

March 31, 1942.

L. Y. LACY

2,278,177

COMMUNICATION SYSTEM

Filed Oct. 24, 1940

2 Sheets-Sheet 1

FIG. 1A

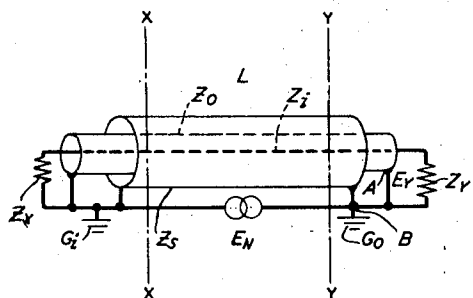


FIG. 1B

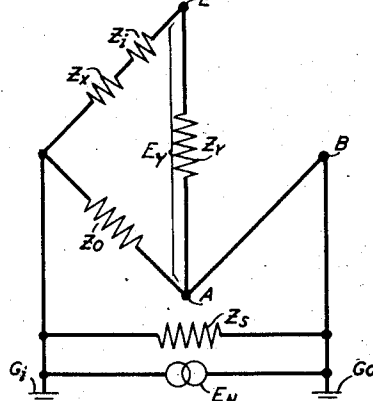


FIG. 2A

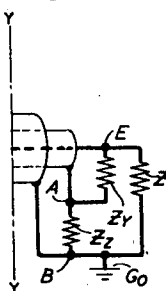


FIG. 2B

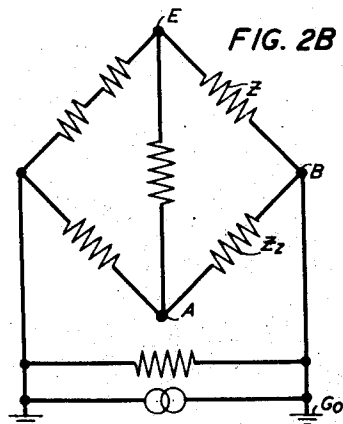


FIG. 3A

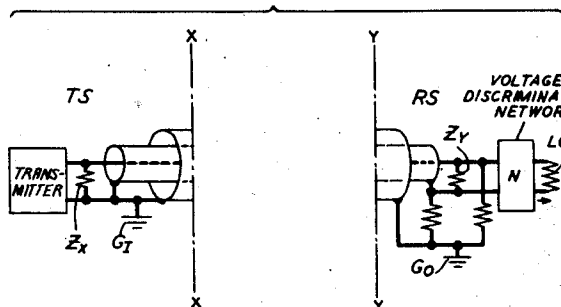
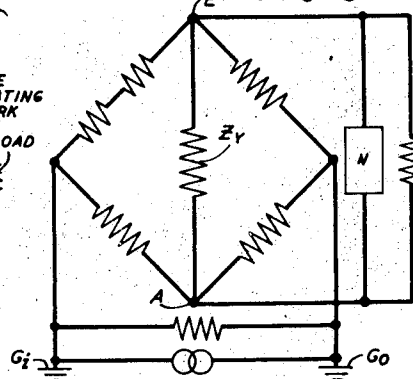


