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TONE UNIT

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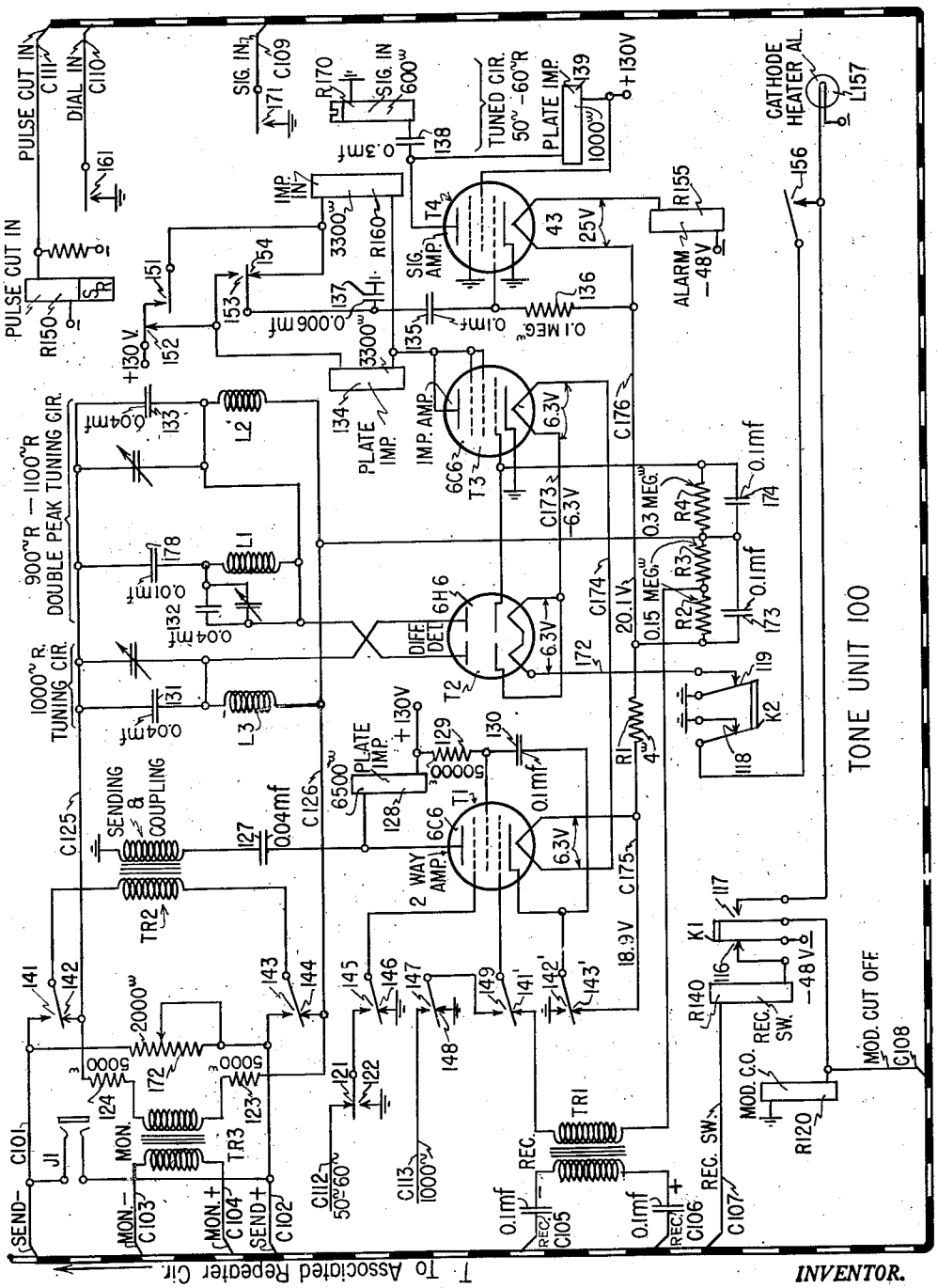

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TONE UNIT

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6 Claims. (Cl. 179—16)

1

The present invention relates to telephone systems and, more particularly, to tone units incorporated therein.

A telephone system of the type disclosed in United States Patent No. 2,155,176, granted April 18, 1939, to John Wicks, comprises a two-way toll line terminated at the opposite ends thereof in repeater circuits provided with associated tone units of the character disclosed in United States Patent No. 2,159,081, granted May 23, 1939, to Otho D. Grandstaff. The tone unit of the present application constitutes an improvement in the tone unit of the Grandstaff patent mentioned and is adapted to be incorporated in the telephone system disclosed in the copending application of John Wicks and Otho D. Grandstaff, Serial 749,758, filed May 22, 1947; which last-mentioned telephone system constitutes an improvement in the telephone system of the Wicks patent mentioned.

In the telephone system of the Wicks patent, an operator at an operator position in a first exchange may extend a connection over the toll line to switching apparatus in a second exchange, and then control the switching apparatus further to extend the connection. During these operations a first tone unit associated with a first repeater circuit, associated with a first end of the toll line in the first exchange, cooperates with a second tone unit associated with a second repeater circuit, associated with a second end of the toll line in the second exchange. Each of the tone units is capable of transmitting and of receiving both unmodulated 1000 cycle signals and 50–60 cycle modulated 1000 cycle signals, which are utilized for the various dial and supervisory purposes.

It has been found that it is desirable for the operator at the operator position in the first exchange to monitor the further extension of the connection by the switching apparatus in the second exchange; which direct monitoring arrangement in the telephone system of the Wicks patent mentioned is not altogether satisfactory since it tends to interfere with the reception of supervisory signals by the first tone unit in the first exchange, that are transmitted over the toll line from the second tone unit in the second exchange, during the further extension of the connection.

Moreover, it has been found that the tone unit of the Grandstaff patent mentioned has a tendency to become overloaded when it receives strong 1000 cycle signals, whether they are modulated or unmodulated, resulting in occasional damage to the vacuum tubes incorporated therein.

