Feb. 6, 1951 J. N. DEAN ET AL 2,540,164

HIGH-FREQUENCY COAXIAL CABLE HAVING A DOUBLE LAYER INNER CONDUCTOR

Filed Oct. 28, 1946

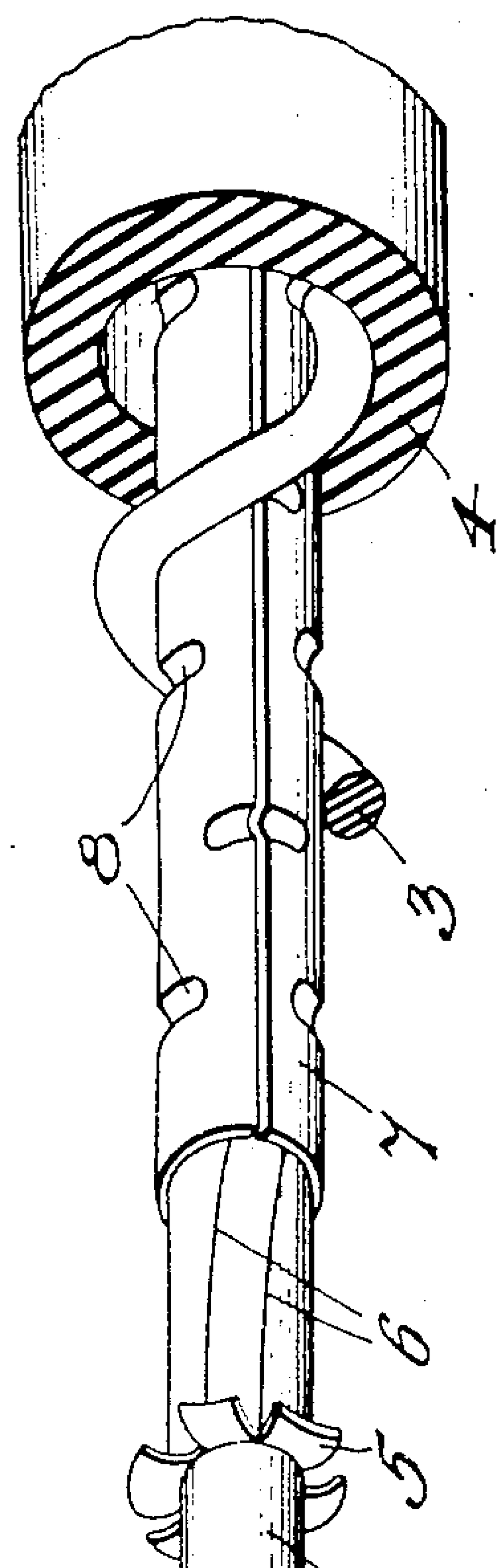

Fig. 1.

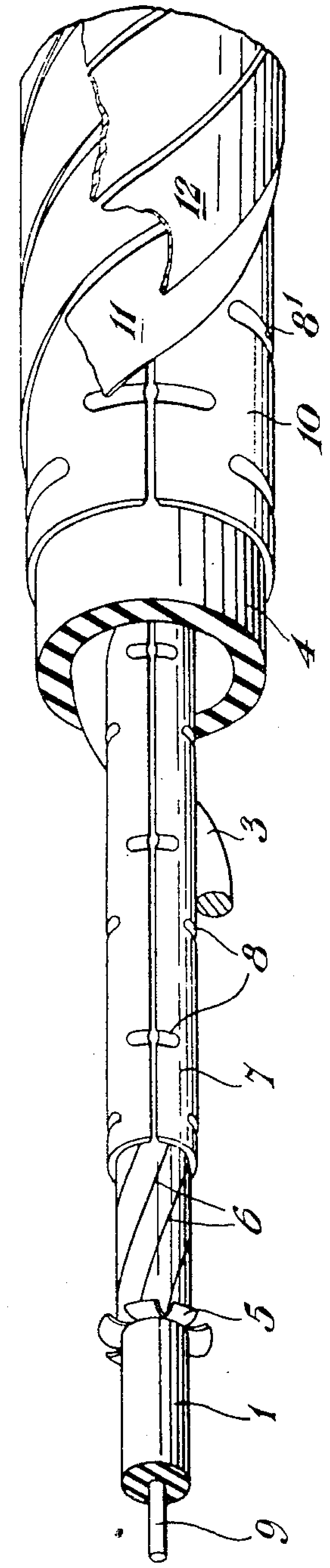

Fig. 2.

