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R. A. SHETZLINE
COMMUNICATION SYSTEM

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FIG. 1

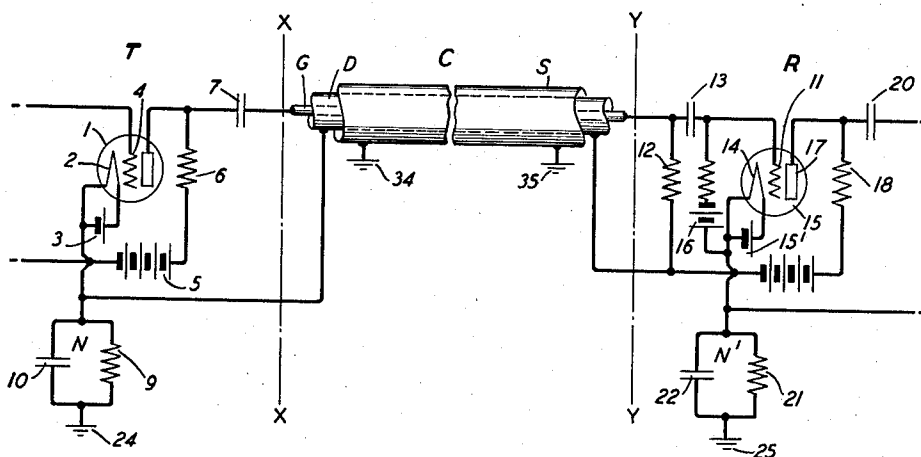


FIG. 2

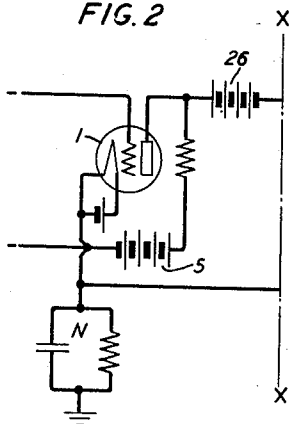
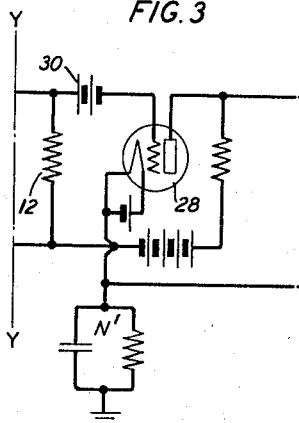


FIG. 3



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COMMUNICATION SYSTEM

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3 Claims. (Cl. 178-69)

This invention relates to communication systems and more particularly to means for minimizing the effect of interfering currents introduced into a signal transmission channel.

When signals are transmitted over a line which has both terminals grounded and which passes through a zone supplied with energy from sources external to the signaling system, interfering currents of considerable magnitude may be introduced into the line.

An object of this invention is the provision of improved means for minimizing the effect of interfering currents upon signals transmitted over a line of the type described above.

A feature of the invention relates to the provision of means whereby a line adapted to be used under the adverse conditions specified above, may be operated at practically ground potential.

Another feature relates to means for materially reducing and thereby simplifying the insulation required to effectively insulate the apparatus units of the system from ground.

The invention will be hereinafter described, by way of example, as applied to a system in which a television image current is transmitted over a coaxial conductor which may be enclosed in, but insulated from, a grounded sheath.

The present invention has special advantages when used with coaxial conductor systems, for the reason that, when signals are transmitted over conductive systems 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 energy supplied by sources external to the signal system may be readily picked up and introduced into the signal path, and the apparatus to be hereinafter described operates to minimize the effect of interfering energy introduced into the transmission line via one of its conductors without materially affecting the level of the signal energy.

Present day television image currents extend continuously over a frequency range having an upper limiting frequency of one or more million cycles per second and a lower limiting frequency of a few cycles per second and may even include direct current, depending upon the rate at which the field of view or subject is scanned and also whether the direct current component is transmitted or not. Coaxial conductor systems may be efficiently used for the transmission of television currents of the wide frequency range mentioned above. At the upper end of this range, the grounded sheath serves as an effective shield

against interfering currents, but at the low frequency end of the range, its efficiency as a shielding means is low. Again, the outer coaxial conductor operates as an effective shield in the upper portion of the frequency range and hence serves to prevent the introduction of interfering currents in this portion of the frequency range into the signal transmission path, but, the shielding effect of the outer conductor at the low frequency end of the range is small and interfering currents in this portion of the frequency range will be introduced into the signal transmission path.

Since both terminals of the outer coaxial conductor are connected to ground, this conductor is included in series with ground return. If the ground return includes voltage sources which set up a difference of potential between the ground connections of the outer conductor, a current, corresponding in frequency to the frequency of the sources and of an amplitude proportional to the respective differences of potential, will be caused to flow along the outer conductor. The magnitudes of these currents may be large and hence cause serious interference with efficient transmission of signals over the line.