Accordingly, it is an object of the present invention to provide a tone unit of the character described that is capable of rendering monitoring supervision to an associated operator position during the extension of a connection over an associated toll line, without in any way interfering with the concurrent reception of supervisory signals thereby.

2

Another object of the invention is to provide a tone unit of the character described that is arranged to render to an associated operator position both audible and visual supervisory signals during the extension of a connection over an associated toll line.

Another object of the invention is to provide amplifying apparatus capable of receiving alternating current signals over a considerable range of intensities and comprising an improved arrangement for preventing overloading thereof incident to the reception of such signals that exceed in intensity the upper limit of the range mentioned.

A further object of the invention is to provide amplifying apparatus comprising a tuning arrangement rendering the same selectively responsive to alternating current signals within a given frequency band and an improved arrangement for limiting the response thereof to strong signals within the band mentioned.

A further object of the invention is to provide a tone unit of the type described embodying improved and simplified circuit arrangements for transmitting and for receiving both modulated and unmodulated alternating current signals.

Further features of the invention pertain to the particular arrangement of the circuit elements of the tone unit, whereby the above outlined and additional operating features thereof are attained.

The invention both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawing in which the single figure illustrates diagrammatically a tone unit connected and arranged in accordance with the present invention.

Referring now to the drawing, the tone unit 100 there illustrated embodies the features of the invention and essentially comprises a receiving transformer TR1, a sending and coupling transformer TR2, a monitoring transformer TR3, a two-way amplifier T1 in the form of a vacuum tube of the well-known pentode 6C6 type, a differential detector T2 in the form of a vacuum tube of the well-known dual diode 6H6 type, an impulse amplifier T3 in the form of a vacuum tube of the well-known pentode 6C6 type, and a signal amplifier T4 in the form of a vacuum tube of the well-known pentode 43 type. Also, the tone unit 100 comprises a relay group including a modulation cutoff relay R120, a receiving switch relay R140, a pulse cut-in relay R150, an alarm relay R155, an impulse-in relay R160 and a

signal-in relay R170; as well as a plate impedance 128 associated with the tube T1, a plate impedance 134 associated with the tube T3, and a plate impedance 139 associated with the tube T4. Further, the tone unit 100 comprises circuit elements described in detail hereinafter and interconnecting the elements mentioned; as well as a group of conductors extending to the associated repeater circuit and including a sending — conductor C101, a sending + conductor C102, a monitoring — conductor C103, a monitoring + conductor C104, a receiving — conductor C105, a receiving + conductor C106, a receiving switch conductor C107, a modulation cutoff conductor C108, a signal-in conductor C109, a dial-in conductor C110 and a pulse cut-in conductor C111; together with a 50–60 cycle conductor C112 extending to an associated 50–60 cycle generator, not shown, and a 1000 cycle conductor C113 extending to a 1000 cycle generator, not shown.

The tubes T1 and T3 are each provided with a cathode heater having a nominal rating of 6.3 volts, at which voltage 0.3 ampere is drawn; the tube T2 is provided with a two-section cathode heater having a nominal rating of 6.3 volts, at which voltage 0.3 ampere is drawn; and the tube T4 is provided with a cathode heater having a nominal rating of 25 volts, at which voltage 0.3 ampere is drawn. The cathode heaters of the tubes T1, T2, T3 and T4 are connected in series circuit with a 4 ohm resistor R1 and the winding of the alarm relay R155 across a 48 volt exchange battery, the positive pole of which is grounded. More particularly, the circuit mentioned extends from ground by way of the contacts 119 of a normally operated key K2, the cathode heater of the tube T2, a conductor C173, the cathode heater of the tube T3, a conductor C174, the cathode heater of the tube T1, a conductor C175, the resistor R1, a conductor C176, the cathode heater of the tube T4, and the winding of the alarm relay R155 to the negative pole of the 48 volt exchange battery. Accordingly, the series circuit above traced is normally completed, whereby the cathode heaters heat the associated cathodes of the tubes mentioned rendering them electron emissive and effecting operating of the alarm relay R155. Of course, it will be understood that in the event any one of the tubes mentioned is removed from its socket or develops a burned out or broken cathode heater, the above traced series circuit is interrupted, causing the alarm relay R155 to restore in order to complete, at the contacts 156, a circuit including the contacts 118 of the key K2 for illuminating a cathode heaters alarm lamp L157, thereby to indicate the failure mentioned. Moreover, the potential drop along the above-traced series cathode heater circuit is employed at various points for grid biasing purposes, explained more fully hereinafter; and, in passing, it is noted that a negative potential of 6.3 volts appears upon the conductor C173, a negative potential of 18.9 volts appears upon the conductor C175, and a negative potential of 20.1 volts appears upon the conductor C176.

The tube T1 is employed as a two-way amplifier, being utilized as an outgoing amplifier and modulator in the transmission of signals to the associated repeater circuit. The screen grid of the tube T1 is supplied with positive potential from a 130 volt source of plate current, the negative pole of which is grounded, through an associated 50,000 ohm resistor 129 and is by-passed to the cathode of the tube T1 by a 0.1 mf. condenser 130 connected therebetween; and the suppressor grid of the tube T1, employed as a modulation grid, is connected either to ground potential or to the 50–60 cycle conductor C112, depending upon the operated or restored condition of the modulation cutoff relay R120 and the receiving switch relay R140 as explained more fully hereinafter.

For the reception of signals, the primary winding of the receiving transformer TR1 is connected to the receiving — conductor C105 and to the receiving + conductor C106 through the two illustrated 0.1 mf. condensers; the secondary winding of the receiving transformer TR1 is normally connected by way of the contacts 141' of the normally operated receiving switch relay R140 to the control grid of the tube T1 in order to control the potential applied thereto; a negative potential of 20.1 volts being normally applied to the control grid of the tube T1 from the conductor C176 by way of a 0.15 megohm resistor R2, the secondary winding of the receiving transformer TR1 and the contacts 141' of the receiving switch relay R140. The cathode of the tube T1 is normally connected by way of the contacts 143' of the normally operated receiving switch relay R140 to the conductor C175 having negative 18.9 volt potential applied thereto. Accordingly, the control grid of the tube T1 has a negative biasing potential of 1.2 volts applied thereto with respect to the cathode by virtue of the 1.2 volt drop across the resistor R1.