Inventors:
John N. Dean
and
Esmond W. Smith
By Baldwin, Wight & Prevost
their Attys.

Patented Feb. 6, 1951

2,540,164

UNITED STATES PATENT OFFICE

2,540,164

HIGH-FREQUENCY COAXIAL CABLE HAVING A DOUBLE LAYER INNER CONDUCTOR

John Norman Dean, Brasted, and Esmond Wassell Smith, Beechcroft, Chislehurst, England, assignors to The Telegraph Construction and Maintenance Company Limited, London, England

Application October 28, 1946, Serial No. 706,212
In Great Britain November 1, 1945

11 Claims. (Cl. 174—29)

1

This invention relates to high frequency cables, particularly those of large size, and has for its object to provide an improved construction of central conductor therefor whereby a high efficiency in the metallic circuit is obtained. It is well known that the most efficient conductor for high frequency currents is one having a smooth cylindrical surface. For this reason the preferred form of conductor is a solid wire or a uniform tube. It is obvious, however, that such constructions have the disadvantage of lack of flexibility which becomes especially noteworthy when applied to large cables, for example to a coaxial transmission line having a centre conductor of diameter of the order of half-an-inch or more.

Constructions are known in which a number of tapes laid up to form a substantially cylindrical conductor are employed. The lay of the individual tapes forming such conductors, however, has hitherto been relatively short, e. g. of the order of 8–12 inches, since this short lay is necessary to preserve the flexibility of the cable, and to enable it to be handled without displacement or buckling of the conductor tapes during manufacture.

A conductor with short lay tapes, however, is not electrically efficient, especially at frequencies of the order of 1 megacycle per second or more. It has been found that the electrical efficiency increases as the length of the lay of the tapes increases, but that in order to approach the efficiency of a uniform tube a very long lay, such as for example 24 inches, is required.

It has therefore been proposed previously to form the centre conductor of a high frequency coaxial cable of one or more conductive tapes applied with a very long lay (in certain cases an infinitely long lay) onto an insulating support to give a single conductive layer.

Such constructions are, however, very liable to mechanical damage when being handled and the tapes may be cracked or even broken. The object of the present invention therefore is to provide a construction of inner conductor which will ensure longitudinal continuity even should such damage occur.

According to the present invention there is provided a high frequency coaxial cable having a central conductor which is a composite structure comprising a non-conductive supporting core, an inner conductive layer having a plurality of metal tapes arranged in edge to edge contact and applied to the core with a relatively long lay, and an outer conductive layer consisting of a

2

single metal tape applied longitudinally over and enwrapping the inner tapes, means consisting of dielectric material being applied over the outermost conductive layer to hold the tapes in position.

A binder consisting of a helix of dielectric material having low loss encircles the outer conductive layer for the purpose of holding the tapes in position on the supporting core. Preferably this helix is an open spiral and is utilized to support the central conductor from an outer insulating envelope which in turn supports the outer conductor of the cable, but the pitch of the spiral may be varied down to zero to cater for varying conditions of service of the cable.

We have observed that in cases where the helix of dielectric material is an open one there is a tendency for relatively large buckles to occur in the conductor tapes at irregular and comparatively long intervals when the conductor is bent or otherwise handled. This tendency may be overcome, according to a further feature of the invention, by employing conductor tapes transversely crimped or indented or otherwise corrugated. This transverse crimping provides places at regular and relatively short intervals at which buckling is found to occur, with the consequence that the degree of buckling at each crimp is much reduced. The buckling of the conductor tapes can thus be reduced to a minimum and at the same time be caused to appear in a controlled instead of an uncontrolled manner. We have found that with a crimped conductor the electrical properties of the conductor after buckling are superior to those of an uncrimped conductor.

