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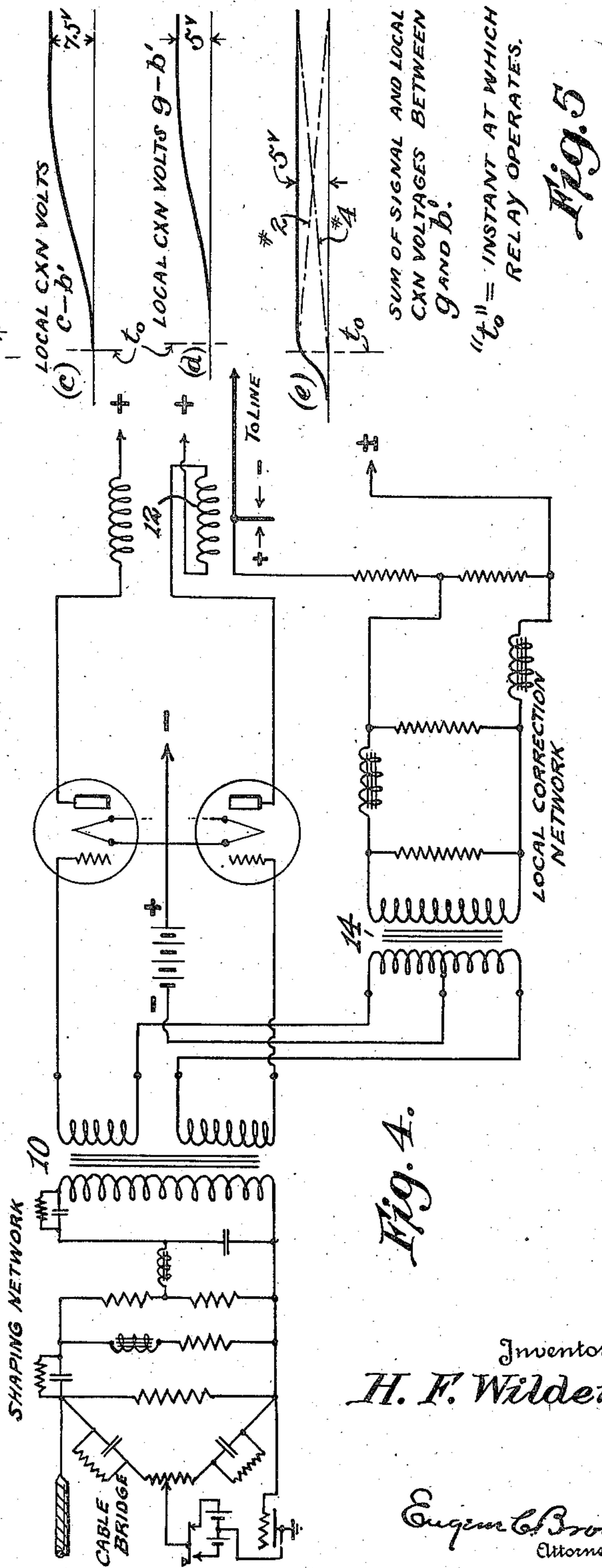
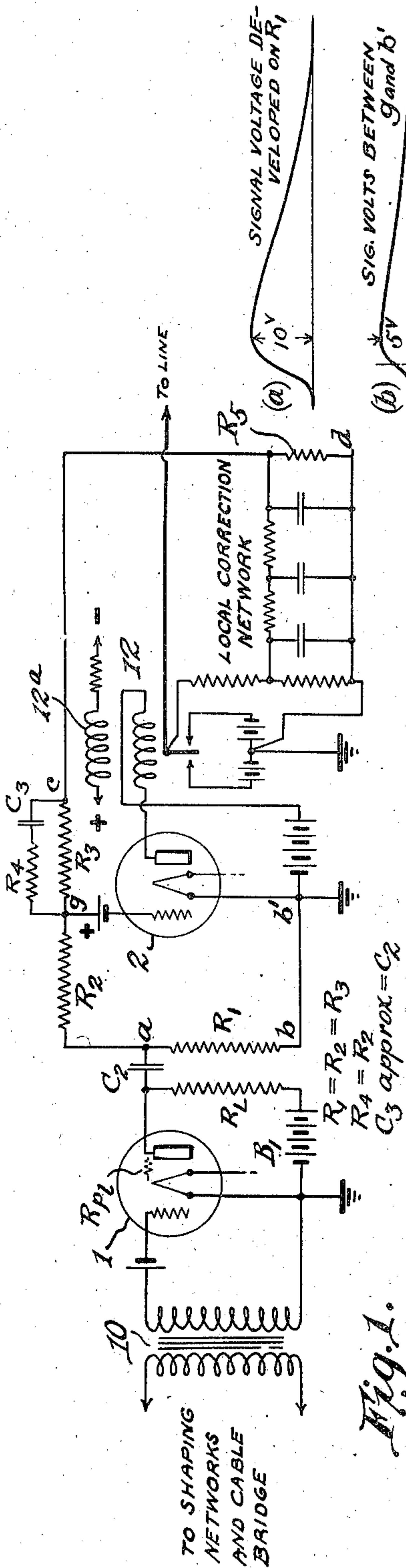
H. F. WILDER

