z_C Z_D+2\sqrt{Z_C Z_D}}{Z_A}=\frac{Z_L+Z_N}{Z_T} \tag{3}$$

The power distribution ratio from Z_T to Z_L has the reciprocal property and equals that from Z_L to Z_T; that is, with the source in Z_T the ratio of power delivered to Z_L to the total that can be delivered by Z_T is equal to the ratio of the power received by Z_T, with the source at Z_L, to the total power that can be delivered by Z_L.

Where

Z_T is the plate impedance of tube **26** (internal impedance);
Z_R is the impedance of the receiver **6**;
Z_L is the impedance of the telephone line leading to the telephone exchange;
Z_A is the impedance of coil **69**;
Z_C is the impedance of coil **83**;
Z_D is the impedance of coil **82**; and
Z_N is the impedance of resistors **86** and **87** and of capacitor **88**.

The power distribution ratio Y is equal to the ration of power received by Z_T to the power received by Z_R with the source in the line. In the above circuit when the condition given by Equation 1 is satisfied Y is given by

$$Y=\frac{Z_L}{Z_N} \tag{4}$$

In the present arrangement the transmitting output can be increased by the volume control, that is, by increasing the amplification. This feature can be taken advantage of to increase the receiving efficiency, as compared to conventional sets, even though there is no amplification for receiving. The ratio Y can be made small so that the power transmitted to the line, with an E. M. F. in the transmitter, will go down, but the power in the receiver, with an E. M. F. in the line, will increase, and by utilizing amplification to step up transmitting efficiency, both high transmitting and receiving efficiencies may be attained.

The choice of Y for the present arrangement is a first step. This fixes Equations 4 and 1. Then Equation 3 can be applied to connect the tube to its required load of 10,000 ohms by using this value of rated load impedance in the equation in place of Z_T (internal impedance). While this will not be a maximum output circuit, it will be the best working condition for the tube. The first conjugacy condition for side-tone balance, as given by Equation 1, will be maintained.

If the tube impedance were actually 10,000 ohms and delivered maximum power by Equation 3, while Equation 1 held, and if the second conjugacy condition held as given by Equation 2, then it can be shown that the network is a maximum output network, and an E. M. F. at Z_L will deliver its maximum power to Z_T and Z_R while no power is given to Z_N from Z_L. The total power delivered from Z_L is divided between Z_T and Z_R by the relation 4, and Z_R will receive all of the power that can be given to it from Z_L with the chosen value of Y.

From the first conjugacy condition and the reciprocity theorem, it can be shown that the receiving efficiency, measured by the value of the current in Z_R with an E. M. F. in Z_L, is not affected by changes in the resistance of the transmitter. Therefore, if the best value of Z_R is calculated when the network is treated as if it were of the maximum output type, with the receiving power the highest that can be given to it with the chosen value of Y, the receiving efficiency will still be highest when the tube impedance is 120,000 ohms. Of course, this destroys the second conjugacy condition and the condition that the total power delivered from Z_L is maximum, but the power transferred into Z_R is not lessened and is still equal to the full amount that it would be if the network were of the maximum output type.

The foregoing conclusion may be summed up mathematically by eliminating Z_A and Z_T from Equations 2 and 3, for the receiving efficiency is independent of Z_T and Z_A.

Rearranging (2) gives

$$\frac{Z_A}{Z_T}=\frac{\sqrt{Z_C Z_D}}{Z_R} \tag{5}$$

and rearranging (3) gives

$$\frac{Z_A}{J_T}=\frac{Z_C+Z_D+2\sqrt{Z_C Z_D}}{Z_L+Z_N} \tag{6}$$

Equating the right hand members of (5) and (6) and solving for Z_R yields

$$Z_R=\frac{\sqrt{Z_C Z_D}(Z_L+Z_N)}{Z_C+Z_D+2\sqrt{Z_C Z_D}} \tag{7}$$

Having chosen a value of Y and fixing Z_N by Equation 4, Equation 7 then gives the value of Z_R for delivery to Z_R from Z_L of the full receiving power called for in the ratio Y. When Y vanishes all the power that can be transferred from Z_L is delivered to Z_R, but this would leave no possibility of power delivery to Z_L from Z_T. With a value $Y=.52$ used in the present arrangement, Z_R receives from Z_L power which is 1.82 decibels below all the power that could be transferred from Z_L, and the power delivered into Z_L is 4.65 decibels below the maximum that could be transferred from Z_T. A gain in receiving of 2.8 decibels, which equals the loss in transmitting, is calculated in relation to an induction coil of the conventional type with a value of $Y=1.9$.

