March 31, 1936. H. J. HARRIS 2,036,045

SHIELDING

Filed Feb. 8, 1933

FIG. 1

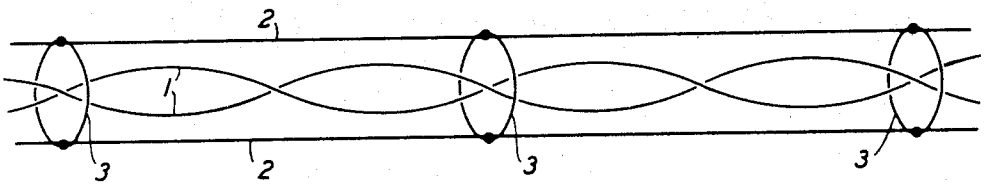


FIG. 2

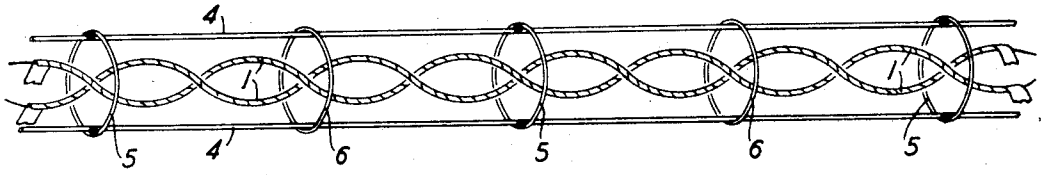


FIG. 3

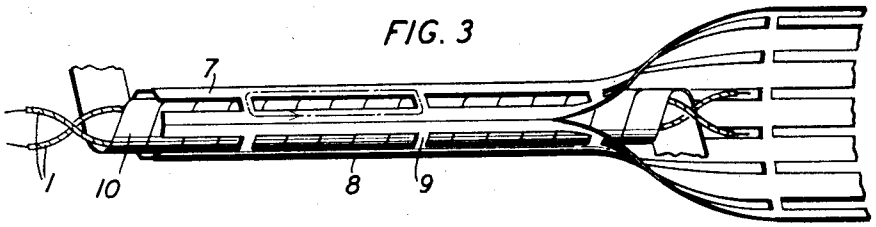


FIG. 4

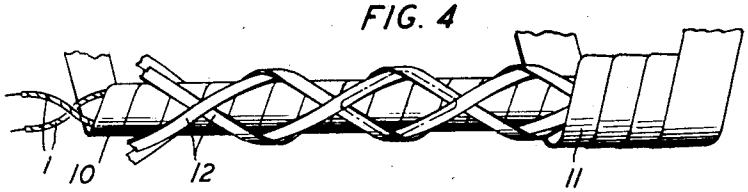
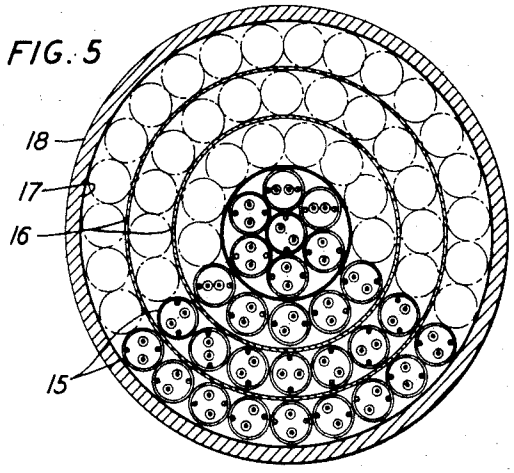


FIG. 5



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SHIELDING

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10 Claims. (Cl. 173—81)

This invention relates to shields for electrical circuits and more particularly to shields for signaling circuits comprising a plurality of conductors bound together.

An object of the invention is to shield a circuit effectively without thereby introducing a high energy loss in the circuit shielded.

Another and more particular object of the invention is to reduce cross-talk between the circuits of a signaling cable.

It has been suggested heretofore that to protect a signaling circuit from the effects of external electrostatic and electromagnetic fields it be inclosed in a continuous metallic sheath, as of tinfoil. The interfering field induces in the shielding material circulating currents which reduce the intensity of the field within the sheath. Signals traversing the shielded circuit, however, likewise create currents in the sheath and the loss resulting therefrom causes an attenuation of the signals. At high frequencies, particularly, the energy loss in the shielded circuit tends to become excessive and to preclude this type of shielding.