2,109,982

LOCAL CORRECTION OF CABLE SIGNALS

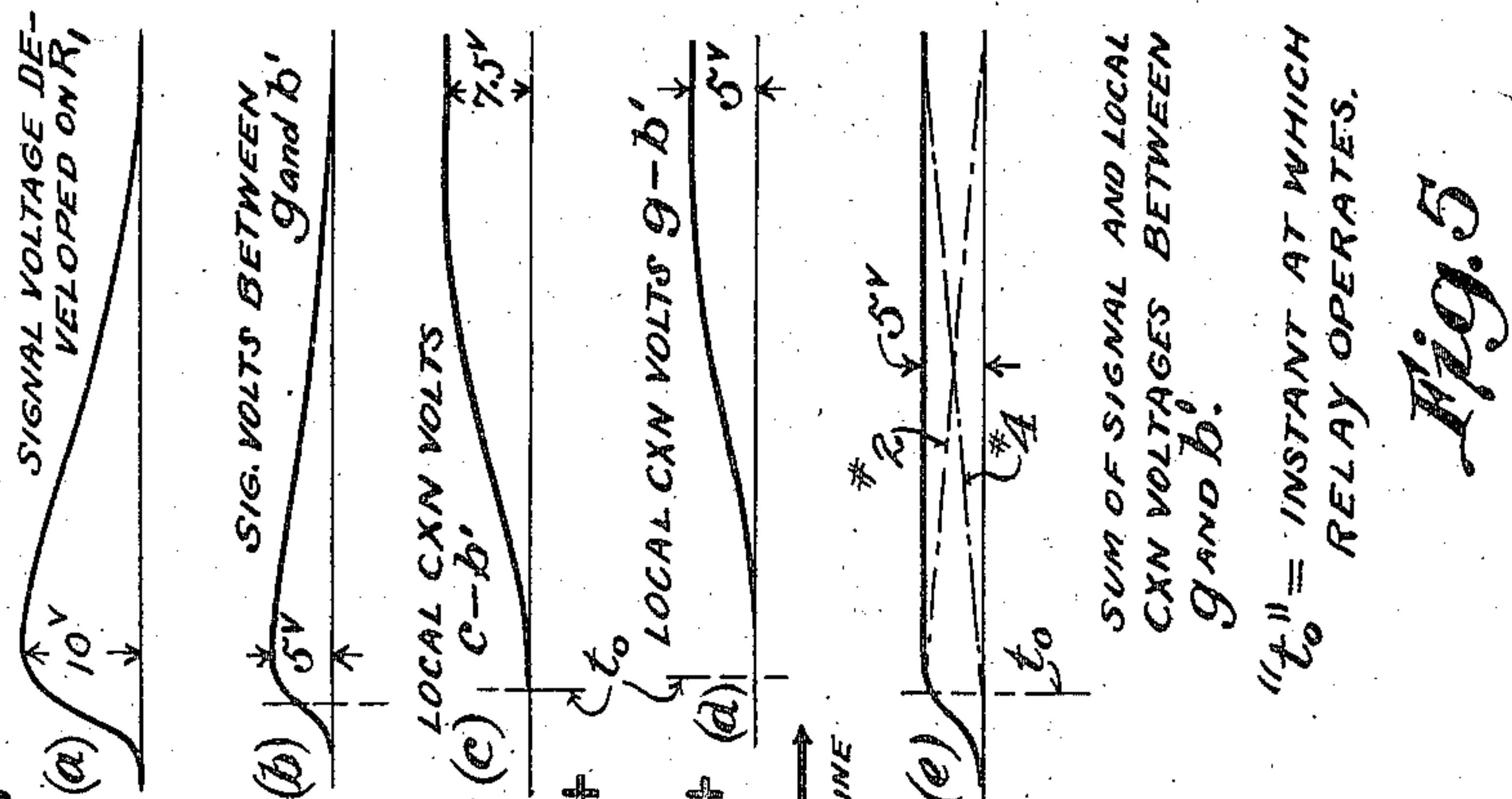
Filed April 21, 1937

2 Sheets-Sheet 1



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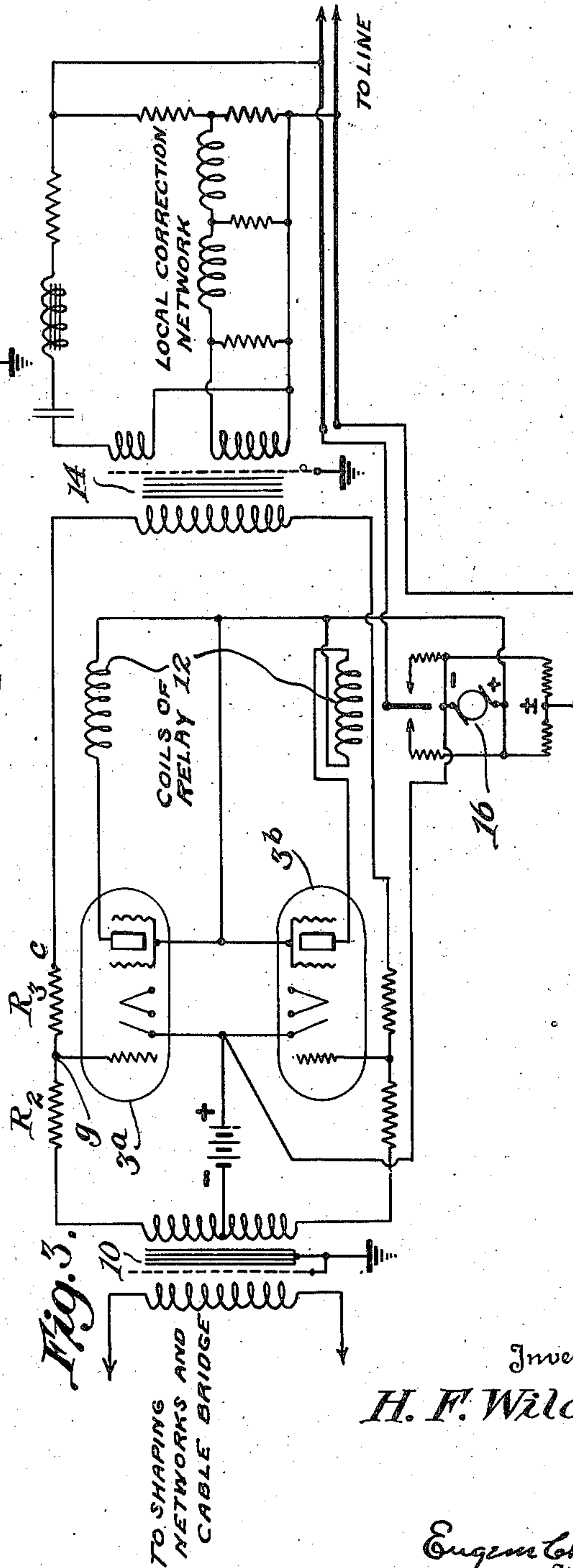
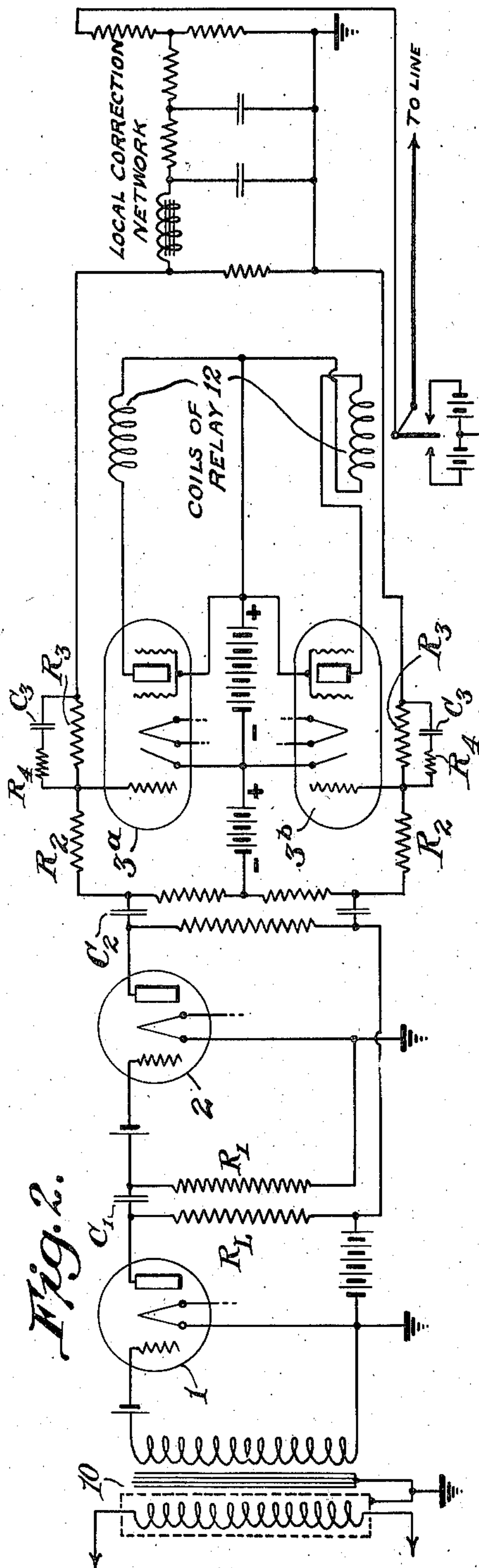
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2 Sheets-Sheet 2



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LOCAL CORRECTION OF CABLE SIGNALS

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Application April 21, 1937, Serial No. 138,262

7 Claims. (Cl. 178—70)

This invention relates to ocean cable telegraph systems and pertains particularly to circuit arrangements for restoring the signal waves to their proper shape by supplying through a local correction circuit the low frequency components of the telegraph signals which are suppressed in filters and amplifiers of the primary receiving equipment.

It is well known that telegraph signals are attenuated and distorted in their passage through a cable, due to the resistance, capacity and inductance of the cable. In recent years the effect of the capacity of the cable conductor to the sheath and the earth in attenuating the higher frequency components to a greater extent than the lower frequencies has been greatly reduced by continuously "loading" the conductor with a material which increases the inductive reactance of the line. The higher frequencies from approximately twice the frequency of the signal reversals to infinity are entirely dissipated in transmission, but the signal is nevertheless quite suitable for the control of retransmitting or printing equipment. It is necessary, however, to pass the signals through shaping networks and amplifiers before they enter the receiving apparatus. Due to the loss of low frequency components in the shaping networks and the amplifier, the signal waves are distorted or are not sustained in amplitude and if the signal frequency becomes sufficiently low, the current through the receiving impedance may approach zero and the entire generated E. M. F. will become stored on the capacity.