With the receiving switch relay R140 in its normal operated position, the suppressor grid of the tube T1 is connected by way of the contacts 146 thereof to ground potential, as previously noted; and the secondary winding of the sending and coupling transformer TR2 is connected, at the contacts 142 and 144 of the operated receiving switch relay R140, across the leads C125 and C126. The primary winding of the monitoring transformer TR3 is connected by way of the two 5000 ohm resistors 123 and 124 across the leads C125 and C126; while the secondary winding of the monitoring transformer TR3 is connected directly to the monitoring — conductor C103 and the monitoring + conductor C104 extending to the associated repeater circuit. Thus, audible signals amplified by the tube T1 and impressed through the sending and coupling transformer TR2 across the leads C125 and C126 are supplied through the monitoring transformer TR3 to the monitoring — and monitoring + conductors C103 and C104 extending to the associated repeater circuit, for a purpose more fully explained hereinafter. Further, the plate of the tube T1 is connected by way of the associated 6500 ohm plate impedance 128 to the positive terminal of the 130 volt source of plate current supply, and is also connected by way of a 0.04 mf. coupling condenser 127 to one terminal of the primary winding of the sending and coupling transformer TR2, the other terminal of the primary winding mentioned being grounded.

An inductance coil L3 is connected across the leads C125 and C126 in series with a 0.04 mf. tuning condenser 131, which condenser is shunted by the indicated trimmer condenser of such capacity as to render the couple series-resonant at 1000 cycles. Finally, the junction between the inductance coil L3 and the tuning condenser 131 is connected to the right-hand plate of the tube T2, whereby a relatively high potential is placed on the right-hand plate of the tube T2 by the voltage drop across the inductance coil L3 when a 1000 cycle current is being received and amplified by the tube T1. In order to enable the sys-

tem to respond to impulses of 1000 cycles plus or minus an amount equal to about 50–60 cycles, so as to allow for the reception of 50–60 cycle modulated, 1000 cycle pulses, and to cut off sharply when frequencies higher or lower than the allowable band are received, an arrangement is provided including inductance coils L1 and L2 and 0.04 mf. tuning condensers 132 and 133. The inductance coils L1 and L2 and the condensers 132 and 133 are arranged to form a double-peak tuning circuit which peaks at 900 cycles and at 1100 cycles. The 900 cycle and 1100 cycle peaks are produced in addition to the 1000 cycle peak that is produced by the inductance coil L3 and the associated tuning condenser 132. More particularly, the inductance coil L2 is arranged in series with the tuning condenser 133, which condenser is shunted by the indicated trimmer condenser of such capacity as to render the couple series-resonant at 1100 cycles, provided substantially no current is permitted to flow through an associated 0.01 mf. shunt condenser 178; which series-resonant couple, including the inductance coil L2 and the tuning condenser 133, is connected directly across the leads C125 and C126. Finally, the junction between the inductance coil L2 and the tuning condenser 133 is connected to the left-hand plate of the tube T2. More particularly, the inductance coil L1 is arranged in parallel with the tuning condenser 132, which tuning condenser is shunted by the indicated trimmer condenser of such capacity as to render the couple parallel or shunt-resonant at 1100 cycles. In turn, the shunt-resonant couple, including the inductance coil L1 and the tuning condenser 132, is connected between the left-hand plate of the tube T2 and one terminal of the shunt condenser 178; the other terminal of the shunt condenser 178 being connected directly to the lead C125. Current of 1100 cycles is substantially prevented from flowing through the shunt condenser 178 by the shunt-resonant effect of the inductance coil L1 and the associated tuning condenser 132, as this couple is shunt-resonant at 1100 cycles. When current is received at some other frequency, however, the shunt-resonant effect is not present in the couple, including the inductance L1 and the associated tuning condenser 132, whereby current is permitted to pass through the shunt condenser 178 by way of the inductance coil L1 and the associated tuning condenser 132. The capacity of the shunt condenser 178 is so chosen that it, connected in multiple with the tuning condenser 133 through the system composed of the inductance coil L1 and its associated tuning condenser 132, causes the inductance coil L2 to have a resonant peak at 900 cycles in addition to the previously described peak at 1100 cycles. The manner in which the triple-peak tuning arrangement operates to control the tube T3 by way of the tube T2 is pointed out in detail hereinafter.

