

Oct. 10, 1939.

F. A. LEIBE
COMMUNICATION SYSTEM

2,175,202

Filed Dec. 31, 1937

FIG. 1

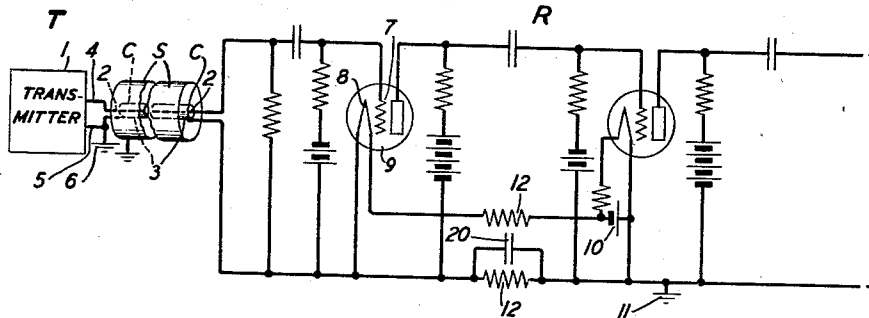


FIG. 2

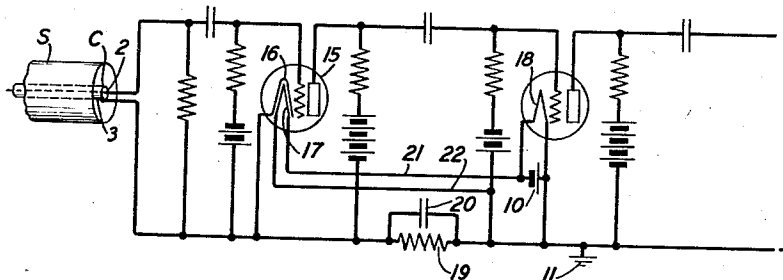
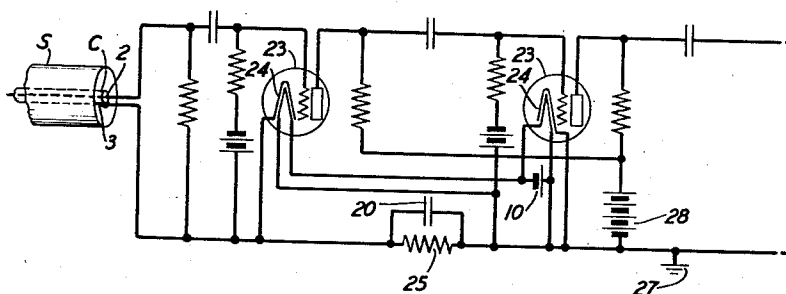


FIG. 3



INVENTOR
F. A. LEIBE
BY *J. H. McNeill*
ATTORNEY

UNITED STATES PATENT OFFICE

2,175,202

COMMUNICATION SYSTEM

Frank A. Leibe, Quakertown, Pa., assignor to Bell
Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

Application December 31, 1937, Serial No. 182,657

2 Claims. (Cl. 178—69)

The present invention relates to communication systems and more particularly to means for reducing the effect of interfering energy, introduced into the path over which useful energy is transmitted.

When signals or other useful energy is transmitted from a sending to a receiving station over a communication path comprising a plurality of conductors, one of which has both of its terminals connected to ground locally, whereas the other conductor is isolated from ground, the grounded conductor will be associated via the local terminal connections with a ground return to provide a series circuit, and, if sources external to the system produce a difference of potential between the locally applied ground connections, currents of considerable magnitude and of the frequency of the extraneous sources may be caused to flow through this series circuit including the grounded conductor. When the currents thereby introduced lie in a portion of the frequency range occupied by the useful or signal energy, they may seriously interfere with the efficient transmission of the useful or signal energy.

In one typical example of a communication system of the character described above, the signal or useful energy is transmitted between stations over a path comprising a coaxial conductor having the terminals of its outer conductor locally grounded.

As is well known, a coaxial conductor system is well adapted to the transmission of signal currents extending over a wide frequency range, and, as a matter of fact, conductive systems of the type are being used at the present for the transmission of television image currents, or other signal currents, which extend from an upper limiting frequency of one or more million cycles per second to a few cycles per second, and, in some cases, to zero frequency.