The object of my invention is to restore the signal waves to their normal undistorted condition without the presence of low frequency disturbance by returning to the signal waves an E. M. F. of the proper shape having frequency components equal in magnitude but opposite in phase to those components suppressed by the local capacitance.

In the following description of my invention I shall refer to the accompanying drawings, in which—

Figures 1, 2, 3 and 4 are diagrams illustrating conventionally the circuit arrangements of equipment embodying my invention which may be employed at the receiving end of a cable. Figure 5 illustrates the graphs of voltages developed by the signal waves and the voltages developed in the local correction circuits and showing the manner of combining these voltages to produce a perfect signal wave for retransmission.

The receiving end of the cable is connected to

the duplex bridge and to the shaping networks in the manner shown in my prior application Serial No. 90,804, filed July 15, 1936 and are well understood by engineers. The manner of determining the characteristics of the cable and the proportions of the shaping and amplifying elements at the terminal are set forth in said prior application.

In order to electrically separate the cable from the amplifier and its associated circuits and also to suppress low frequency interference or induction, the amplifier is coupled to the shaping networks by a transformer 10. To suppress high frequency induction and interference due to natural potential differences between the terminals of the cable and from mis-matching of the cable and artificial line impedances under duplex conditions, as pointed out in said application, a low pass network is introduced between the shaping networks. These same sources may produce interference at frequencies well below the signal frequency, although the natural potentials are usually predominant.

The introduction of a transformer distorts the signals by suppressing their lower frequency signal components. During a magnetic storm or a period in which the earth's magnetic field shifts or changes in magnitude perpendicular to the axis of the cable, an E. M. F. of a relatively low frequency will appear at the receiving terminal, upon which the signals are superposed, thereby causing the latter to deviate from their so-called zero position. These adverse frequencies of a low order may be effectively suppressed or prevented from entering the receiving apparatus by the interposition of a condenser or a properly adjusted high pass filter. The latter also suppresses low frequency components in the signal waves, so that the longer signal pulses are not sustained in amplitude and fall to zero, with consequent distortion and susceptibility to interference as the E. M. F. declines to zero.

It becomes necessary, therefore, to locally restore the missing low frequency components thus suppressed, in order to reform the signal to its original condition. The object of my invention is to provide means embodying thermionic vacuum tubes for thus locally restoring these missing components to the receiving equipment.

For the purpose of explaining my method of restoring the missing components by local correction, I will refer to the circuit arrangement of Fig. 1, and the explanatory diagrams of Fig. 5. A two-stage vacuum tube signal-shaping telegraph amplifier is shown. The amplifier is con-

connected to the shaping network and cable by means of the transformer 10. A resistance capacitive coupling having a relatively high time constant, in the order of twenty seconds, is employed between the stages of the amplifier. By means of an extra biasing winding 12^a, on the retransmitting relay 12, the D. C. component of the plate current of the vacuum tube 2, is neutralized, to allow the relay to be freely operable by the signal A. C. component.

Assuming that a negative signal pulse modulates the grid of vacuum tube 1, the plate current I_{p1} will be decreased, thereby causing point a to become more positive, since the battery B_1 is opposed by a smaller IR drop in resistance R_L . The consequent positive charging current into condenser C_2 and to ground through resistance R_1 will raise the potential of the grid of vacuum tube 2, causing a positive pulse of current to flow through the operating coil of relay 12.