More particularly, the cathode of the tube T3 is connected directly to ground potential while the control grid of the tube T3 is connected directly to the right-hand cathode of the tube T2, the left-hand cathode of the tube T2 being connected directly to the conductor C173. Also, the control grid of the tube T3 is connected to the right-hand terminal of a 0.3 megohm resistor R4, the left-hand terminal of which is connected directly to the lead C126. Also, the left-hand terminal of the resistor R4 is connected to the right-hand terminal of a 0.15 megohm resistor R3, the left-hand terminal of the resistor R3 being connected to the right-hand terminal of the resistor R2 previously mentioned. In other words, the resistors R2, R3 and R4 are connected in series circuit relation between the conductor C176 and the control grid of the tube T3. Since the resistors R2 and R3 each comprise 0.15 megohm and the resistor R4 comprises 0.3 megohm, the center tap of this composite resistor is connected to the lead C126, as previously explained. Further, the resistors R2 and R3 are by-passed by an associated 0.1 mf. storage condenser 173, and the resistor R4 is by-passed by an associated 0.1 mf. storage condenser 174. Accordingly, a negative bias of 20.1 volts is normally provided the control grid of the tube T3 by virtue of the connection through the resistors R4, R3 and R2 to the conductor C176 having the potential mentioned impressed thereon; the conductor C176 being included in the previously traced cathode heaters circuit. By virtue of the connection of the lead C126 to the center tap of the grid resistor, including the sections R2, R3 and R4, associated with the tube T3 and the connection of the left-hand terminal of the resistor R2 to the conductor C176, a negative potential of 20.1 volts is normally maintained on the right-hand plate and the left-hand plate of the tube T2 through the inductance coils L3 and L2, respectively. The right-hand cathode of the tube T2 is also supplied with a biasing potential of negative 20.1 volts by virtue of the above described connection including the resistors R4, R3 and R2 to the conductor C176, whereby there is normally no potential difference between the right-hand cathode and the right-hand plate of the tube T2. On the other hand, the left-hand cathode of the tube T2 is connected directly to the conductor C173 having negative 6.3 volts appearing thereon, whereby there is normally a negative 13.8 volts potential difference between the left-hand plate and the left-hand cathode of the tube T2. Specifically, the left-hand plate is biased with respect to the left-hand cathode of the tube T2 by the rather substantial adverse potential of 13.8 volts, whereby no current passes through the left-hand portion of the tube T2 until this rather substantial adverse bias of 13.8 volts is overcome.

During the reception of a signal, the building up of 1000 cycle potential across the inductance coil L3 causes current to flow through the right-hand plate and the right-hand cathode of the tube T2 in series with the resistor R4. Thus, half-wave rectified current passes through the resistor R4 and, together with the associated smoothing condenser 174, renders the right-hand terminal thereof more positive than the left-hand terminal thereof, thereby offsetting to this extent the negative bias normally applied to the control grid of the tube T3. On the other hand, when the signal contains a sufficient component of 900 cycle or 1100 cycle potential to cause a sufficient potential to be built up across the inductance coil L2 to overcome the 13.8 volt bias normally present between the left-hand plate and the left-hand cathode of the tube T2, current flows between the left-hand plate and the left-hand cathode of the tube T2. Thus, half-wave rectified current passes through the resistors R1, R2 and R3 causing the midpoint of the composite resistor, including the resistors R2, R3 and R4, and specifically the junction between the resistors R3 and R4, to become more negative than the right-hand terminal of the resistor R4 by virtue of the potential drop through the resistors R2 and R3. Therefore, when a signal other than a wanted signal is received, and which

falls in the neighborhood of 900 cycles or 1100 cycles, the current flowing through the inductance coil L2 and obtained through the resistors R2 and R3, together with the associated smoothing condenser 173, renders the control grid of the tube T3 more negative than it normally is, thereby preventing a response of the tube T3 to the signal, notwithstanding the fact that sufficient current may be flowing through the resistor R4 otherwise to secure a response of the tube T3.

The plate, the suppressor grid and the screen grid of the tube T3 are connected together to produce a triode of the desired characteristics and are, in turn, connected both to one terminal of the associated 3300 ohm plate impedance 134 and to one terminal of the 3300 ohm winding of the impulse-in relay R160. The other terminal of the plate impedance 134 is normally connected, by way of the contacts 152 of the normally restored pulse cut-in relay R150, to the positive terminal of the 130 volt plate current supply; and the other terminal of the impulse-in relay R160 is normally connected, by way of the contacts 154 of the normally restored pulse cut-in relay R150 and the 0.1 mf. coupling condenser 135, to the control grid of the tube T4, the junction between the contacts 154 and the coupling condenser 135 being connected by way of the 0.006 mf. by-pass condenser 137 to ground potential. The previously mentioned grid bias of negative 20.1 volts applied to the control grid of the tube T3 is sufficient to block the flow of current from the 130 volt source of plate current through the plate impedance 134 under normal conditions. However, when a signal is received which causes the potential on the control grid of the tube T3 to be brought down to a negative value of about 16 volts, current starts to flow through the tube since the screen grid and the suppressor grid are connected to the plate of the tube T3 to secure a triode action of the desired characteristics, as previously noted. As the potential of the control grid of the tube T3 is rendered still less negative the current traversing the plate impedance 134 is increased. In passing, it is noted that the pulse cut-in relay R150 may be operated over the associated pulse cut-in conductor C111, thereby to interrupt, at the contacts 152, the previously traced circuit, including the plate impedance 134, between the 130 volt source of plate current and the plate of the tube T3; and to complete, at the contacts 151, an obvious substituted circuit, including the winding of the impulse-in relay R160, between the 130 volt source of plate current and the plate of the tube T3. Also, upon operating, the pulse cut-in relay R150 interrupts, at the contacts 154, the previously traced connection, including the winding of the impulse-in relay R160, between the plate of the tube T3 and the coupling condenser 135; and completes, at the contacts 153, a substitute circuit, including the plate impedance 134, between the plate of the tube T3 and the coupling condenser 135.

When the pulse cut-in relay R150 occupies its operated position and a signal is received, the potential of the control grid of the tube T3 is rendered less negative, as previously explained, whereby the plate current of the tube T3 traverses the winding of the impulse-in relay R160; and when this plate current reaches a value of about 4.5 milliampere the impulse-in relay R160 is sufficiently energized to operate; about 9 milliampere being preferable for maintaining operated the impulse-in relay R160 during the reception of dial pulses. Upon operating, the impulse-in relay R160 completes, at the contacts 161, an obvious path for applying ground potential to the dial-in conductor C110 extending to the associated repeater circuit. Since the inductance coil L3 and the associated tuning condenser 131 comprise a resonant couple having the maximum response at 1000 cycles, but not sharply peaked, the double-peak inductance coil L2 associated with the left-hand plate and left-hand cathode of the tube T2 offers an opposing effect to afford definite frequency cutoff points above and below the desired 1000 cycle resonant point while there is a rather flat frequency response over the selected band. This band is about 100–120 cycles wide in order to provide for the reception of 50–60 cycle modulated, 1000 cycle signal impulses. By arranging that the response curves of the inductance coils L3 and L2 intermingle, the inductance coil L2 peaks at 900 cycles and at 1100 cycles but still builds up an appreciable voltage at 1000 cycles. The voltage built up across the double-peak inductance coil L2 at the 1000 cycle signal frequency and over the upper portion of the signal-strength range is sufficient to reduce considerably the positive grid-swing tendency of the control grid of the tube T3, thereby tending to secure a uniform response over a wide range of input voltage. The weak signals, however, are not handicapped by the opposing effect of the inductance coil L2 as the adverse bias is not then overcome.

