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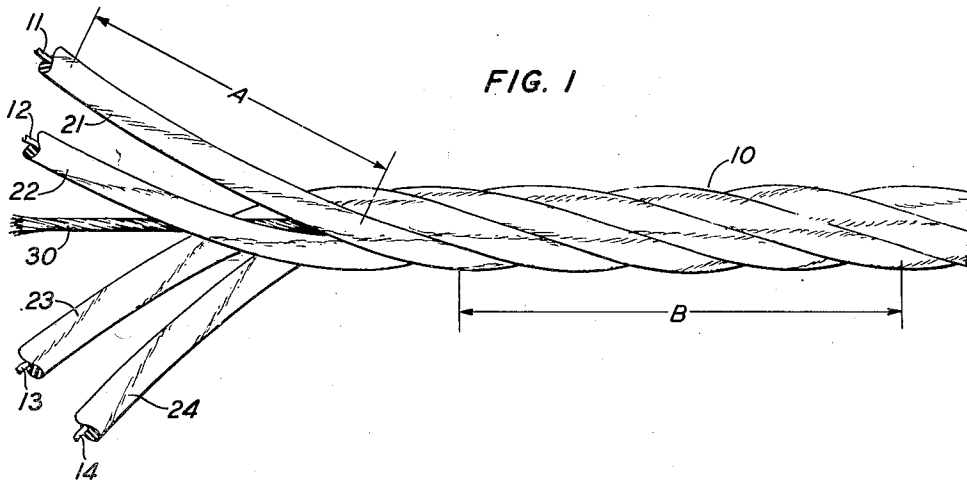
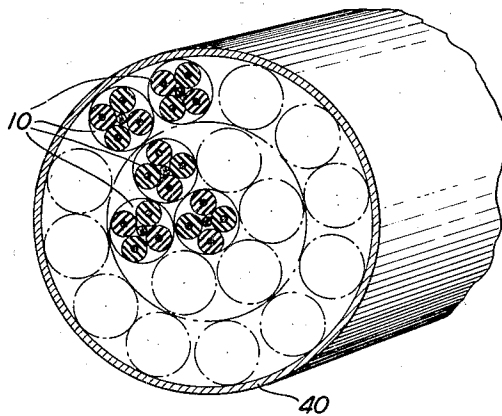


FIG. 2



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ELECTRIC COMMUNICATION CABLE

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6 Claims. (Cl. 173—81)

This invention relates to electric communication cables and particularly to multi-conductor cables in which the conductors are grouped in units such as quads.

Two types of quads have hitherto been generally used in one of which the conductors are first twisted together into pairs and the pairs then twisted together to form a quad; and in the other of which the conductors form a star quad, also termed, spiral four quad. It is well-known that the coupling between the conductors of a pair is closer in the quads of spiraled pairs than in the spiral four quads. It is also well-known that the coupling between the two pairs is closer in the spiral four quads than in the spiraled pair quads.

For these reasons it is evident that in order to prevent cross-talk between the pairs within a quad, greater uniformity of the individual conductors and their insulation as well as of their relation within the quad is required in the star or spiral four quads than in the spiraled pair quads.

An object of the invention is to insure low cross-talk between the pairs of a star quad.

Another object is to counteract the effect of non-symmetry of the individual conductors of a star quad in order to insure low cross-talk effect.

Another object of the invention is to produce a star quad of a rugged construction and of high efficiency for communication purposes and which will be simple to manufacture.

Still another object is to make the use of pulp insulation for star-quadded communication conductors commercially feasible.

In recent years much work has been done in developing suitable porous wood pulp insulation for communication conductors and cables such as are used for telephone and telegraph purposes.

Difficulties have, however, been encountered in attempting to produce pulp insulated conductors of a uniform circular cross-section and in which the conductors were exactly centrally located within the insulation. For this reason pulp insulation has not been used for conductors of quads where an especially high degree of uniformity and symmetry is required.

In accordance with the invention, the lack of symmetry of the structural dimensions and therefore of the distribution of the electrical properties of pulp insulated conductors is at least partly overcome in the production of star quads, or of similar strands with a greater number of pairs, by twisting the individual insulated

conductors relatively to one another in such a way that they continuously or continually present new aspects to one another. The pitch of the twist of the individual conductors is preferably of the order of the pitch of the twist of the quad. However, this relation may be varied considerably with satisfactory results.

The invention will now be described as applied to a specific embodiment such as shown in the accompanying drawing.

In the drawing:

Fig. 1 shows a portion of a four-conductor strand arranged as a star quad; and

Fig. 2 shows a portion of a multi-conductor cable with a plurality of quads such as shown in Fig. 1.

Referring particularly to Fig. 1, the conductor unit or strand 10 comprises four conductors 11, 12, 13, and 14 surrounded by their respective coatings of pulp insulation 21, 22, 23, and 24. The conductors are spiraled about a central cord 30 which may be of hemp or twisted paper, which serves to maintain the star formation of the conductors. This cord may be eliminated, if desired. The pitch B of the quad spiral is preferably of the order of a few inches and it is advantageous to vary this pitch from one quad to another, so that in the finished cable adjacent quads will have different pitches and thus will have the chances of cross-talk between them materially reduced.