While the outer conductor is an effective shield at the upper end of the frequency range occupied by the signal currents and hence operates to prevent the introduction of high frequency interfering or noise currents into the signal path, its efficiency as a shielding means at the lower end of the frequency spectrum is relatively small; consequently extraneous low frequency voltage sources, which are effectively associated with the signal path, will cause low frequency currents to flow through the outer conductor of the coaxial system, and thereby cause energy of corresponding frequencies, commonly referred to as noise currents, to be introduced into the signal path.

In order to minimize the effect of the noise cur-

rents introduced into the signal path, via the outer conductor of a coaxial system, it has been proposed to supply the incoming signal and noise currents to a receiving circuit which, by virtue of its impedance or selective characteristics and the inclusion of an attenuator connected in the series circuit comprising the outer conductor, causes the receiving apparatus to discriminate in favor of the signal and to the detriment of the noise currents; thereby materially increasing the ratio of signal-to-noise. This arrangement may necessitate the use of one or more devices having power supply circuits, including one or more supply sources which must be insulated from ground.

The present invention is directed to a system similar to that described in the preceding paragraph.

An object of the present invention is to provide an improved arrangement of the type referred to above.

Another object is to minimize the effect of interfering energy picked up by a channel over which signals are transmitted to an apparatus, including one or more elements directly connected to ground, by connecting the channel to ground over a circuit of the apparatus including means for causing this apparatus to discriminate in favor of the signals.

The invention will be herein described as applied, by way of example, to a system in which television image currents are transmitted over a coaxial conductor, the image currents having a frequency band width which extends from, and may include direct current, to an upper limiting frequency of a million or more cycles.

According to one aspect of this invention, it provides a means for minimizing the effect of interfering or noise energy introduced into the signal transmission path via one conductor of the transmission line without materially affecting the signals. It is therefore especially adapted for use in systems in which signals are transmitted over a coaxial conductor, because, in conductors of this type, the inner conductor is shielded from extraneous sources by the outer conductor, whereas the latter is connected to ground and hence provides a means whereby the energy supplied by external sources may be readily picked up and introduced into the transmission line.

A detail description of the invention follows and is illustrated in the attached drawing, in which:

Fig. 1 illustrates a diagrammatic circuit embodying the invention; and

Figs. 2 and 3 show other circuits which may be

used at the receiving station in place of that shown in Fig. 1.

Referring now to Fig. 1, a station T, including means 1 for producing an image current having a frequency band width extending from a million or more cycles per second to a few cycles per second, is connected to a remote station R by a coaxial conductor system C, enclosed in a grounded sheath S.

Station T may comprise a studio in which a transmitter 1 is used to scan a field of view or subject, that may be a motion picture film, and station R may be a distributing point, whence the image current may be supplied over lines in its normal frequency range, or as a modulation of a carrier wave adapted to be transmitted over a line or a radio link, to remote television subscribers' stations, either alone or in association with accompanying sound currents; or it may be any station at which the television image current is produced in its normal frequency range, for example, a broadcast receiving station, whence the image current is distributed to a series of subscribers.

Coaxial conductor C is of a well-known type, comprising an inner conductor 2 enclosed in a tubular conductor 3, which in turn is surrounded by, but insulated from, a grounded sheath S.

Conductors 2 and 3 are respectively connected to the output terminals 4 and 5 of the image current producing device 1, and, except for stray capacity effects between the sheath S and the outer conductor 3, the ground connection 6 at station T and the ground connection applied to the apparatus of the receiving station R, the coaxial system is insulated from ground.

Sheath S and conductor 3 are respectively connected to ground and hence cooperate with ground return to provide two series circuits through which currents supplied by sources external to the system may flow. Such sources may have voltages of such value that they cause currents of considerable magnitude, as compared with the signal currents, to flow through the two series circuits. The sheath being insulated from the coaxial conductor, current flowing there-through will not be introduced into the signal path, but, since the conductor 3 is an element of the coaxial system, the difference of potential between its ground connections, due to the external sources, tends to cause noise currents to flow through this conductor, and if the difference of potential is large the amplitude of the noise currents will be large. The effect of these noise currents is most important at the low-frequency end of the range, because the higher frequency noise currents flowing through conductor 3 are confined largely to its outer surface, whereas the signal currents flow along its inner surface, with the result that this conductor serves to shield the signal path against the introduction of noise currents of higher frequencies. On the other hand, low-frequency noise currents tend to be distributed over the entire conductive cross-section of the outer conductor, along with the low-frequency signals. Therefore, although conductor 3 operates to substantially prevent pick-up of current variations of high frequency, it is not effective to exclude low-frequency variations. Such being the case, extraneous voltages in the low-frequency range may cause currents in this range of relatively large amplitude to flow through the outer conductor of the coaxial system in such a manner that low-frequency energy is transferred to the signal path, and these cur-

rents will interfere with efficient transmission of the signals. In the case of the transmission of television signals, they will cause serious distortion of the reproduced image.