However, in order positively to prevent damage to the various tubes employed in the tone unit 100, the control grid of the tube T3 is arranged to cause rectification when strong 1000 cycle signals are received. More particularly, when strong 1000 cycle signals are received, the current traversing the right-hand portion of the tube T2 becomes sufficiently large to cause the potential drop across the resistor R4 to become sufficiently large so that the control grid of the tube T3 is rendered positive with respect to the associated cathode thereof, whereby rectification at the control grid of the tube T3 takes place. This control grid rectification in the tube T3 causes a potential drop across the resistors R4, R3 and R2 that is proportional to the strength of the incoming 1000 cycle signal. The voltage drop across the resistor R2 adds to the voltage drop across the resistor R1, thereby increasing the negative bias applied to the control grid of the tube T1. This increased negative bias applied to the control grid of the tube T1 on strong 1000 cycle signals reduces the output thereof and the consequent response thereof to the strong 1000 cycle signals, whereby the current through the right-hand section of the tube T2 is proportionally reduced, rendering less positive the bias applied to the control grid of the tube T3. Thus, this arrangement prevents overloading of the tubes T1, T2 and T3 in response to the reception of strong 1000 cycle signals.

The cathode and the suppressor grid of the tube T4 are connected directly to ground potential while the control grid of the tube T4 is provided with a normal negative biasing potential of 20.1 volts through a 0.1 megohm resistor 136 connected thereto and to the conductor C176 having the negative potential mentioned thereon. More particularly, the control grid of the tube T4 is connected to the junction between the resistor 136 and the coupling condenser 135. The plate of the tube T4 is connected directly by way of the 1000 ohm plate impedance 139 to the 130 volt source of plate supply; and the screen grid of the tube T4 is connected directly to the 130 volt plate supply.

At this biasing potential substantial plate current flows through the plate circuit of the tube T4 and the plate impedance 139 from the 130 volt source of plate current; the tube T4 being connected to provide the usual form of pentode operation. The coupling condenser 135 serves to couple the plate of the tube T3 to the control grid of the tube T4 in order to transmit the 50–60 cycle signal impulses to the tube T4. After amplification by the tube T4 the signal impulses pass to the 600 ohm winding of the signal-in relay R170 by way of a 0.3 mf. coupling condenser 138. The capacity of the coupling condenser 138 and the inductance of the winding of the signal-in relay R170 are so chosen that this circuit containing them constitutes a series-resonant circuit at 50–60 cycles, whereby this couple responds vigorously to 50–60 cycle current but does not respond when the 1000 cycle dial impulses, following each other at about ten to fourteen impulses per second, are received. When the series-resonant circuit, including the coupling condenser 138 and the winding of the signal-in relay R170, responds vigorously to the 50–60 cycle current mentioned, the signal in relay R170 operates in order to complete, at the contacts 171, an obvious path for applying ground potential to the signal-in conductor C109 extending to the associated repeater circuit. The by-pass condenser 137 is arranged to by-pass to ground high frequency currents in the plate circuit of the tube T3 in order to prevent these frequency currents from being impressed upon the control grid of the tube T4.

Considering now the operation of the tone unit 100 in conjunction with the associated repeater circuit, when the tone unit 100 is in its normal position the modulation cutoff relay R120 is normally restored and the receiving switch relay R140 is normally operated, the receiving switch relay R140 being operated in a circuit including the grounded receiving switch conductor C107 extending to the associated repeater circuit and the contacts 116 of the normally restored key K1. Also, the pulse cut-in relay R150 is in its normally restored condition whereby the impulse-in relay R160 is disconnected from and the plate impedance 134 is connected into the plate circuit of the tube T3. This is the condition of the tone unit 100 when it receives a 50–60 cycle modulated 1000 cycle seizing pulse from the associated repeater circuit when the associated toll line is taken for use in the distant exchange. This pulse comes into the tone unit 100 through the receiving — and receiving + conductors C105 and C106 and passes through the receiving transformer TR1 to the grid-cathode circuit of the two-way amplifier tube T1. The signal is amplified by the tube T1 and passes through the coupling condenser 127 through the primary winding of the sending and coupling transformer TR2. From the secondary winding of the sending and coupling transformer TR2 the signal passes through the contacts 142 and 144 of the operated receiving switch relay R140 and is impressed between the leads C125 and C126. This signal then passes through the inductance coils L3 and L2 and through the differential detector tube T2 to the grid-cathode circuit of the impulse amplifier tube T3. The signal is amplified by the impulse amplifier tube T3 and passes by way of the coupling condenser 135 to the grid-cathode circuit of the signal amplifier tube T4. The signal is amplified by the signal amplifier tube T4 and passes through the coupling condenser 138 and the winding of the signal-in relay R170, causing the latter relay to respond to the flow of alternating current therethrough. The signal-in relay R170 responds since the winding thereof, together with the coupling condenser 138, constitutes a couple resonant at the 50–60 cycles of the modulating signal, as previously noted. Upon responding, the signal-in relay R170 operates to complete, at the contacts 171, the previously mentioned path for applying ground potential to the signal-in conductor C109 extending to the associated repeater circuit; which ground potential is maintained upon the signal-in conductor C109 as long as the signal-in relay R170 remains operated, which condition prevails for the duration of the reception of the 50–60 cycle modulated signal. At the conclusion of the 50–60 cycle modulated seizing pulse the signal-in relay R170 restores in order to interrupt, at the contacts 171, the application of ground potential to the signal-in conductor C109 extending to the associated repeater circuit.