FIG. 3B



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FIG. 4A

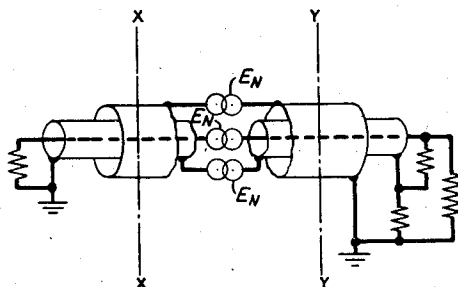


FIG. 4B

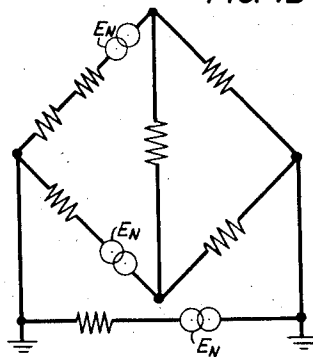


FIG. 5A

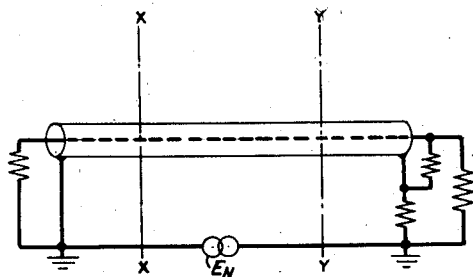


FIG. 5B

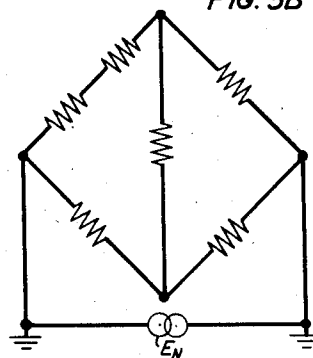


FIG. 6A

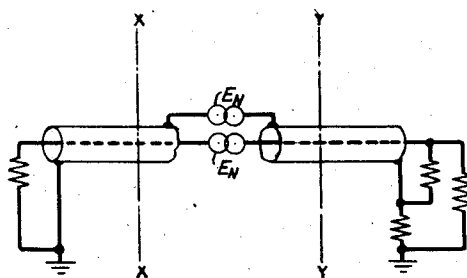
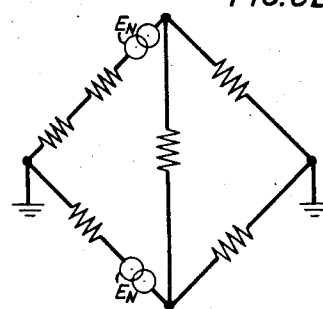


FIG. 6B.



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UNITED STATES PATENT OFFICE

2,278,177

COMMUNICATION SYSTEM

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Application October 24, 1940, Serial No. 362,544

6 Claims. (Cl. 178—44)

This invention relates to communication systems, and more particularly to an arrangement for minimizing the effect of interfering currents introduced into such systems.

When signals or other useful energy is transmitted over a line comprising a plurality of conductors, one of which has each of its terminals connected to a local ground, whereas the other conductor is isolated from ground except at its terminals where it is connected to ground via terminating networks, both conductors, being associated via the local terminal connections with a ground return, will constitute a complete circuit. If sources external to the communication system produce a difference of potential between the locally applied ground connections, extraneous currents of considerable magnitude and of the frequency of the external sources may be caused to flow through such circuit. When the extraneous currents 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 latter energy.

In one typical example of the above type of communication system, the signal or useful energy is transmitted between sending and receiving stations over a path comprising a coaxial conductor having the terminals of its outer conductor grounded. As is well known, such system may be expeditiously adapted for the transmission of signal currents extending over a wide frequency range, such as television or other signal currents, which extends, for example, from an upper limiting frequency of one or more million cycles per second down to a few cycles per second. The coaxial conductor embodied in such systems is enclosed in, but insulated from, a grounded sheath.

The outer conductor of a coaxial conductor operates to shield effectively the signal transmission path against high frequency currents flowing in the outer conductor, but for current in the low frequency portion of the spectrum, the efficiency of the latter conductor as a shielding element is relatively low. Consequently, earth potentials or voltages induced in the coaxial conductor from external sources may introduce low frequency circulating current in the signal transmission path to impair seriously the efficient transmission of signals. The signal transmission path is protected against the introduction of noise currents through the sheath, as the latter is effective as a shielding element at the high frequency end of the range, and the insulation, between the sheath and the concentric conductor, 55

serves to isolate the latter at the low frequency end of the range.

The present invention will be hereinafter described as applied to a communication system in which television image currents having a frequency band of the order of one or more million cycles per second are transmitted over a coaxial conductor transmission line.

Accordingly, the present invention contemplates for use in such system an arrangement to minimize the effect of interfering noise currents introduced into the signaling path of a coaxial conductor line while at the same time, to avoid substantially any disturbance of the transmission of the signal currents, or, in other words, to increase substantially the signal-to-noise ratio.

A general object of the invention is to discriminate favorably with respect to signaling currents and unfavorably with respect to noise currents.

Another object is to produce equal noise voltages at the output terminals of the inner and outer conductors of a coaxial conductor line.