The signal voltage wave developed across the resistance R_1 is of the form shown at Fig. 5— a . Resistances R_2 and R_3 are made equal and constitute a potentiometer, dividing the signal voltage approximately in half. The signal voltage developed between the points g and b' is thus shown at Fig. 5— b . The operation of the armature of relay 12 applies a voltage from battery to the input terminals of the local correction network. Ultimately this potential, assumed to be 7.5 volts, will appear across the resistance R_4 but the rate at which the maximum is reached is controlled by the electrical constants of the correction network to be an inverse function of the decay of the "tail" of the arrival curve. This local correction (abbreviated CXN) voltage developed between the points c and d is symbolically shown at Fig. 5— c .

This local correction network voltage transient will in turn develop a potential of 2.5 volts across R_1 , 2.5 volts across R_2 and 2.5 volts across R_3 and the sum of the drops across R_1 and R_2 is 5 volts which is, in the steady state condition, exactly equal to the maximum peak deflection of the signal transient, also between points g and b' . The voltage transient developed between the points g and b' by the local correction network is represented at Fig. 5— d . Hence the combined effect of the signal voltage at point g with the local correction voltage at said point g produces a resultant operating pulse which is maintained at steady state value throughout its extent, as illustrated at Fig. 5— e .

The operation of my local correction system of cable signals as above described is theoretically correct. In practice it has been found helpful to shunt the resistance R_3 with a series capacity-resistance network $R_4 C_3$ to compensate for the effect of the initial charging current to the condenser C_2 through the tube plate impedance R_{p1} and the tube load resistance R_L in parallel. As the local correction voltage begins to appear across R_1 , the effect of the condenser C_2 and the preceding tube plate circuit is to lower, for a brief charging interval, the effective resistance between the points a — b . The shunt $R_4 C_3$ is adjusted to just compensate for this interval by passing to the resistance R_2 an extra current component during the time that C_2 is being charged and thus prevents the voltage ratios in the signal-correction mixing network from being momentarily changed from their steady state ratios.

I have disclosed in detail my method of applying a local correction to the received cable signals whereby the low frequency components sup-

pressed in the primary receiving equipment are restored to the signal waves, with particular reference to the circuit arrangement of Fig. 1. The operation of the other modifications shown in Figs. 2, 3 and 4 will be obvious without further detailed description.

Certain types of four-element high mutual conductance vacuum tubes, the UX48 for example, offer the desirable possibility of very efficient and powerful operation of a magnetic relay when the coils of the latter are connected as in the push-pull output circuit of Figure 2. The local correction current is supplied by modulating the grids of the tubes by means of the symmetrical grid circuit and low pass filter.

In cables of less attenuation an amplifier having tubes of the type above mentioned in push-pull arrangement, may be employed and connected as indicated in Fig. 3. In this case a transformer 14 is introduced between the local correction network and the potentiometer grid bridge circuit. This arrangement also permits the station generator 16 to be utilized as a supply both for the push-pull tube circuit and for the local correction network. The transformer may also be equipped with a tertiary winding for the purpose of introducing an opposing oscillatory voltage to compensate for undershoot in the signal as is sometimes desirable under conditions of severe interference in the high frequency end of the signal spectrum.

In Fig. 4, I have shown another modification of this invention which may be advantageously employed under certain conditions. Thus if the ratio of transformation of the transformer is great the high internal impedance of the secondary may prevent the loading of the latter with even a resistance grid potentiometer of several megohms. The secondary is split and the correction E. M. F. is introduced between the two half windings by the transformer 14. As the primary of 14 is shunted by a low resistance, in the order of several hundred ohms, the impedance looking into the transformer 14 from the secondary is approximately the same for a ratio of transformation of unity and the introduction of this impedance is, therefore, negligible.

In order that the low frequency correction currents shall pass through the correction transformer 14 without distortion, the ratio of the primary inductance of the transformer to the resistance of the primary winding, plus the reflected secondary load resistance, plus the resistance of the correction network shunted across the primary, should be kept high as possible. Ratios of L/R of 4 and 6 have been found satisfactory for the majority of signal circuits. A transformer so constructed is large physically but quite practical and is in general use in cable signaling equipment.