When the associated repeater circuit responds to the seizing pulse it applies ground potential to the pulse cut-in conductor C111, whereby the pulse cut-in relay R150 in the tone unit 100 is operated. Upon operating, the pulse cut-in relay R150 substitutes the impulse-in relay R160 for the plate impedance 134 in the plate of circuit of the impulse amplifier tube T3, as previously explained. Consequently, when the dial pulses of unmodulated 1000 cycle current are transmitted from the associated repeater circuit to the tone unit 100, these pulses pass through the circuits in the tone unit 100, in the manner previously explained, whereby the current in the plate circuit of the impulse amplifier tube T3 effects operation of the impulse-in relay R160. More particularly, the impulse-in relay R160 is operated momentarily upon the receipt of each of these dial pulses and restores between the reception of adjacent dial pulses. Each time the impulse-in relay R160 operates and then restores it completes and then interrupts, at the contacts 161, an obvious path for applying ground potential to the dial-in conductor C110 extending to the associated repeater circuit. The dial pulses in the plate circuit of the tube T3 are received at about ten to fourteen per second and pass through the plate impedance 134, the contacts 153 and the coupling condenser 135 into the control grid-cathode circuit of the signal amplifier tube T4. These dial pulses are amplified by the signal amplifier tube T4 and pass into the 50–60 cycle resonant circuit including the coupling condenser 138 and the winding of the signal-in relay R170. However, the resonant circuit mentioned does not respond appreciably to the amplified dial pulses and, accordingly, the signal-in relay R170 does not operate.

After the train of dial pulses has been received by the tone unit 100 the associated repeater circuit interrupts the application of ground potential upon the pulse cut-in conductor C111 in order to cause the pulse cut-in relay R150 to restore shortly thereafter, it being of the slow-to-release type. Upon restoring, the pulse cut-in relay R150 again removes the impulse-in relay R160 from and replaces the plate impedance 134 in the plate circuit of the impulse amplifier tube T3, thereby positively preventing further response by the impulse-in relay R160 while permitting the signal-in relay R170 to respond to any further received current at 1000 cycle carrier frequency which is modulated at the predetermined 50–60 cycle rate, as previously explained.

When the tone circuit 100 is to be used to transmit a seizing pulse by way of the associated repeater circuit over the associated toll line, the receiving switch relay R140 is restored, the modulation cutoff relay R120 being normally restored, as previously noted. Upon restoring, the receiving switch relay R140 transfers the control grid of the two-way amplifier tube T1 from the secondary winding of the receiving transformer TR1 to the 1000 cycle control conductor C113, and transfers the suppressor or modulation grid of the two-way amplifier tube T1 from ground potential to the 50–60 cycle control conductor C112. More particularly, upon restoring, the receiving switch relay R140 interrupts, at the contacts 141', the previously traced connection between the control grid of the two-way amplifier tube T1 and the secondary winding of the receiving transformer TR1; and completes, at the contacts 149 and 147, the previously mentioned connection between the control grid of the two-way amplifier tube T1 and the 1000 cycle control conductor C113. Also, the receiving switch relay R140 interrupts, at the contacts 146, the previously traced path for applying ground potential to the suppressor or modulation grid of the two-way amplifier tube T1; and completes, at the contacts 145, the previously mentioned connection, including the contacts 121, for connecting the suppressor or modulation grid of the two-way amplifier tube T1 to the 50–60 cycle control conductor C112. Also, the receiving switch relay R140 interrupts, at the contacts 142 and 144, the previously traced connection between the secondary winding of the sending and coupling transformer TR2 and the leads C125 and C126; and completes, at the contacts 141 and 143, an alternative connection between the secondary winding of the sending and coupling transformer TR2 and the sending — and sending + conductors C101 and C102 extending to the associated repeater circuit. At this point, it is noted that a 2000 ohm adjustable resistor 172 is connected between the sending — and the sending + conductors C101 and C102 extending to the associated repeater circuit in order to control the output level of the signal from the tone unit 100. At this time a 1000 cycle variation is produced in the plate current of the two-way amplifier tube T1 and passing through the plate impedance 128. At the same time the suppressor or modulation grid of the two-way amplifier tube T1 connected to the 50–60 cycle control conductor C112 causes, on each negative half cycle of the potential on the control conductor C112, the current flow in the plate circuit of the two-way amplifier tube T1 to cease altogether; while on each positive half cycle of the potential on the control conductor C112, the plate current in the two-way amplifier tube T1 is permitted to flow unimpeded. In this manner fifty–sixty uniformly separated pulses of 1000 cycle current are caused to flow through the plate circuit of the two-way amplifier tube T1 through the plate impedance 128; which pulses are permitted to pass through the coupling condenser 127 to the primary winding of the sending and coupling transformer TR2. Since the secondary winding of the sending and coupling transformer TR2 is connected, by way of the above traced path, to the sending — and sending + conductors C101 and C102 extending to the associated repeater circuit, the 50–60 cycle modulated 1000 cycle current is transmitted over the sending — and sending + conductors C101 and C102 to the associated repeater circuit and thence over the associated toll line. At the conclusion of the transmission of the seizing pulse, the receiving switch relay R140 is reoperated by the associated repeater circuit in order to return the tone unit 100 to the normally existing receiving condition previously explained.

