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MEANS FOR REDUCING DISTURBANCES IN CONCENTRIC LINES

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Fig. 1.

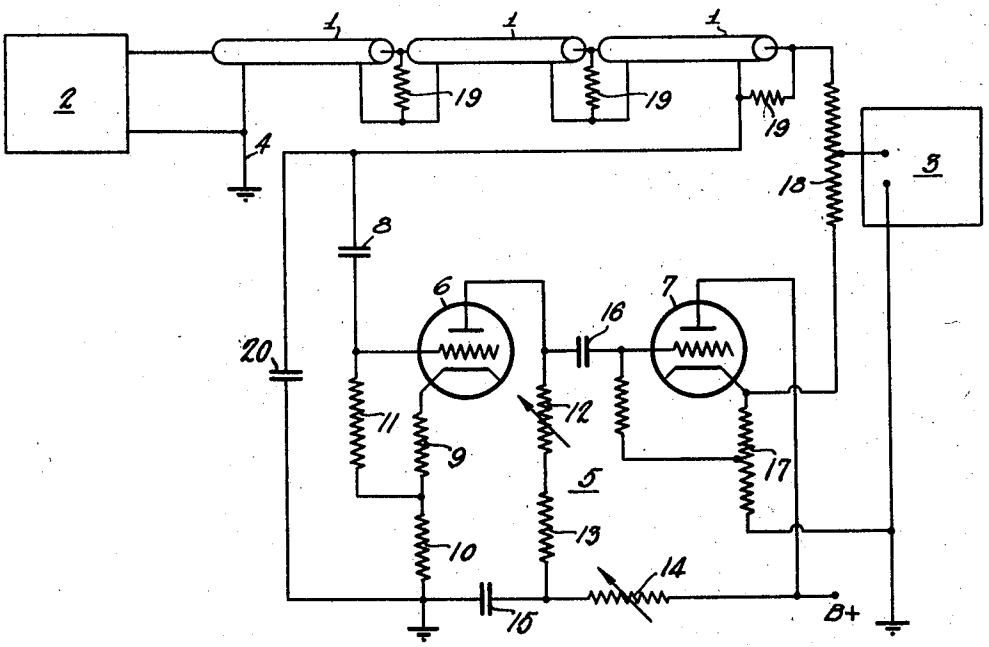
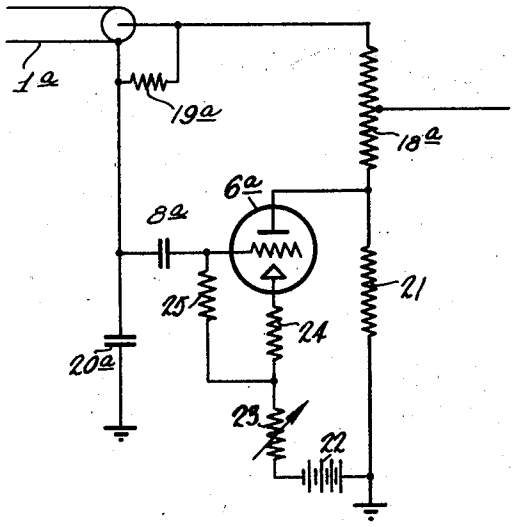


Fig. 2.



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MEANS FOR REDUCING DISTURBANCES IN CONCENTRIC LINES

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5 Claims. (Cl. 178—69)

This application relates to the reduction of interference in communications circuits, such as that emanating from power circuits, and more particularly to the elimination of hum and other distortion from concentric or coaxial cable circuits.

It is one object of my invention to reduce or eliminate hum from coaxial transmission lines used for wide band transmission, such as employed in television practice.

It is another object of the invention to provide an amplifier for producing a hum component equal and opposite to that appearing in the coaxial line, thereby to neutralize or balance out the hum in said line.

It is still another object of the invention to counteract differences in ground potentials between the sending and receiving end of a transmission line.

It is a further object of the invention to reduce the distortion of signals in transmission through a concentric line.

It is another object of the invention to provide a line capable of transmitting a broad frequency spectrum without excessive attenuation of any part of the band.

Other objects of the invention will be apparent from the following description and the accompanying drawing which, while illustrative of the invention, is not intended as a limitation of the same, since many modifications are possible without departing from the scope of the invention.

In the drawing:

Fig. 1 shows a coaxial transmission line embodying one form of the invention; and

Fig. 2 shows a modified form of the invention.

Referring first to Fig. 1 of the drawing, there is shown a concentric transmission line 1 for transmitting signals from a source 2 to a relatively remote apparatus 3. Source 2, for example, may be a video amplifier located at one point, while 3 may be another video amplifier which may be at the transmitter or at some intermediate point. At the sending end the cable sheath is connected to ground, e. g., by the ground wire 4, and the remainder of the transmission line is insulated from ground.