The invention is illustrated in the accompanying drawings, in which—

Fig. 1 is a view, partly in section, showing a large size high frequency coaxial cable (with the outer conductor, serving and armouring omitted) embodying a central conductor according to the invention.

Fig. 2 is a similar view showing a preferred form of conductor including the outer conductor, serving, and armouring.

Referring to Fig. 1 of the drawings, the cable is built up from a central conductor, the conductor being constructed with a smooth solid core or heart 1 formed of a suitable material. For example a core of polythene or jute or polythene cord with a reinforcement of jute or other material will give satisfactory results.

On the core 1 is built up a composite layered inner conductor. The inner layer comprises a series of copper or other conductive metal tapes 5. These tapes, of which there may conveniently be six although the number will vary according to the design of the cable, are laid around the core 1 with their edges 6 in abutting contact so as to provide a substantially closed tube. The lay of the tapes should be long, i. e. greater than twelve inches, and may be infinitely long.

A single conductive tape or strip is next applied over the tapes 5 by means of a shaping mandrel through which the core and the tape are drawn simultaneously. The mandrel is bell-mouthed or trumpet-shaped and causes the outer tape 7 to be folded around the core in the form of a closed cylinder tightly embracing the core.

Immediately following the application of the lower tapes 5 and upper tape 7, the core 1 is passed through a normal tape laying, whipping or lapping machine to apply over the conductor a binding layer 3 which in the embodiment illustrated consists of a stout thread of polythene, but which may alternatively be a tube or tape of this or any other suitable dielectric material. In the illustration, in which the diameter of the conductor 2 is of the order of half-an-inch, the binder 3 is in the form of a short pitch open helix and has a thickness of approximately 0.2 inch, but obviously the size will vary with the size of the conductor or cable.

Finally there is applied over the helical binder an outer insulation layer 4 which preferably consists of an extruded tube of the same dielectric material, e. g. polythene, as that employed for the binder.

By utilizing a composite inner conductor it is possible to take advantage of the high electrical efficiency of the outer longitudinal folded tape 7 and at the same time to ensure that no complete electrical discontinuity shall occur even under the most severe bending conditions. Very severe and repeated bending might crack and even part outer tape 7, but the chances of all the inner tapes breaking at the same spot would be very remote.

In addition the shorter lay inner tapes assist in reducing the D. C. resistance of the conductor, a feature of value when D. C. current has to be fed over it, e. g. to a series of incorporated repeaters.

In certain cases, we may provide an inner or third conductor 9 which may be used to supply current to repeaters, etc. in which case the heart must be of polythene or other good insulating material.

In order to control and even out along the tape 7 the buckling that occurs when a conductor of this type is bent or otherwise handled, the tape 7 is preferably as shown crimped at intervals as indicated at 8. The tape illustrated has the crimpings arranged in two series in staggered relationship to one another, but obviously this may be varied to suit requirements and the size of the cable.

In carrying this form of the invention into effect, to produce the cable illustrated, the core built up with the conductive tapes 5 and 7 is passed between two pairs of oppositely located steel or other rollers, one pair of rollers being staggered by 180° relatively to the other pair. The circumferential surfaces of the rollers are of concave form to accommodate the wrapped heart and are provided at intervals with projecting transverse ribs, preferably rounded off at the edges. The inwardly projecting crimps or indentations formed in the copper tape by each roller thus extend from a quarter to half way round the circumference of the conductor, perpendicular or approximately perpendicular to the axis thereof, the preferred extent being 120° when the two sets are staggered. The two pairs of rollers and the spacing of their projectiny ribs may be so adjusted that the crimps produced by them in the copper tape are all in the same position with respect to length along the conductor or are staggered in relation to one another as illustrated.