In order to prepare for the transmission of an unmodulated 1000 cycle signal from the tone unit 100 to the associated repeater circuit, battery potential is applied in the associated repeater circuit to the modulation cutoff conductor C108, thereby to effect operation of the modulation cutoff relay R120 in the tone unit 100. Upon operating, the modulation cutoff relay R120 interrupts, at the contacts 121, a further point in the previously traced path for connecting the suppressor grid of the two-way amplifier tube T1 to the 50–60 cycle control conductor C112; and prepares, at the contacts 122, a path traced hereinafter for connecting directly to ground potential the suppressor grid of the two-way amplifier tube T1. Subsequently, when the associated repeater circuit is in readiness to receive the unmodulated 1000 cycle signal from the tone unit 100, ground potential is removed from the receiving switch conductor C107, thereby to cause the receiving switch relay R140 in the tone unit 100 to restore. Upon restoring, the receiving switch relay R140 completes, at the contacts 147 and 149, the previously traced path for connecting the control grid of the two-way amplifier tube T1 to the 1000 cycle control conductor C113; and completes, at the contacts 145, the previously mentioned path, including the contacts 122, for connecting to ground potential the suppressor grid of the two-way amplifier tube T1. Also, upon restoring, the receiving switch relay R140, recompletes, at the contacts 141 and 143, the previously traced connection between the secondary winding of the sending and coupling transformer TR2 and the sending — and sending + conductors C101 and C102 extending to the associated repeater circuit. At this time unmodulated 1000 cycle current flowing in the plate circuit of the two-way amplifier tube T1 passes through the coupling condenser 127 and the primary winding of the sending and coupling transformer TR2; whereby the secondary winding of the sending and coupling transformer TR2 projects an unmodulated 1000 cycle signal over the sending — and sending + conductors C101 and C102 to the associated repeater circuit. It will be understood that the unmodulated 1000 cycle signal transmitted from the tone unit 100 to the associated repeater circuit is connected and disconnected in the associated repeater circuit to the toll line associated with the repeater circuit mentioned at a rate of about ten to fourteen times per second, in order to form dial pulses to be transmitted over the toll line mentioned to the distant exchange. After the transmission of one or more series of unmodulated 1000 cycle dial pulses from the associated repeater circuit over the associated toll line to the distant exchange, the associated repeater circuit subsequently effects restoration of the modulation cutoff relay R120 and operation of the receiving switch relay R140 in the tone unit 100, whereby the tone unit is again returned to the normally existing receiving condition.

Thereafter when the switching apparatus associated with the repeater circuit in the distant exchange extends the connection, an end of dialing signal is returned over the toll line to the repeater circuit associated with the tone unit 100.

which end of dialing signal is in the form of a 50–60 cycle modulated 1000 cycle signal; which signal received by the tone unit 100 effects operation of the signal-in relay R170, all in the manner previously explained. Also, it is noted that this 50–60 cycle modulated 1000 cycle signal is first received by the receiving transformer TR1 and amplified by the two-way amplifier tube T1 and then applied by the sending and coupling transformer TR2 between the leads C125 and C126. Since the primary winding of the monitoring transformer TR3 is connected by way of the resistors 124 and 123 across the leads C125 and C126, this audible signal passing through the primary winding of the monitoring transformer TR3 causes a corresponding audible signal to be transmitted from the secondary winding of the monitoring transformer TR3 over the monitoring — and monitoring + conductors C103 and C104 extending to the associated repeater circuit. Accordingly, in the event the monitoring — and monitoring + conductors C103 and C104 extending to the associated repeater circuit are at this time connected to an associated operator position, the operator thereat may hear through her headset the audible signal mentioned. This arrangement gives the operator, at the operator position associated with the repeater circuit that is in turn associated with the one unit 100, monitoring supervision of the connection as it is extended over the associated toll line, without interfering in any way with the subsequent reception of supervisory signals over the toll line associated with the repeater circuit with which the tone unit 100 is associated. For example, following the reception of the end of dialing signal above mentioned, the repeater circuit associated with the toll line in the distant exchange may transmit a supervisory signal indicating a busy condition in the distant exchange, which supervisory or busy signal is in the form of a 50–60 cycle modulated 1000 cycle signal. This busy signal, returned over the toll line associated with the repeater circuit with which the tone unit 100 is associated, is received by the tone unit in order to cause operation of the signal-in relay R170 therein, in the manner previously explained, as well as to cause this audible signal to be returned via the monitoring transformer TR3 to the operator position associated with the repeater circuit with which the tone unit 100 is associated; all without interference.

In the event it is desirable during repair or test of the tone unit 100 to open the cathode heaters circuit, the key K2 may be restored for this purpose. When the key K2 is thus restored there is interrupted, at the contacts 118 thereof, a further point in the previously traced circuit for illuminating the cathode heaters alarm lamp L157, thereby to prevent illumination thereof incident to the restoration of the alarm relay R155. Subsequently, the key K2 is returned to its normal operated position in order to close the cathode heaters circuit and to bring about reoperation of the alarm relay R155.

In the event that it is desired to test the transmission level of the tone unit 100, the key K1 may be actuated and a test plug associated with the test equipment may be inserted into the jack J1 connected across the sending — and sending + conductors C101 and C102. When the key K1 is thus operated there is interrupted, at the contacts 116 thereof, the previously traced circuit for maintaining operated the receiving switch relay R140 in order to cause the latter relay to restore; and there is completed, at the contacts 117 thereof, a series circuit for operating the modulation cutoff relay R120 and for illuminating the cathode heaters alarm lamp L157. When the modulation cutoff relay R120 is thus operated and the receiving switch relay R140 is thus restored, the tone unit 100 is placed in its transmitting position, whereby an unmodulated 1000 cycle signal is transmitted over the sending — and sending + conductors C101 and C102; which signal effects operation of the test equipment associated with the jack J1. At this time the resistor 172 should be so adjusted that the output level of the unmodulated 1000 cycle signal received by the test equipment associated with the jack J1 is —10 db. from 0.006 watt. At this time the test equipment may be removed from the associated jack J1 and the key K1 returned to its normal position, whereby the modulation cutoff relay R120 restores and the receiving switch relay R140 reoperates. At this time the tone unit 100 is returned to its normal existing receiving condition.