In determining the value of the receiver impedance, as previously discussed, it has also been found necessary to decide where the peak response of the reeciving response-frequency characteristic curve should be. A response-frequency characteristic which favors the lower frequencies, will suffer less in effective transmission than a characteristic with a higher relative response on the higher frequencies. In the latter case, the reliance is placed on the higher frequencies to carry the intelligibility, but these frequencies are attenuated the most on the longer lines. In accordance with the present invention I prefer that the relative response on the lower frequencies, for example in the range from approximately 300 to 1500 cycles be increased over that of the conventional substation set.

The substation circuit arrangement, as disclosed in Fig. 1, is powered exclusively from the commercial lighting outlet at the subscriber's substation. Where the commercial lighting source is subject to occasional failure, it may be desirable to provide a carbon microphone **85** in standby relation to the crystal microphone **5**, the carbon microphone being powered from the battery at the telephone exchange. Such an arrangement is illustrated in Fig. 5 wherein the two-stage amplifier, including the tubes **20** and **26**, is energized from the power supply device including the rectifiers **36** and **37** with their related filters F_1 and F_2, as above described. However, the power supply includes a relay **89** which is energized as long as the power supply is functioning to supply the amplifier. While relay **89** is energized, it opens the connection of the carbon microphone **85** in series with the telephone line and the battery at the telephone exchange, not shown. When the lighting source fails relay **89** releases to complete the connection of the carbon microphone in series with the mentioned battery. Under such conditions the carbon microphone **85** is substituted for the crystal microphone **5**.

What I claim is:

1. In a telephone subset network of the type comprising a receiver telephonically connected therein for reception of signals from a telephone line, a microphone connected in said network, an amplifier for amplifying the response of said microphone and for delivering said amplified response to the telephone line, said amplifier including an electron discharge tube having a filamentary cathode directly heated by the flow of current therethrough, the combination therewith of means for temporarily causing pulsating current to flow through said cathode when the amplifier is initially placed in operation and means for thereafter causing substantially continuous current to flow through said cathode during the remainder of the operation of the amplifier.

2. In a telephone subset network of the type comprising a receiver telephonically connected therein for reception of signals from a telephone line, a microphone connected in said network, an amplifier for amplifying the response of said microphone and for delivering said amplified response to the telephone line, said amplifier including an electron discharge tube having a filamentary cathode directly heated by the flow of current therethrough, the combination therewith of means for temporarily causing pulsating current and a surge current to flow through said cathode, and means effective shortly thereafter for causing substantially continuous current to flow through said cathode during the remaining operation of the amplifier.

3. In a telephone subset network of the type comprising a receiver telephonically connected therein for reception of signals from a telephone line, a mircophone connected in said network, an amplifier for amplifying the response of said microphone and for delivering said amplified response to the telephone line, said amplifier including an electron discharge tube having a filamentary cathode directly heated by the flow of current therethrough, the combination therewith of means for temporarily causing unfiltered rectified current to flow through said cathode and means effective shortly thereafter for causing filtered rectified current to flow through said cathode during the remaining operation of the amplifier.

4. A telephone subset network comprising a receiver telephonically connected therein for the reception of signals from a telephone line, a microphone connected in said network, an amplifier for amplifying the response of said microphone and for delivering said amplified response to the telephone line, said amplifier including an electron discharge tube having a filamentary cathode directly heated by the flow of current therethrough, a source of alternating current, a rectifier for converting said alternating current into pulsating current, a filter operably connectible to said rectifier for substantially eliminating any alternating current component from said pulsating current whereby substantially continuous current is supplied to said filament, means for initially connecting said pulsating current directly to said filament when the amplifier is first set into operation and means effective shortly thereafter to operatively connect said filter to said rectifier whereby continuous current is supplied to said cathode.