A further object is to eliminate at the output terminal of a coaxial conductor line the noise voltages without materially interfering with the signal voltages.

In accordance with a preferred embodiment, the invention comprises a coaxial conductor line having inner and outer conductors terminated at their input and output terminals with suitable impedance networks and ground connections, and arranged such that both the inner and outer conductors and the input and output terminating impedance networks constitute the arms of a bridge network, with the output terminating network between the output terminals of the inner and outer conductors forming one diagonal, and ground connections at the input and output terminals applied to the opposite diagonal. Noise currents introduced in the inner and outer conductors flow in circuits including the latter, the terminating networks and the ground connections. A balanced condition of this bridge network serves to produce equal noise voltages to ground on the inner and outer conductors at the opposite terminals of the output terminating network connected therebetween. A network coupling the output terminating network to a load discriminates between the noise and signal voltages such that the noise voltages are eliminated from the load and the signal voltages are supplied thereto.

The invention will be readily understood from

the following description taken together with the accompanying drawings, in which:

Fig. 1A is a schematic representation of a coaxial transmission system operating without the present invention;

Fig. 1B is a bridge arrangement of Fig. 1A;

Fig. 2A is a schematic illustration of a simplified form of the invention;

Fig. 2B is a bridge form of Fig. 2A;

Fig. 3A is a schematic delineation of a coaxial transmission system embodying the form of the invention illustrated in Figs. 2A and 2B;

Fig. 3B is a bridge arrangement of Fig. 3A; and

Figs. 4A, 4B, 5A, 5B, 6A and 6B are schematic illustrations of other simplified forms of the invention.

Referring to Fig. 1A, a coaxial conductor line L utilized for signaling transmission comprises an inner conductor Z_i and an outer conductor Z_o , both of which are enclosed in, but insulated from, a sheath Z_s . At the left-hand or input end the inner and outer conductors are terminated in a network Z_x which is also connected to the sheath Z_s applied to ground connection G_i . At the right-hand or output end a ground connection G_o is common to both the outer conductor Z_o and sheath Z_s while a terminating network Z_y is applied across the inner and outer conductors. It is to be noted that the terminating network Z_y is also connected to the ground connection G_o . It is assumed that the line L extends through a region in which a noise voltage source E_n , external to a signal system and effective through the ground connections G_o and G_i , causes noise current to flow from ground connection G_i , which has a different potential than ground connection G_o , to the ground connection G_o through several paths embodying the sheath and inner and outer conductors, and the input and output terminating networks.

As pointed out above this noise voltage E_n may introduce noise currents into the signaling transmission path. Hence, noise current may flow in a path comprising ground connection G_i , input terminating network Z_x , inner conductor Z_i , output terminating network Z_y and ground connection G_o . The noise current flowing in the output terminating network Z_y will produce unequal noise voltages at the opposite terminals thereof. As the output terminating network Z_y is also common to a signal load, not shown, such noise voltages may tend to interfere with the transmission of signals. Fig. 1B represents the transmission line of Fig. 1A arranged in the form of a bridge, with the arms and diagonals embodying elements corresponding to the respective elements of the line. Thus, in Figs. 1A and 1B unequal noise voltages may exist at the terminals E and A.

However, if an impedance were interposed between the output terminals A and B, Figs. 1A and 1B, it is obvious that the flow of noise current through the output terminating network Z_y would tend to decrease, depending on the value of such impedance, and would be substantially zero as the value of such impedance approached infinity. This condition is usually attainable in practice only at low frequencies where the shielding effect of the outer conductor is limited, as the distributed capacity between the outer conductor and sheath of the coaxial conductor permits a flow of some noise current. As the flow of noise current increases with fre-

quency, reduction of the former tends to become somewhat less at the higher frequencies.

In accordance with the invention, Fig. 2A shows in the output terminal of the outer conductor Z_o an impedance Z_z disposed between the points A and B and corresponding to the impedance mentioned in the next preceding paragraph, and in addition an impedance Z applied in the output terminal between the inner conductor Z_i and ground connection G_o . The arrangement of Fig. 2A which also includes the portion shown to the left of the line Y—Y in Fig. 1A may be represented as a bridge as illustrated in Fig. 2B. For minimum residual noise energy appearing across the output terminating impedance Z_y , the proper relationship of the various arms of the bridge is expressed as follows:

$$\frac{Z_o}{Z_x + Z_i} = \frac{Z_z}{Z}$$

in which

Z_o =impedance of the outer conductor of the conductor line L.