Finally, it is noted that the connection between the control grid of the two-way amplifier tube T1 and the 1000 cycle control conductor C113 includes the contacts 147 and 149 of the receiving switch relay R140 in series-circuit relationship; which connection when interrupted, at the contacts 147 and 149, causes one of the contact springs of the contacts 147 to be grounded at the contacts 148. This arrangement reduces the intercontact capacity which might otherwise be sufficient to cause a slight local 1000 cycle voltage to be impressed upon the control grid of the two-way amplifier tube T1, even with the receiving switch relay R140 in its operated position. This tendency is, of course, positively prevented by the grounded contacts 148 disposed intermediate the contacts 147 and 149 of the receiving switch relay R140.

In view of the foregoing, it is apparent that there has been provided an improved tone unit capable of receiving unmodulated 1000 cycle dial pulses, as well as 50–60 cycle modulated 1000 cycle supervisory signals; and capable of transmitting an unmodulated 1000 cycle signal for dialing purposes, as well as 50–60 cycle modulated 1000 cycle supervisory signals. Also, the tone unit comprises an improved arrangement for preventing damage as a consequence of over-loading of the various tubes incorporated therein in response to the reception of strong 1000 cycle signals; as well as an improved arrangement for permitting monitoring over a toll line associated with a repeater circuit with which the tone unit is associated while the tone unit is conditioned to receive supervisory signals from the associated repeater circuit over the associated toll line, without interference.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various modifications may be made therein, and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a signaling system, a receiving channel adapted to receive during a given time interval a predetermined frequency modulated audio frequency current as well as dial pulses at a given rate of said audio frequency current, a circuit network, means including an amplifier for coupling said receiving channel to said circuit network, a monitoring channel, means including an

impedance element for coupling said circuit network to said monitoring channel, a rectifier operatively connected to said circuit network and operative to produce during said given time interval direct current impulses at said predetermined frequency and to produce direct current impulses at said given rate, a local circuit, first means controlled in response to said direct current impulses at said predetermined frequency for repeating during said given time interval a signal pulse into said local circuit, and second means controlled in response to said direct current impulses at said given rate for repeating dial impulses at said given rate into said local circuit.

2. In a signaling system, a receiving channel adapted to receive during a given time interval a predetermined frequency modulated audio frequency current, a circuit network, means including an amplifier for coupling said receiving channel to said circuit network, a monitoring channel, means including an impedance element for coupling said circuit network to said monitoring channel, means including a rectifier operatively connected to said circuit network for producing during said given time interval direct current impulses at said predetermined frequency, a local circuit, and means controlled in response to said direct current impulses at said predetermined frequency for repeating during said given time interval a signal pulse into said local circuit.

3. In a signaling system, a receiving channel adapted to receive dial pulses at a given rate of audio frequency current, a circuit network, means including an amplifier for coupling said receiving channel to said circuit network, a monitoring channel, means including an impedance element for coupling said circuit network to said monitoring channel, means including a rectifier operatively connected to said circuit network for producing direct current impulses at said given rate, a local circuit, and means controlled in response to said direct current impulses at said given rate for repeating dial impulses at said given rate into said local circuit.

4. In a signaling system, a receiving channel adapted to receive audio frequency signals, a circuit network, means including an amplifier for coupling said receiving channel to said circuit network, a monitoring channel, means including an impedance element for coupling said circuit network to said monitoring channel, an electron discharge device including input and output electrodes, an output circuit coupled to said output electrodes, a first tuned circuit coupled to said circuit network and having a frequency response characteristic that peaks at a predetermined audio frequency, a second tuned circuit coupled to said circuit network and having a frequency response characteristic that peaks at two audio frequencies respectively disposed above and below said predetermined audio frequency, means controlled in accordance with the signal voltage across said first tuned circuit for impressing a first control voltage between said input electrodes, and means controlled in accordance with the signal voltage across said second tuned circuit for impressing a second control voltage between said input electrodes, said first and second control voltages being in opposition to each other so that the current in said output circuit is controlled in accordance with the difference in magnitudes of the signal voltages across said first and second tuned circuits.

5. In a signaling system, a receiving channel adapted to receive during a given time interval a predetermined frequency modulated audio frequency current, a circuit network, means including an amplifier for coupling said receiving channel to said circuit network, a monitoring channel, means including an impedance element for coupling said circuit network to said monitoring channel, a conductor, means for impressing a biasing potential upon said conductor, means including a first rectifier operatively connected to said circuit network for impressing during said given time interval impulses of signal potentials at said predetermined frequency on said conductor, said signal potentials being in opposition to said biasing potential on said conductor, means including a second rectifier operatively connected to said conductor for drawing current therefrom when the signal potential overcomes the biasing potential on said conductor, means controlled in response to the drawing of current from said conductor by said second rectifier for controlling said amplifier to increase the coupling impedance between said receiving channel and said circuit network, a local circuit, and means controlled in response to said impulses of signal potentials at said predetermined frequency on said conductor for repeating during said given time interval a signal pulse into said local circuit.

6. In a signaling system, a receiving channel adapted to receive dial pulses at a given rate of audio frequency current, a circuit network, means including an amplifier for coupling said receiving channel to said circuit network, a monitoring channel, means including an impedance element for coupling said circuit network to said monitoring channel, a conductor, means for impressing a biasing potential upon said conductor, means including a first rectifier operatively connected to said circuit network for impressing impulses of signal potentials at said given rate on said conductor, said signal potentials being in opposition to said biasing potential on said conductor, means including a second rectifier operatively connected to said conductor for drawing current therefrom when the signal potential overcomes the biasing potential on said conductor, means controlled in response to the drawing of current from said conductor by said second rectifier for controlling said amplifier to increase the coupling impedance between said receiving channel and said circuit network, a local circuit, and means controlled in response to said impulses of signal potentials at given rate on said conductor for repeating dial impulses at said given rate into said local circuit.

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Certificate of Correction

Patent No. 2,482,478 September 20, 1949

OTHO D. GRANDSTAFF

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

Column 16, line 57, before the word "given" insert *said*;

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

Signed and sealed this 31st day of January, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.