According to this invention, both terminals of the outer coaxial conductor are connected to ground through networks, each including a resistance of relatively low value shunted by a condenser. The shunting condensers are so chosen that, while they provide a fixed capacity to ground, their impedance is low for high frequency currents, but high, compared with the resistances with which they are associated, for low frequency currents. As will appear from the following description, the networks operate to increase the impedance of the path over which low frequency extraneous currents are supplied to the outer coaxial conductor, without increasing the impedance of the coaxial system for the signal currents. At high frequencies the networks introduce no appreciable additive impedance which is unnecessary because of the excellent shielding qualities of the coaxial system already described. Except at very low frequencies the outer conductor of the coaxial system operates at practically ground potential, and as a result, stray capacity effects are minimized. Again the use of the networks simplifies the apparatus insulation problem compared to the alternative of operating a non-grounded coaxial system.

Fig. 1 is a diagrammatic representation of a circuit embodying the invention; and

Figs. 2 and 3 illustrate apparatus units that

may be substituted for that at the left of section line X—X and for that at the right of section line Y—Y of Fig. 1.

The system shown in Fig. 1 comprises a station T connected by a line C, comprising a coaxial conductor, to a receiving station R. The line consists of an inner conductor G and an outer conductor D, which is enclosed in, but insulated from, a grounded sheath S.

Station T may include a studio at which a field of view or subject of any type, including a motion picture film, is scanned to control the production of an image current extending over a frequency band having an upper limiting frequency of one or more million cycles per second down to a few cycles per second, and station R may be a broadcasting station, when the image current is transmitted as a modulation of a carrier current over a line or radio link. Station T may also be a broadcast receiving or other distributing station, whence the image current in its natural frequency range may be transmitted to a remote station or stations R, over a coaxial conductor system.

The television image current producing equipment is represented by a vacuum tube 1, which may be the final stage of a power amplifier, used to raise the image current to the proper energy level for transmission to the remote station R.

The image current is impressed upon the input electrodes of the vacuum tube amplifier 1, comprising a cathode 2, supplied with heating current from a source 3, and a grid 4. Space current is supplied to the tube by a source 5 through a resistance 6, and the amplified image current is supplied to the line C, having its inner conductor G connected to the plate of the tube through a blocking condenser 7 and its outer conductor D to the cathode 2.

The cathode of tube 1 is connected to ground 24 by a network N including a resistance 9 shunted by a condenser 10.

At the receiving station, the inner conductor G is connected to the grid 11 by the well-known coupling circuit comprising a resistance 12 and a condenser 13, and the coaxial conductor D is connected to the cathode 14 of a vacuum tube amplifier 15. The cathode 14 is supplied with heating current from a source 15' and bias potential may be impressed upon the grid 11 by a source 16. The plate circuit of this tube includes a space current supply source connected to the plate 17 through a resistance 18, and the output circuit for the signal extends from the plate 17 over a path, including a blocking condenser 20, which may be connected to an additional amplifier, or amplifiers, or to an image producing device, which may be of any well-known type adapted to utilize an image current of the band width specified above.

The cathode 14 is connected to ground 25 through a network N', comprising a resistance 21 shunted by a condenser 22.

In the absence of the networks N and N', a difference of potential in the ground return path between stations T and R, due to sources extraneous to the signal system, will cause appreciable current to flow over two circuits respectively including ground 34, the sheath S, ground 35 and a return path through ground, and ground 24, the outer conductor D, ground 25 and the return path through ground. Since, particularly at low frequencies, the impedance of both of these circuits is low and the magnitude of the external voltages will frequently be relatively

large, extraneous current of considerable amplitude may flow through the sheath and outer conductor D.

The sheath and outer conductor, each operates as an efficient shield for the currents of higher frequency flowing along them and hence each serves to prevent currents in this range from being introduced into the signal path. On the other hand, for currents of low frequency these conductors serve as inefficient shields and the insulation between the outer conductor and the sheath, operates to minimize the coupling between the sheath and the outer coaxial conductor. While the introduction of extraneously produced low frequency currents flowing along the sheath are prevented from entering the signal path by the insulation between the sheath and conductor, similarly produced currents of like frequency, which flow along the outer conductor D, will be introduced into the signal path and would seriously interfere with the image current transmitted over the coaxial conductor system and cause the reproduced image to be badly distorted.

By connecting relatively small resistances 9 and 21 between the cathodes 2 and 14, and so that they are included in series with the conductor D, the low frequency impedance of the series circuit including this conductor and ground return will be materially increased and hence the amplitudes of the interfering currents will be considerably reduced. For a coaxial conductor a few miles long, the outer conductor of which has a direct circuit resistance of a few ohms, the value of these resistances may be of the order of 50 to 100 ohms. With resistances of these values and assuming that the condensers 10 and 21 are of reasonable value, i. e., of the order of 2 microfarads, at the higher frequencies where stray capacity effects may be important the signal system operates at practically ground potential. The shielding effect of the coaxial conductor is entirely depended upon to suppress extraneous potentials in the high frequency portion of the range. The resistances, being outside the path traversed by the signal currents, do not affect their transmission.