Z_i =impedance of the inner conductor of the concentric conductor line L.

Z_x =input terminating network.

Z_z =output termination of the outer conductor.

Z =output bridge termination of the inner conductor.

Z_y =termination applied across output terminals of inner and outer conductors.

Z_s =impedance of sheath.

E_n =voltage of external or noise source.

E_y =noise voltage across output impedance Z_y .

The value of Z_z is not critical from a noise standpoint, but once it is selected, it obviously requires a definite value of Z as indicated in the above equation.

In the event that two concentric conductors are embodied within the same sheath, cross-talk between two such conductors is dependent on the value of Z_z , and, therefore, this value is initially selected to provide minimum cross-talk.

Thereafter, the value of Z may be adjusted to effect maximum noise reduction in the output terminating network Z_y .

Fig. 3A illustrates the arrangements of Figs. 2A and 2B embodied in a signaling transmission system which comprises a transmitting station TS applied to the input terminating network Z_x , and a receiving station RS connected to the output terminating network Z_y . At the receiving station a voltage discriminating network N connects the output terminating network Z_y to a suitable load, and functions in a manner that will be hereinafter explained. It is to be understood that the portion included between the lines X—X and Y—Y of Fig. 1A is to be included between the similarly identified lines of Fig. 3A, and, further, that the arrangement of Fig. 3A may be represented by the bridge illustrated in Fig. 3B.

Station TS may include a studio in which a suitable transmitter serves to scan a field of view or subject of any type, including a motion picture film, and 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. Station RS may be a distributing point from which the image current may be supplied over lines in its normal frequency range, or it may be a broadcasting station from which the image current is transmitted as a modulation of a carrier wave over a line or link to a remote

television subscriber's station, either alone or in association with accompanying sound current; or it may be any station at which television image current is received in its normal frequency range, whence the image current is redistributed to a series of subscribers.

As previously pointed out, noise current circulating in the inner conductor may be introduced into the signal transmission path to produce noise voltages E_y which would appear across the output terminating Z_y network to interfere with the efficient transmission of the signal voltages which are also common to the latter network. Assuming the bridge arrangement shown in Figs. 3A and 3B to be balanced, then equal noise voltages will exist across the respective upper and lower terminals E and A of the output terminating network Z_y with regard to the output ground connection G_o , Figs. 3A and 3B.

The coupling network N serves to discriminate between the signal voltage appearing across the output terminating network Z_y and the equal noise voltages appearing on the terminals E and A of the output terminating impedance Z_y such that the equal noise voltages are eliminated and the signal voltages are passed to the load. A suitable coupling network for effecting such voltage discrimination is disclosed in the copending application of S. Doba, Jr., Serial No. 303,778, filed November 10, 1939, now Patent No. 2,226,238, December 24, 1940. It is to be understood that a well-balanced transformer would also serve to provide the same discrimination between such noise and signal voltages.

The arrangements of Figs. 1A, 1B, 2A, 2B, 3A and 3B are described with respect to the introduction of noise currents in the signaling path of the line from an external source through earth potentials effective via ground connections G_i and G_o . In addition the invention is equally applicable to a condition in which the noise voltages are magnetically induced in the signaling path of the line. This is represented in Figs. 4A and 4B both of which are otherwise identical with the respective Figs. 2A and 2B.

Also, the invention is similarly applicable to a coaxial conductor line which is not enclosed within a sheath, such, for example, as a line mounted on poles. Such application is illustrated in Figs. 5A and 5B both of which are otherwise the same as the respective Figs. 2A and 2B. Further, the invention is expeditiously serviceable in the case in which the noise voltages are introduced in the signal path via magnetic induction as illustrated in Figs. 6A and 6B, which are otherwise the same as Figs. 4A and 4B.

It is to be understood that the arrangements illustrated in Figs. 4A, 5A and 6A may be embodied in a signaling transmission system in the manner illustrated in Fig. 3A by substituting between the lines X—X and Y—Y of the latter the portions between the lines X—X and Y—Y of the former, respectively.