In the operation of the transmission line in the general vicinity of alternating current power circuits there may appear between ground at the sending point and ground at the receiving point an A. C. difference in potential, e. g., in the form of a 25 or 60 cycle hum. This difference in ground potential will cause both the central conductor and the outer sheath of the concentric line to have an A. C. hum voltage with respect to ground at the receiving point. Consequently if the output terminals of the line were connected to a conventional amplifier the hum voltage would be amplified along with the desired signal voltage. In conventional amplifiers cross-modulation between hum and signal is so pronounced that known hum-bucking methods have proven altogether unsatisfactory in practice. The present invention furnishes a means for separating the hum signal from the desired signal without providing an opportunity for cross modulation to take place, and thus the desired signal can be derived from the line free of all hum or distortion due to hum.

In accordance with the preferred form of the present invention, there is provided a hum balancing circuit designated generally by reference character 5 and comprising tubes 6 and 7. Any difference in potential between the outer sheath and ground is applied to the grid of the first tube 6 through the condenser 8, which is of large enough capacity so as not seriously to distort the wave-form of the low frequency voltage (e. g., 25 or 60 cycles). This tube is heavily cathode loaded with the unbypassed resistors 9 and 10 so as to be highly degenerative and have little gain. The grid of the tube is biased through the leak resistor 11 connected to the junction of cathode resistors 9 and 10. The plate load circuit of the tube 6 comprises the resistors 12 and 13. The variable resistor 14 by-passed by the condenser 15 provides a variable plate voltage supply. The gain of the tube can be changed by varying the load resistor 12.

The A. C. hum voltage impressed on the grid of tube 6 from the transmission line is inverted in phase in passing through the tube and appears across the anode resistors 12 and 13 exactly 180° out of phase with the voltage applied on the grid. The A. C. hum voltage appearing on the anode of the tube 6 is applied through the relatively large coupling condenser 16 to the grid of the second vacuum tube 7. The entire load resistance of this second tube is in the cathode circuit, and the A. C. output is derived from this load. This A. C. output will be in phase with the grid voltage, as is well known in the art, and hence is out of phase with the voltage on the grid of tube 6. The impedance of the cathode load 17 is low, which results in a suitable impedance match with a circuit of comparatively low impedance, for example, the concentric line itself. Since the phase of the voltage appearing between the cable sheath and ground is reversed once in

the circuit 6, i. e., in tube 6, and since the circuit is without other substantial causes of phase shift, the voltage appearing on the cathode of the tube 7 with respect to ground will be opposite in phase to the voltage between the grid of the tube 6 and ground—i. e., the voltage between the external conductor of the concentric line and ground at the receiving end of the line. If the voltage between the external conductor and ground is e_h, the voltage on the cathode of tube 7 will be $-ke_h$ and by proper setting of the resistor 12 may be made equal to $-e_h$. The hum voltage gradient across the resistor 18 will then vary from $+e_h$ to $-e_h$, and by taking the signal from the center point of resistor 18, the hum voltage to ground at the receiving point will be zero at all times. It will be observed that the signal voltage across the upper section of the voltage divider resistor 18 is not utilized since it includes components of the undesired hum voltage.

Particular note should be made of two of the features of the circuit of Fig. 1. Whereas, in prior practice it has been customary to ground both ends (and occasionally intermediate points) of long coaxial lines, according to the present invention, it is important that the receiving end of the line be left ungrounded in order that the amplifier may be properly combined therewith in the manner heretofore described. Secondly, it should be observed that at no point in the circuit is the combined signal-plus-hum voltage passed over a non-linear tube characteristic and thereby cross modulated. Only the hum is amplified, and that through heavily cathode-loaded tubes to reverse polarity without distortion.

As shown in Fig. 1 there may be inserted at each junction between the sections of the cable a shunt conductance 19. These shunt conductances are designed to have such a value that $L/C=R/G$, where L is the series inductance of a length of cable, C is the shunt capacitance between conductors, R is the series resistance, and G is the shunt conductance. Since there is practically no leakage between conductors, practically all of the conductance must be inserted by use of the shunt resistors 19. At the terminating end of the line a small R. F. by-pass condenser 20 is provided between the cable sheath and ground to carry away any radio frequency currents which might be induced in the line. This condenser need be but very small as compared with the condenser 8, and therefore will have negligible effect on the hum amplifier.