In order to more completely disclose this invention I have shown several circuit arrangements which may be employed to suit different conditions but it will be evident to engineers that various other modifications may be made and that any combination of the circuits for amplifying and correcting may be made to best suit the power sources available, without departing from this invention or from the scope of my claims.

I claim:—

1. In a communication system having a receiving terminal provided with signal shaping and amplifying means which distort the received signals by suppressing the lower frequency components of the received signal impulses, the method of restoring to normal amplitude the dis-

torted portions of the signal impulses, which consists in initiating the local generation of a voltage impulse by the operation of a received distorted signal impulse, shaping and developing said generated impulse to correspond to an inverse function of the decay of said distorted impulse, and electrostatically controlling the transmission of a signal impulse by the conjoint action of said distorted impulse and said generated impulse.

2. In a communication system having a receiving terminal provided with signal shaping and amplifying means which distort the received signals by suppressing the lower frequency components of the received signal impulses, the method of restoring to normal amplitude the distorted portions of the signal impulses, which consists in locally generating a voltage impulse, shaping and developing said impulse as an inverse function of the decay of the distorted received signal impulse, and retransmitting an undistorted signal impulse under the joint electrostatic control of said distorted impulse and said locally generated impulse.

3. In a communication system having a receiving terminal provided with signal shaping and amplifying means which distort the received signals by suppressing the lower frequency components of the received signal impulses, the method of restoring to normal amplitude the distorted portions of the signal impulses, which consists in initiating the local generation of voltages by the operation of the received distorted signal impulses, shaping said generated voltages in inverse ratio to the decay of said distorted voltages, combining the distorted and locally generated voltages to produce resultant sustained voltages and electrostatically applying said sustained voltages to control the transmission of undistorted signals.

4. In a communication system having a receiving terminal provided with signal shaping and amplifying means which distort the received signals by suppressing the lower frequency components of the received signal impulses, a repeating or relaying apparatus embodying a circuit arrangement having a thermionic vacuum tube provided with anode, cathode and grid elements, a current source, a relay for repeating or relaying signal impulses from said source to a recorder or transmission line, said relay having its operating coil in the output of said tube, means for producing a correction voltage having characteristics which are an inverse function of the decay of the distorted received signal voltages, and means to subject the grid of said tube to the conjoint control of the received distorted voltage and the

correction voltage, whereby the repeating relay transmits undistorted signals.

5. A repeating or relaying apparatus as set forth in claim 4, said correction means comprising a low pass filter network having characteristics which produce voltage transients embodying components corresponding to the low frequency components of the received signals suppressed in the shaping and amplifying means.

6. In a communication system having a receiving terminal provided with signal shaping and amplifying means which distort the received signals by suppressing the lower frequency components of the received signal impulses, a resistance connected across the output of said amplifying means, a repeating or relaying circuit connected in shunt to said resistance and having a pair of high resistance potentiometers, a pair of thermionic vacuum tubes having anode, cathode and grid elements connected at mid-points respectively of said potentiometers and in inverter arrangement, means for locally generating voltages in synchronism and phase with the received signals and embodying components corresponding to the suppressed components of the received signals, means for subjecting the grids of the tubes to the conjoint control of the voltages of the received signals and the locally generated voltages and means controlled by the output of the tubes for repeating signals corresponding to the original undistorted signals into a recorder or transmission line.

7. In a communication system having a receiving terminal provided with signal shaping and amplifying means which distort the received signals by suppressing the lower frequency components of the received signal impulses, a repeating or relaying arrangement connected to the output of said amplifying means embodying a transformer and a pair of thermionic vacuum tubes having anode, cathode and grid elements, said tubes being connected in inverter arrangement with their grid elements connected to the secondary of the transformer, a source of electrical energy, a correction network having characteristics which transmit only frequency components corresponding to said suppressed components of the received signals, means for connecting said network to said source in synchronism with the received signals, means for subjecting said tubes to the conjoint control of the received signals and the output of said network, and means in the output of the tubes for repeating signals into a recorder or transmission line.

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