While the invention has been described with relation to a system in which image currents of wide frequency are transmitted over a concentric conductor line, it will be apparent that it may also be utilized with equal facility to minimize the effect of interfering or noise currents in a system designed to transmit a series of discrete 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 the efficient transmission of the signals, or with other types of transmission systems into

which the noise currents are introduced through one of the conductors embodied therein.

What is claimed is:

1. In combination, a coaxial conductor line comprising inner and outer conductors and having input and output terminals at opposite ends, each end of said line including a local ground connection, means to apply input waves to said input terminals for transmission over said line to the opposite end and a load at said latter end connected to said output terminals, and means to protect said load against disturbing voltages existing between said ground connections comprising impedances connected to said load and said terminals and forming with said conductors and said load a bridge configuration in which said load and the effective impedance between said ground connections appear in respectively conjugate diagonals.

2. In combination, a coaxial conductor line comprising inner and outer conductors and subject to the introduction of noise currents therein from a noise source external of said line, an impedance network applied across the input terminals of both said conductors, an impedance network applied across the output terminals of both said conductors, a ground connection common to each of said input and output terminating networks and said outer conductor so that the noise currents may flow in circuits including both said input and output ground connections, both said inner and outer conductors, and both said input and output terminating networks and thereby to produce unequal noise voltages at the opposite terminals of said output terminating network, and means to equalize the noise voltages produced at the opposite terminals of said output terminating network, said voltage equalizing means comprising an impedance network applied between the output terminal of said inner conductor and said output ground connection, an impedance network disposed between the output terminal of said outer conductor and said output ground connection, and both said latter networks together with both said conductors and said input and output terminating networks applied between both said conductors constituting a bridge network comprising in series a first arm including said input terminating network and said inner conductor, a second arm including said impedance network connected between the output terminal of said inner conductor and said output ground connection, a third arm including said impedance network connected between the output terminal of said outer conductor and said output ground connection, a fourth arm including said outer conductor, one diagonal including said output terminating network applied between the output terminals of both said conductors and the opposite diagonal connected to both said input and output ground connections.

3. The combination according to claim 2 in which the noise currents are introduced in the circuit including both said input and output ground connections, said input terminating network, said inner conductor and said output terminating network through both said input and output ground connections.

4. The combination according to claim 2 in which the noise currents are magnetically induced in the circuit including both said input and output ground connections, said input terminating network, said inner conductor and said output terminating network.

5. A communication system comprising a line

including a coaxial conductor comprising inner and outer conductors over which signaling current may be transmitted, said line extending through an area including a source of noise current in the same frequency range as at least a part of the signaling current and which noise current may be introduced in said inner conductor, a network to terminate the input terminals of both said conductors, signaling means applied to said input terminating network, a network to terminate the output terminals of both said conductors, a load applied to said output terminating network, and a ground connection common to each of said input and output terminating networks and said outer conductor so that noise current may flow in circuits including both said input and output ground connections, both said inner and outer conductors and both said input and output terminating networks to produce at the opposite terminals of said output terminating network unequal noise voltages that tend to interfere with the signaling voltages which also appears across the opposite terminals of said output terminating network and are applied to said load, and means to eliminate the effect of the unequal noise voltages from said output terminating network and said load and to apply the signaling voltages to said load, said last-mentioned means comprising an impedance network connecting the output

terminal of said outer conductor to said output ground connection, an impedance network connecting the output terminal of said inner conductor to said output ground connection and a voltage discriminating network applied to the opposite terminals of said output terminating network and interposed between said latter network and said load.

6. The communication system in accordance with claim 5 in which both said inner and outer conductors, both said input and output terminating networks, both said inner and outer conductor output terminating impedance networks and both said input and output ground connections constitute a bridge network comprising a first arm including in series said input terminating network and said inner conductor, a second arm including said impedance network connected between the output terminal of said inner conductor and said output ground connection, a third arm including said impedance network applied between the output terminal of said outer conductor and said output ground connection, a fourth arm including said outer conductor, one diagonal including in sequence said output terminating network, said voltage discriminating means and said load, and the opposite diagonal connected to said input and output ground connections.

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