5. A telephone subset network comprising a receiver telephonically connected therein for the reception of signals from a telephone line, a microphone connected in said network, an amplifier for amplifying the response of said microphone and for delivering said amplified response to the telephone line, said amplifier including an electron discharge tube having a filamentary cathode directly heated by the flow of current therethrough, a source of alternating current, a rectifier for converting said alternating current into pulsating current, a filter operably connectible to said rectifier for substantially eliminating any alternating current component from said pulsating current whereby substantially continuous current is supplied to said filament, a hookswitch having a primary set of contact springs and a secondary set of contact springs operating in the sequence named, means including said primary set of contact springs for initially connecting said pulsating current directly to said filament when the amplifier is first set into operation, and means including said secondary set of contact springs effective shortly thereafter to operatively connect said filter to said rectifier whereby continuous current is supplied to said cathode.

6. A telephone subset network comprising a receiver telephonically connected therein for the reception of signals from a telephone line, a microphone connected in said network, an amplifier for amplifying the response of said microphone and for delivering said amplified response to the telephone line, said amplifier including an electron discharge tube having a filamentary cathode directly heated by the flow of current therethrough, a source of alternating current, a rectifier for converting said alternating current into pulsating current, a filter of the resistance-capacitor type operably connectible to said rectifier for substantially eliminating any alternating current component from said pulsating current whereby substantially continuous current is supplied to said filament, means for initially con-

necting said pulsating current directly to said filament when the amplifier is first set into operation, and means effective shortly thereafter to operatively connect said filter to said rectifier whereby continuous current is supplied to said cathode.

7. A telephone subset network comprising a receiver telephonically connected therein for the reception of signals from a telephone line, a microphone connected in said network, an amplifier for amplifying the response of said microphone and for delivering said amplified response to the telephone line, said amplifier including an electron discharge tube having a filamentary cathode directly heated by the flow of current therethrough, a source of alternating current, a rectifier for converting said alternating current into pulsating current, a filter operably connectible to said rectifier for substantially eliminating any alternating current component from said pulsating current whereby substantially continuous current is supplied to said filament, means for initially connecting said pulsating current directly to said filament when the amplifier is first set into operation, and means including a dashpot effective shortly thereafter to operatively connect said filter to said rectifier whereby continuous current is supplied to said cathode.

8. A telephone subset network comprising a receiver telephonically connected therein for the reception of signals from a telephone line, a microphone connected in said network, an amplifier for amplifying the response of said microphone and for delivering said amplified response to the telephone line, said amplifier including an electron discharge tube having a filamentary cathode directly heated by the flow of current therethrough, a source of alternating current, a rectifier for converting said alternating current into pulsating current, a filter operably connectible to said rectifier for substantially eliminating any alternating current component from said pulsating current whereby substantially continuous current is supplied to said filament, a hook-

switch having a primary set of contact springs and a secondary set of contact springs operating in the sequence named, means including said primary set of contact springs for initially connecting said pulsating current directly to said filament when the amplifier is first set into operation, means including said secondary set of contact springs effective shortly thereafter to operatively connect said filter to said rectifier whereby continuous current is supplied to said cathode, and a dashpot controlling the speed of operation of said secondary set of contact springs.

9. In a telephone subset network of the type comprising a receiver telephonically connected therein for reception of signals from a telephone line, a microphone connected in said network, an amplifier for amplifying the response of said microphone and for delivering said amplified response to the telephone line, said amplifier including an electron discharge tube having a directly heated filamentary cathode, a source of rectified pulsating current for heating said filamentary cathode, and a filter for converting said rectified pulsating current into substantially constant current, the combination of means for temporarily lowering the effectiveness of said filter, whereby the amount of voltage initially available at the output of said filter is raised, and means for thereafter restoring said filter to full effectiveness.

ARNOLD LESTI.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,018,464	Nebel	Oct. 22, 1935
2,055,921	Baker	Sept. 29, 1936
2,275,581	Barton	Mar. 10, 1942
2,282,405	Herrick	May 12, 1942
2,346,504	Place	Apr. 11, 1944
2,369,352	Herrick	Feb. 13, 1945

Certificate of Correction

Patent No. 2,487,455

November 8, 1949

ARNOLD LESTI

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 7, line 50, for the word "ration" read *ratio*; column 8, lines 44 and 45, for that portion of the equation reading

$$\frac{Z_A}{J_T} \quad \text{read} \quad \frac{Z_A}{Z_T}$$

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 4th day of July, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.