At station R the terminals of the inner and outer conductors 2 and 3 are respectively connected by a resistance-capacity coupling to the grid 7 and cathode 8 of a vacuum tube 9 included in the first stage of a plural stage amplifier.

Cathode 8 and similar cathodes of the vacuum tubes included in successive stages of the amplifying device are supplied with heating current from the source 10, one terminal of which is grounded at 11.

Each conductor of the circuit extending from source 10 to cathode 8 is provided with a resistance 12. Since both of these resistances are included in the series circuit comprising the outer coaxial conductor and ground return, they operate to attenuate the interfering currents.

The value of resistances 12 should be such that their impedance is large enough, compared with the resistance of the outer conductor 3, to provide noise isolation, but of such magnitude, compared with the impedance of the tube circuits, that the signal currents are not materially attenuated. In a system including a coaxial conductor of short length, namely, a few miles long, the resistances 12 may each be of the order of 200 to 2,000 ohms, and their combined value, while high compared with the direct current resistance of conductor 3, which is a few ohms, is low compared with the impedance of the tube circuit, which would be of the order of several thousand ohms, in which they are included. Condenser 20 may represent the capacity to ground of the first stage of the amplifier and its plate supply or it may be a condenser which is introduced to dominate this capacity and thereby provide a fixed value of capacity in the ground connection. At low frequencies this capacity has substantially no effect on the operation of the circuit. At high frequencies it tends to cancel the effect of the resistances 12, but in this range the shielding effect of conductor 3 is sufficient to render the use of additional noise suppressing means unnecessary.

According to Fig. 2, the first amplifying tube 15 includes a cathode 16 adapted to be raised to electron emitting temperature by an associated filament 17, while the second amplifying tube is provided with a directly heated cathode 18. Heating current is supplied to the filament 17 and cathode 18 from a source 10 having one terminal grounded at 11.

The cathode 16 is connected to the cathode 18 by a conductor including a resistance 19 shunted by a condenser 20, and the filament 17 is connected to the source 10 by conductors 21 and 22. The resistance 19 is included in the connection extending from the outer conductor 3 and cathode 16 to the ground 11, which is directly connected to the cathode 18. This resistance is, therefore, included in the series circuit comprising the outer conductor 3 and the ground return path over which current from extraneous sources flow, and hence serves to attenuate the interfering currents.

The value of resistance 19, for conductor of short length, may be of the order of 100 to 1,000 ohms, which is high compared with the direct current resistance of the outer conductor 3, i. e., a few ohms, but low compared to the impedance of the circuits of tube 15, i. e., several thousand

ohms, consequently it will not materially affect the signal currents.

In the system shown in Figs. 1 and 2, while the source supplying heating current to the cathode or heating unit of the first amplifying tube, in each case, is directly connected to ground at 11, the source applying space current to the first tube, in each case, is insulated from ground by the resistances 12 and 19 respectively.

Fig. 3 illustrates an amplifier having a plurality of stages, each including a tube 23 having a unipotential cathode 24, with these electrodes connected by a conductor including a resistance 25 shunted by a condenser 20, and with the filaments of the respective tubes connected to the heating current source 10. One terminal of source 10 is connected to ground at 27, which also serves to ground one terminal of the source 28 which supplies space current to the amplifying tubes 23.

For conductors of the length given above, the value of resistance 25 may be of the order of 100 to 1,000 ohms, and it is included in the series circuit comprising the outer conductor 3 and ground return.

In this case, heating current and space current are supplied by sources 10 and 28 both of which are grounded, and, as in the case of Figs. 1 and 2, resistance 25 is of a high value compared with the direct current resistance of conductor 3 and of low value compared with the impedance of circuits of the first tube 23. Since resistance 25 is included in the series circuit comprising conductor 3 and the ground return path, it operates to materially attenuate the interfering currents without materially affecting the signal currents, and, because of the impedance step-up due to the high impedance of the tube circuits compared with that of the cable, there is introduced a discriminatory effect which tends to increase the ratio of the signal-to-noise.