In accordance with the present invention there is provided for signaling circuits a shielding system which effectively protects the signaling circuits from external interference and which at the same time introduces but little loss in the circuits shielded. The system depends for its operation on the fact that the space-phase relations of the fields generated by the signaling circuit generally vary with respect to those of extraneous fields. The conducting paths for circulating current essential to the shielding action can therefore be so arranged with respect to the shielded circuit that the electromotive force which the signals at one point along the circuit induce in a given circulating path may be neutralized by an oppositely-phased electromotive force induced in that path at another point. The circulating current resulting is accordingly small and the loss of energy from the signaling circuit is likewise small.

In one aspect, it may be said that the invention has the effect that the shielding efficiency is greater with respect to fields arising outside of the shielded system than to those arising within it.

As applied to the common form of signaling circuit comprising a pair of conductors twisted together, in which each of the conductors occupies a series of positions constituting a number of complete and similar cycles, the invention contemplates inclosing the circuit in a metallic netting or screen, the conducting loops or openings of which are of the same length as one complete cycle or length of twist of the twisted circuit or a multiple of that length. Then the vector resultant electrostatic or electromagnetic field extending outward through any one of these loops will be approximately zero, and consequently there will be little or no energy loss in the screen or netting resulting from the fields originating in the shielded pair. The presence of the screen or netting will therefore not have any very significant effect upon transmission losses in the shielded circuit or circuits. On the other hand, stray fields from other sources, unless such fields are similar to those caused by the shielded circuit itself, will set up eddy currents around the conducting loops and as a result of the accompanying energy loss and opposing fields created, the strength of the interfering field reaching the shielded twisted pair will be very small.

It is only where the disturbing fields are similar to the fields created by the shielded circuit that a screen or netting in accordance with the present invention will be of little effect. That is, if over one complete conducting loop of the screen the vectorial resultant of the field linking that loop is zero, no circulating currents will be induced in the screen and the shielding action will be small. In a multi-circuit cable embodying the invention, it is accordingly preferred that conductor pairs having equal lengths of twist be separated in order to avoid excessive interference between them.

Referring to the drawing:

Fig. 1 shows schematically a structure adapted for shielding a twisted-pair circuit;

Figs. 2, 3 and 4 show specific forms which the shield may take; and

Fig. 5 represents a multi-circuit cable shielded in accordance with the present invention.

In Fig. 1 there is represented schematically a pair of twisted signaling conductors 1 inclosed between two shielding wires 2. The shielding wires are connected by conducting bands 3 which are spaced along the circuit at intervals substantially equal to the pitch of the twist of the conductors. With respect to the loop formed by two consecutive bands 3 and the portion of the shielding wires 2 included between them, it will be noted that the sense of the field created in one-half of the included section of the signaling circuit is opposite to that in the other half. The electromotive force induced in one half of the conducting loop is accordingly neutralized by that induced in the

other half. The circulating current resulting is zero and but little loss is introduced in the signaling circuit.

As to external disturbing fields, however, the neutralizing effect described will exist only in those exceptional cases where the space-phase relations of the disturbing field are similar to those of the field associated with the signaling system. Circulating currents will be induced in the conducting loop described and the disturbing field will be attenuated in the vicinity of the signaling pair.

Since the general form of any one conductor of a twisted circuit is that of a helix in space rather than that of a plane curve, it is not necessary that the loops bear any particular phase relation to the twisted circuit. It is desirable, however, that the distance between the successive conducting bands 3 be uniformly equal to the length of twist and that the longitudinal conducting paths 2 be fairly symmetrical circumferentially.

The embodiment shown in Fig. 2 is similar to the schematic representation of Fig. 1 except that the length of the conducting loops is a multiple of the twisting pitch. This structure may be preferred where the twisting pitch is short or a high shielding effect is not required. The twisted pair 1 is inclosed by a pair of longitudinal metallic wires 4, or as many more as may be required, which are bonded to the conducting rings 5 that are placed at intervals equal to twice the twisting pitch. Intermediate rings 6 of insulating material may be provided to hold the shielding wires to the signaling conductors where a long twisting pitch is employed. The number and size of the shield wires may be varied, of course, according to the degree of shielding required. For the sake of clarity in the drawing, no attempt has been made to show the structures to scale.