While the circuits described above are designed for the transmission of an image current which does not include a direct current or zero frequency component, it is to be noted that, in case the image or signal current to be transmitted includes a direct or zero frequency component, the transmitting and receiving amplifiers 1 and 15, respectively, should be replaced by amplifiers of the type shown in Fig. 2 or 3.

As shown in Fig. 2, the final power stage 1 of the transmitting apparatus has its plate connected to the inner conductor G by a lead including a battery 26. This battery has its positive terminal connected to the plate circuit of the power tube 1 and its negative terminal connected to the conductor G. Battery 26 which is substituted for blocking condenser 7, supplies the same voltage as formerly existed across the blocking condenser which it replaces. While the battery permits signal currents including direct or zero frequency current to be supplied to the line D—G, it operates to prevent the dissipation in the line of current supplied by the battery 5.

At the receiving station, the incoming signal current is supplied to an amplifier designed to amplify the received signal current including the zero frequency component. This amplifier may be similar to that shown in Fig. 1, with the ex-

ception that the coupling circuit between the line and tube would have to be modified by omitting the condenser 13 as illustrated in Fig. 3.

The voltage of battery 30 is such as to insure that the proper biasing potential is applied to the grid of amplifier 28.

In the circuits of Figs. 2 and 3, the cathodes of the amplifiers at the transmitting and receiving stations would be connected to ground via networks N and N' respectively, as shown in Fig. 1.

The system herein described possesses the advantage that both terminals of the line are connected to ground by means which minimize stray capacity effects and hence permit the line to be operated at substantially ground potential except at the lowest frequencies and which, in spite of this fact, operate to maintain the amplitude of currents, introduced into the line by sources external to the signal system, at a low energy level, and thereby materially reduces interference and hence improves the signal-to-noise ratio.

An added advantage resides in the fact that the invention operates to alleviate the severity of the insulation requirements for the apparatus units connected to the terminals of the line, and hence simplifies the problem of insulating these units from ground.

In one typical example, including a coaxial conductor several miles long, it was found that the use of grounding networks N and N', each comprising a resistance and a condenser having the values given above and connected as herein described, reduced the energy level of the interfering currents over 30 decibels.

While the invention has been described above as applied to a television system, and specific values for the constants of the networks have been given, it will be apparent that the invention may be used to minimize the effect of interference due to currents which occur in other types of signal transmission systems in which interfering currents may be picked up via one conductor of the signal transmission channel or line. For example, the invention may be applied to systems where this condition obtains and in which the interfering current and a part of the signal current to be transmitted, or one signal current associated with a plurality of other distinct signal currents, are transmitted over the line, and the interfering and signal currents or a part of the latter lie in the low frequency portion of the frequency spectrum and in which the magnitude of the interfering current is liable to prevent efficient transmission of the low frequency signals.

The values given above for the constants of the elements comprising the networks apply to a particular case, but in cases where different operating conditions obtain or a conductor of a

different design is used, the values of the elements constituting the networks may differ widely from those given. Again, the invention may be used with conductors of materially different lengths than that specified above, in the limiting case, the length of the conductor will be determined by the possibility of providing networks which operate to attenuate the interfering currents, while permitting the conductor to be operated at substantially ground potential.

What is claimed is:

1. A communication system comprising a line having a plurality of conductors over which signals are transmitted and in which interfering or noise currents produced by sources external to the system may be introduced over a path including one of said conductors, said signal and noise currents being within the same frequency range, apparatus for impressing signaling current upon said line at the input terminal thereof, said apparatus being connected to said conductors, respectively, a ground connection for said one conductor at said input terminal, a receiving apparatus at the output terminal of said line, said receiving apparatus comprising an amplifier having an input circuit connected to said conductors, respectively, an anode-cathode circuit, and an output circuit connected to said anode-cathode circuit, and a resistor connected between said one conductor and ground, said resistor being external to said anode-cathode circuit, to said input circuit and to said output circuit.

2. A communication system in accordance with claim 1 in which the resistance of said resistor is of the order of 100 ohms.

3. A communication system comprising a line having a plurality of conductors over which signals are transmitted and in which interfering or noise currents produced by sources external to the system may be introduced over a path including one of said conductors, said signal and noise currents being within the same frequency range, apparatus for impressing signaling current upon said line at the input terminal thereof, said apparatus being connected to said conductors, respectively, a ground connection for said one conductor at said input terminal, a receiving apparatus at the output terminal of said line, said receiving apparatus comprising a terminating resistor connected across said line, an amplifier having an input circuit connected across said terminating resistor, an anode-cathode circuit, and an output circuit connected to said anode-cathode circuit, and a second resistor connected between said one conductor and ground, said second resistor being external to said anode-cathode circuit, to said input circuit and to said output circuit, the resistance of said second resistor being of the order of 100 ohms.

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