One roller of each pair is preferably carried on a fixed pivot whilst the other is spring-loaded and capable of being moved toward or away from the core to allow adjustment. Means may be provided for driving one or more of the rollers, but usually it will be found sufficient to rely on the rotating effect of the forwardly moving core.

Instead of effecting the crimping simultaneously with the application of the tapes to the central core, we may employ precrimped tapes, the crimping being carried out as an entirely separate operation or in the shaping operation during the passage of the tapes towards the point of application to the core. Furthermore, the crimps or indentations may project outwardly instead of inwardly as described above. When the crimping is made as a separate operation, the tapes may with advantage be annealed prior to being longitudinally folded or shaped to the circular heart.

In a further modification of the invention the inner tapes may be pre-formed to a spiral and/or concave configuration prior to application, thus imparting to them in advance the optimum shape for close fitting to the central core.

The outer conductor of the cable may be of conventional construction or may be formed of a tape or tapes preferably having a long lay as described with reference to the inner conductor. The outer conductor 10 may likewise be crimped transversely at intervals 8′ in one of the manners above described, and may likewise be preformed as described.

The outer conductor tape or tapes are preferably bound in position by means of a pair of binder tapes 11 and 12 applied helically one over the other, the turns of each helix breaking joint, and those of the upper helix 12 being arranged to cover the gaps between the turns of the lower one 11. In this way good metallic contact is achieved throughout the conductor and the distortion which tends to ocur where the cable is subjected to bending is minimised. Where such a cable is intended for submarine use these binder tapes may act as the usual Teredo protection, which has previously taken the form of a single tape applied with an overlap instead of the two tapes applied one over the other with broken joints described above.

Obviously this invention is not restricted to the use of polythene either as binder or for the main insulation since any thermoplastic, flexible, water-resisting insulating material will be satisfactory, e. g. orientated polystyrene, or mixtures of this substance with polyisobutylene, or mixtures of polythene with polyisobutylene or similar known components.

Alternatively, dielectric material of higher softening point than that subsequently extruded may be used for the binder. The binding helix may have a pitch as stated above of the order of one inch, but the pitch may be somewhat lengthened, or on the other hand may be shortened until complete coverage of the conductor is obtained. Alternatively, when mechanical conditions demand it a 2- 3- or multi-start helix may be employed. It will be realised that if the helix is an open one the advantage of using an appreciable volume of air in the cable dielectric is realised. On the other hand a short pitch may be used where it is desired to make the finished cable resistant to radial pressure, for example, hydrostatic pressure, if the cable is submerged in water to an appreciable depth.

What we claim is:

1. In a high frequency coaxial cable, the combination of a non-conductive supporting core; a conductor surrounding said core and comprising a first conductive layer formed by conductive metal tapes arranged in edge-to-edge contact and applied to the core with a relatively long lay, and a second conductive layer consisting of a single metal tape applied longitudinally over and enwrapping the tapes of said first conductive layer with the edges of said single metal tape being substantially parallel to the axis of the cable; a binder of dielectric material helically applied over the second conductive layer tape; and an outer insulating envelope.

2. In a high frequency coaxial cable, the combination of a non-conductive supporting core; a conductor surrounding said core and comprising a first conductive layer formed by conductive metal tapes arranged in edge-to-edge contact and applied to the core with a relatively long lay, and a second conductive layer consisting of a single metal tape applied longitudinally over and enwrapping the tapes of said first conductive layer with the edges of said single metal tape being substantially parallel to the axis of the cable; a binder of dielectric material helically applied over the second conductive layer tape; and an outer insulating envelope composed of dielectric of the same composition as that used for the binder.