In Fig. 3 is shown another type of shield in accordance with the invention. In this case the shield comprises a hollow metallic tube 7 in which long narrow slits have been cut to provide the circulating paths for induced currents. The length of the longitudinal portions 8 between the circumferential portions 9 is equal to the length of twist of the inclosed twisted circuit 1 or to a multiple of that length. The width of the portions 8 may be chosen according to the mechanical characteristics required. As shown, the tube may be formed from a tape in which slits or openings have been cut. A serving of paper tape 10 over the twisted pair may or may not be provided.

In another embodiment, shown in Fig. 4, the shield comprises a lattice work of narrow metallic tapes 12. The diamond-shaped metallic loops thus provided may again be equal in length to the twisting pitch of the inclosed circuit 1 or to a multiple of that pitch. Over the latticework may be wound a tape of paper 11 for insulating purposes and a similar wrapping 10 may be applied to the conducting pair.

Fig. 5 represents a cross-section of a multiconductor cable suitable for carrier telephone transmission, in which the individual pairs are provided with shields of the type hereinbefore described. The shielded pairs 15 may be arranged in a plurality of layers separated by shielding material 16. A wrapping of heavy paper 17 and a lead sheath 18 complete the structure. The twisting pitches of adjacent pairs are preferably unequal so that the condition will not exist where the disturbing field of one pair is similar to that generated by signals in an adjacent shielded pair, since the efficacy of the shield is then lowest. The longest twisting pitch used may be twice or three times as great as the shortest.

From the foregoing description of the essential nature of the present invention, it is clear that the invention may be embodied in many forms other than the specific ones shown herein for purposes of illustration. The invention includes such other forms as come within the scope and spirit of the appended claims.

What is claimed is:

1. An electrical transmission structure comprising an assemblage of conductors arranged in a periodically repeated configuration, an electromagnetic screen therefor, said screen consisting of closed conducting loops so disposed with respect to said assemblage of conductors that the vector resultant electromotive force induced in each of said loops by currents in said conductors is substantially zero.

2. A signal transmission circuit comprising a pair of conductors twisted together and a low-loss shield for said circuit, said shield consisting essentially of conducting loops so disposed with respect to said conductors that the signal-induced electromotive force at one point of each loop tending to circulate current around said loop is counteracted by the electromotive force induced at another point of the same loop.

3. A transmission circuit comprising a pair of conductors twisted together and a low-loss shield for said circuit, said shield consisting essentially of conducting loops of such nature that the electromotive force induced at one point of each conducting loop by waves in said circuit is neutralized by the electromotive force induced at another point of the same loop.

4. A transmission circuit comprising a pair of conductors twisted together and a low-loss shield enclosing said pair, said shield consisting of conducting loops for the circulation of currents induced by extraneous fields, the resultant electromotive force induced in one portion of each of said loops by the waves in said circuit being substantially neutralized by the resultant electromotive force induced by said waves in the remaining portion of said loop.

5. An electrical transmission line comprising a plurality of conductors twisted together and a shield for said line, said shield comprising a plurality of longitudinal conducting members joined electrically only at intervals equal to the pitch of the twist of said conductors or to a multiple of said pitch.

6. A signaling line comprising a plurality of insulated conductors twisted together and a shield for said line, said shield comprising a plurality of longitudinal wires and members electrically connecting said wires only at intervals approximating an integral multiple of the twisting pitch of said conductors, and means for binding said shield wires to said conductors.

7. A shielded transmission line comprising a plurality of conductors twisted together and a conducting sheath surrounding said conductors, said sheath having portions removed to provide a succession of conducting loops each equal in length to the twisting pitch of said conductors or to a multiple of said pitch.

8. A shielded transmission line comprising a plurality of insulated wires twisted together and a lattice-work of conducting strips surrounding said plurality of wires, said latticework providing, for the circulation of induced currents only loops

equal in length to the twisting pitch of said wires or to a multiple of said pitch.

9. A multi-circuit signaling cable adapted for high frequency transmission comprising a plurality of pairs of conductors twisted together, and a shield for each of said pairs, each of said shields consisting essentially of a plurality of conducting loops whose lengths are equal to the pitch of the twist of the pair shielded or to a multiple of that length.

10. A multi-circuit signaling cable in accordance with the next preceding claim, in which the twisting pitches of adjacent signaling pairs are unequal.

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