In Figs. 2 and 3, the condenser 20 may be similar to that included in Fig. 1, i. e., it may merely represent the capacity to ground of the first stage of the amplifier and its insulated supply source in the arrangement of Fig. 2, or the capacity to ground of the first amplifier stage in Fig. 3, or it may be of such value as to dominate the respective capacities and hence provide a fixed value of capacity to ground.

The description hereinbefore given relates to the case where the signal to be transmitted does not include a component of zero frequency. However, the invention contemplates the provision of means for minimizing the effect of noise currents in systems in which the signal may extend down to and include direct current. In this case, the receiving circuits would be provided with direct current amplifiers of any well-known design, and in order to prevent waste of power supplied at the transmitter, i. e., avoid dissipation of power in the coaxial system, a direct current source should be included in the output lead 4 in place of the blocking condenser normally used for this purpose in alternating current amplifier circuits and this source should supply a voltage equal to that which would be developed across the blocking condenser included in an alternating current amplifier designed for use under the operating conditions that obtain in the system. This source should have its positive terminal connected to the transmitter output terminal and its negative terminal connected to the inner conductor 2. For example, if the transmitter comprises amplifying devices supplied with power by a direct

current source, which is also connected to conductor 2, dissipation of power in the conductor system may be avoided by serially including in the lead 4 a battery supplying a potential of the desired value and having its positive terminal connected to the output terminal of the amplifier and its negative terminal connected to the conductor 2.

While the invention has been described as applied to a television system including a transmission path comprising a coaxial conductor and a plural-stage amplifier having an attenuator in the circuits of the first stage, it may be utilized to minimize the effect of interfering or noise currents in a system for transmitting a series of separate signals over a line, one or more of which signals extends into a portion of the frequency spectrum where noise currents, introduced into the line, interfere with efficient transmission of the signals, or with other types of conductive systems in which the noise currents are introduced via one of the conductors comprising the line. Again the invention contemplates the use of a multiple stage amplifier or repeater having resistances included in the circuits of successive initial stages, or in a series of stages interspersed with others that do not include attenuators.

Certain values for the resistance and the length of the coaxial conductor system have been given, by way of example, as applied to a particular case. However, since an essential requirement of the invention is that the resistance be relatively high compared with the resistance of the conductor while low compared with the impedance of the circuits in which it is included, it will be appreciated that the value of the resistance and the length of the conductor may depart materially from the values given above.

What is claimed is:

1. A communication system including a line comprising a plurality of conductors over which signals are transmitted and between which interfering or noise currents produced by sources external to the system may be introduced over a path including one of said conductors, a terminal apparatus supplied with the combined signal and noise currents received from said line, said apparatus comprising a plurality of cascade connected vacuum tube amplifiers, each tube including a cathode, an anode and a control electrode, said line being coupled to the control electrode and cathode of the first amplifier, said cathode being connected to the conductor included in the path through which interfering current is introduced into the line, a grounded source supplying energizing current in parallel to the cathodes of said vacuum tubes, and means for increasing the signal-to-noise ratio of the energy supplied by said first amplifier to the succeeding amplifiers of said terminal apparatus, said last-mentioned means comprising attenuating means included in the circuit which connects said one conductor of the line and the cathode of the tube included in said first amplifier to the said grounded source.

2. A communication system including a line comprising a plurality of conductors over which signals are transmitted and between which interfering or noise currents produced by sources external to the system may be introduced over a path including one of said conductors, a terminal apparatus supplied with the combined signal and noise currents received from said line, said apparatus comprising a plurality of cascade connected vacuum tube amplifiers, each tube including a cathode, an anode and a control elec-

trode, said line being coupled to the control electrode and cathode of the first amplifier, said cathode being connected to the conductor included in the path through which interfering current is introduced into the line, a grounded source supplying energizing current in parallel to the cathodes of said vacuum tubes, and means for increasing the signal-to-noise ratio of the energy supplied by said first amplifier to suc-

ceeding amplifiers of said terminal apparatus, said last-mentioned means comprising a resistance included in one of the leads connecting one terminal of said grounded source to the cathode of the tube in said first amplifier and a resistance shunted by a condenser included in the other lead connecting said grounded source to said cathode.

FRANK A. LEIBE.