3. In a high frequency coaxial cable, the combination of a non-conductive supporting core; a conductor surrounding said core and comprising a first conductive layer formed by conductive metal tapes arranged in edge-to-edge contact and applied to the core with a relatively long lay, and a second conductive layer consisting of a single metal tape applied longitudinally over and enwrapping the tapes of said first conductive layer with the edges of said single metal tape being substantially parallel to the axis of the cable; a binder of dielectric material helically applied over the second conductive layer tape; and an outer insulating envelope composed of dielectric of the same composition as that used for the binder, and comprising mainly polythene.

4. In a high frequency coaxial cable, the combination of a non-conductive supporting core, which comprises mainly polythene, a first conductive layer formed of a plurality of conductive metal tapes enwrapping and extending longitudinally of the core, a second conductive layer comprising a metal tape applied longitudinally over and enwrapping said tapes, the edges of said metal tape of said second conductive layer being substantially parallel to the axis of the cable, a helically applied binder of dielectric material for holding the tapes to the core, an outer conductor, and an outer insulating envelope composed of dielectric of the same composition as that used for the binder.

5. In a high frequency coaxial cable, the combination of a non-conductive supporting core, which comprises mainly polythene, a first conductive layer formed of a plurality of conductive metal tapes enwrapping and extending longitudinally of the core, a second conductive layer comprising a metal tape applied longitudinally over and enwrapping said tapes, the edges of said metal tape of said second conductive layer being substantially parallel to the axis of the cable, a binder consisting of a comparatively narrow thread of dielectric material applied as an open helix for holding the tapes to the core, an outer conductor, and an outer insulating envelope composed of dielectric of the same composition as that used for the binder.

6. In a high frequency coaxial cable, the combination of a core, a conductor formed by a first conductive layer comprising conductive metal tapes arranged in edge to edge contact and applied to the core with a relatively long lay, said tapes being crimped, a second conductive layer consisting of a conductive metal tape applied over the said first conductive layer with the edges of said tape of said second conductive layer being substantially parallel to the axis of the cable, a binder of dielectric material helically applied over said second conductive layer, and an outer insulating envelope.

7. In a high frequency coaxial cable, the combination of a non-conductive supporting core, a first conductive layer formed by conductive metal tapes arranged in edge to edge contact and applied to the core with a relatively long lay, a second conductive layer consisting of a single metal tape applied longitudinally over and enwrapping said tapes of said first conductive layer with the edges of said single metal tape being substantially parallel to the axis of the cable, a binder of dielectric material helically applied over said second conductive layer, and an outer insulating envelope composed of dielectric of the same composition as that used for the binder, but having a lower melting point than the dielectric used for the binder.

8. In a high frequency coaxial cable, a non-conductive supporting core, a first conductive layer consisting of a plurality of metal tapes arranged in edge to edge contact and applied to the core with a relatively long lay, a second conductive layer consisting of a single metal tape applied longitudinally over and enwrapping the inner tapes of said first conductive layer and being arranged with its edges parallel to the axis of the cable, a helically applied binder of dielectric material applied over the tape of said second conductive layer and holding said tapes in position on said core, and an outer dielectric envelope supported on said helically applied binder.

9. In a high frequency coaxial cable as claimed in claim 1, a structure in which the binder consists of a thread having a thickness of about 0.2 inch.

10. In a high frequency coaxial cable as claimed in claim 1, a structure in which the tape constituting the second layer of the composite conductor is crimped for the purpose specified.

11. In a high frequency coaxial cable as claimed in claim 1, a structure including an outer conductor composed of a conductive tape means applied over the dielectric envelope with a long lay, and a pair of superimposed helically applied metallic binder tapes binding said outer conductor tape means in position, the turns of each

helix breaking joint and those of the upper helix covering the gaps between the turns of the lower helix.

JOHN NORMAN DEAN.
ESMOND WASSELL SMITH.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,944,004	Del Mar	Jan. 6, 1934
2,153,174	Collard	Apr. 4, 1939
2,204,737	Swallow et al.	June 18, 1940
2,223,116	Meyer et al.	Nov. 26, 1940

FOREIGN PATENTS

Number	Country	Date
834,165	France	Aug. 8, 1938
485,400	England	May 19, 1938