In Fig. 2 there is shown a modified form of the invention in which a single tube is used. In this circuit the hum voltage is applied to the grid of the tube 6a and the desired hum-bucking voltage of opposite phase is obtained directly from the drop across the load resistor 21 which is in the plate circuit of the tube. In order to maintain the center-tapped resistor 18a at substantially D. C. ground potential, the plate battery or other high voltage source 22 is connected in the cathode circuit of the tube and its positive terminal is grounded. In the cathode circuit of the tube is also placed an adjustable resistor 23 and the bias resistor 24. The grid is connected to the junction between the resistors 23 and 24 through the grid leak resistor 25. The gain of this circuit is controlled by changing the value of the cathode load resistor 23 and thereby changing the division of load between resistors 21 and 23.

In actual practice it was found that in one installation near an electrified railroad right-of-way a 2,500 foot coaxial transmission line had a hum voltage of from 6 to 10 volts between sending and receiving ends as compared with a signal voltage of one volt. The hum-bucking arrangement as described above completely eliminated this hum, and was entirely satisfactory when the hum voltage was even 10–20 times as strong as the signal voltage.

Referring to the form of the invention shown in Fig. 1 the following values of the circuit elements were used and found satisfactory: Condensers 8 and 16 were each 2.0 m. f.; the grid leak resistor 11 was 1 megohm; resistor 9 was 1000 ohms; resistor 10 was 10,000 ohms; condenser 20 was 0.003 m. f.; resistor 18 was 20,000 ohms, centertapped; resistors 12 and 14 were each 5,000 ohms; resistor 13 was 10,000 ohms; resistor 17 was 11,000 ohms, —1,000 ohms between cathode and grid return, and 10,000 ohms between grid return and ground; and resistor 19 was approximately equal to the characteristic impedance of the line.

It is to be understood, of course, that the invention is not limited to the specific circuits illustrated nor to the values given above, but is capable of various modifications, and that while the transmission line has been described and shown as a coaxial line, since this type line has special advantages in the type of circuit described, the invention might also be applied to other types of lines, e. g. twisted pair lines. The word "amplification" has been used in the following claims in its broad sense, i. e. to include amplification factors of greater than unity, of unity, or even of less than unity.

I claim:

1. A circuit for the reduction of extraneous voltage caused by differences in ground potential along a concentric cable, which comprises in combination an electronic amplifier for amplifying and reversing the phase of the voltage wave between one conductor of the cable and ground, a second electronic device in cascade with said amplifier to isolate the voltage wave, an impedance connected between the output of the second device and the second conductor of the concentric cable, and a tap on said impedance to pick up a signal substantially free of said extraneous voltage.

2. A circuit as defined in claim 1, in which the second electronic device has a cathode load from which the output is derived, whereby to prevent phase reversal in said device.

3. In a circuit for eliminating the deleterious effects of alternating ground potential differences present between the sending and receiving ends of a transmission line, means at the sending end of said line for grounding one of the conductors thereof, apparatus located at the receiving end of said line comprising electronic phase-inverting means having output terminals coupled to an output impedance and having input terminals connected between said grounded conductor and ground, whereby only the alternating ground potential is applied to said phase-inverting means, a load impedance connected between the ungrounded conductor of said line and said output impedance, the alternating ground potential appearing in one polarity at the line end of said load impedance and in reversed polarity at the other end thereof, and a signal utilization means connected between ground and an intermediate point on said load impedance where said alternating potential is substantially zero.

4. A terminating circuit for a concentric cable transmission line in which the voltage between the inner conductor and ground consists of a desired signal combined with an extraneous hum voltage, and the voltage between the outer conductor and ground consists of the said extraneous hum voltage only, comprising an electronic voltage-reversing means connected between said outer conductor and ground and constructed and arranged to provide a source of hum voltage of reversed polarity, an impedance connected between said source of reversed hum voltage and said inner conductor, and a signal utilization means having one input terminal connected to ground and another input terminal connected to an intermediate point on said impedance where the hum voltage is substantially zero.

5. A terminating circuit for a concentric cable transmission line in which the voltage between the inner conductor and ground consists of a desired signal combined with an extraneous hum voltage, and the voltage between the outer conductor and ground consists of the said extraneous hum voltage only, comprising an electronic voltage-reversing and amplifying means connected between said outer conductor and ground and constructed and arranged to provide a source of hum voltage of reversed polarity, gain control means associated with said first-named means for adjusting the magnitude of the reversed voltage to equal that of the hum voltage between the inner conductor and ground, an impedance connected between said source of reversed hum voltage and said inner conductor, and a signal utilization means having one input terminal connected to ground and another input terminal connected to the electrical midpoint of said impedance, at which point the hum voltage is substantially zero.

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