It has been found that a pulp insulated conductor, produced by practical and economical methods of manufacturing, may appear to be of a uniform and circular shape but that upon closer investigation it has a slightly oval cross-section and the conductor may be slightly off-center. These slight irregularities in the geometric configuration of an individual conductor will usually appear over a considerable length of the conductor, and their effects become particularly serious when the pulp insulated conductor is used in a star quad. Without precautions against this contingency it is evident that great unbalances between the pairs of the quad would generally exist.

There may also be a number of erratic irregularities which would reach only over short lengths of a conductor and would be distributed at random in different directions about the central conductor. These, however, may be expected to compensate for each other whether or not precaution is taken to counteract the more extended irregularities first referred to.

The principle upon which the reduction of

cross-talk is based in accordance with the invention involves the placing of the conductors within the quad in such a manner that they continually or continuously present different aspects to their neighboring conductors.

This will have the effect that a certain asymmetry of a conductor will have a given unbalancing effect for a short stretch of the quad and will have an opposing unbalancing effect for another short stretch of the quad, the two effects tending to neutralize each other at frequent intervals along the cable.

Thus, in the embodiment shown in Fig. 1 the conductors with their insulation were individually given a twist about their own axis, as schematically indicated in the drawing by a surface shading. The twist will ordinarily have a pitch A of the order of the pitch B of the quadded spiral and it is preferably in the opposite direction of the quad twist so that the conductors by their natural tension will tend to tighten together in the finished quad. Where a periodicity in the asymmetric aspects of the conductors is observed, it is of course advisable to make the pitch A a small or incommensurable fraction of that periodicity.

The twist of the individual conductors may be a uniform twist evenly distributed throughout a manufacturing length and successive manufacturing lengths of conductors within a cable may be joined to have their twists either in the same or in opposite directions. It is also possible to secure the desired effect by applying twists at intervals along the conductor with straight untwisted portions between them.

In the production of such a quad, as shown in Fig. 1, the conductors may be twisted individually at the same time as they are spiraled into the quad or the conductors may be pre-twisted in manufacturing lengths and wound on storage reels, from which they in turn will be taken to become spiraled into a quad.

In a specific case the pitch of the twist of the individual conductors may be chosen with respect to the pitch of the spiraling of the quad, such that the conductors are subjected to no twist with respect to the general surroundings and yet continuously present different aspects to the adjacent conductors.

Quads such as that shown in Fig. 1 may be assembled to form cables in many ways which depend on the number of conductors to be included in the cable. Thus the cable shown in Fig. 2 comprises a plurality of quads arranged in a plurality of layers about a central quad and completely encased in an air-tight covering such as a thin continuous lead sheath.

It should be understood that the principle of eliminating cross-talk effects disclosed herein is applicable not only to conductors which have dimensional irregularities but will apply as well to

conductors having electrical irregularities due, for example, to variations in the composition of the insulating material. It should also be understood that the principle does not apply alone to quadded strands but may be applied to strands with six or more conductors arranged in one or more layers in which the conductors of one pair are separated by conductors of another pair.

For the purpose of interpretation of the claims, the expression "mass insulated conductors" is intended to comprehend within its scope all types of conductors surrounded by a substantially homogeneous mass of insulating material, the dielectric properties of which may have been substantially improved by the inclusion therein of large quantities of air, finely distributed throughout the mass.

What is claimed is:

1. A signaling cable comprising a group of mass insulated conductors constituting a plurality of parallel pairs and forming a spiraled layer in a strand and in which the conductors of one pair alternate with the conductors of another pair within said layer, characterized in this that each conductor is placed to present different aspects to the adjacent conductors along the length of the cable to reduce cross-talk between the said pairs due to asymmetry of the properties of each conductor along its length.

2. In a multi-conductor cable, a spiral four quad of mass insulated conductors in which progressively along the quad the line of contact between the conductors is gradually shifted transversely about the surfaces of the conductors.

3. A signaling cable comprising a centering strand, a group of four pulp insulated conductors twisted as a group about said strand to form a star quad, in which adjacent insulated conductors are applied with relative twists.

4. A signaling cable comprising a group of four conductors insulated with a porous wood pulp mass and twisted as a group to form a star quad and in which adjacent insulated conductors contact along spiral lines about the individual conductors.

5. A signaling cable in accordance with claim 4 in which the pitch of the spiral lines of contact is of the order of the pitch of the quad twist.

6. A method of producing a star quad of signaling conductors insulated with a wood pulp mass, to reduce cross-talk between the pairs of the quad due to asymmetry of the properties of the conductors, which comprises spiraling all four conductors about a common axis and applying each conductor with a twist relative to said axis to regularly shift its point of contact with the adjacent conductors about its curved surface.

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