

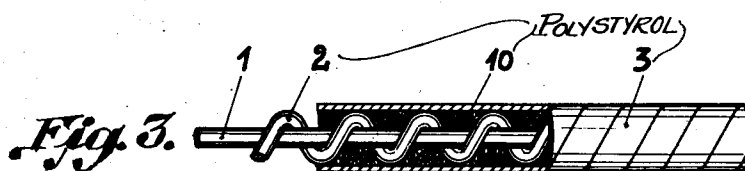
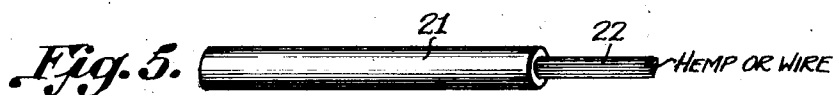
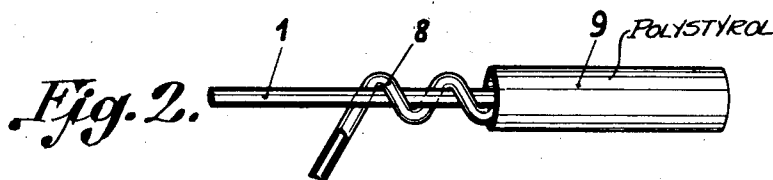
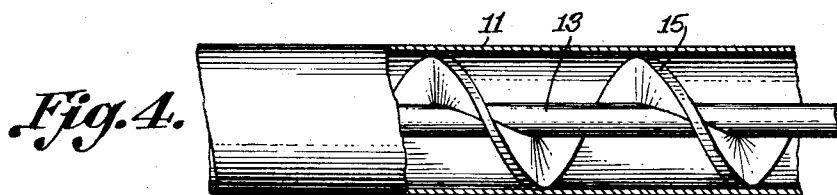
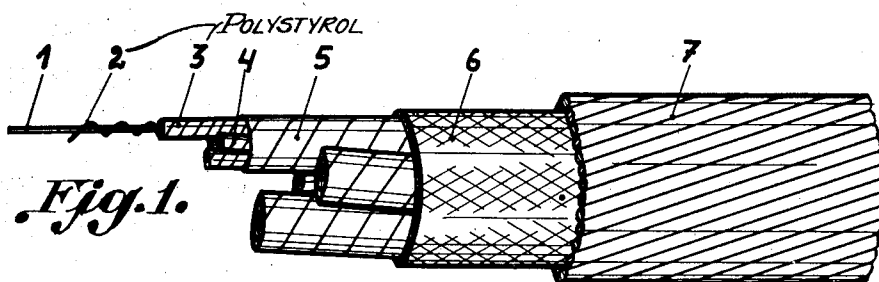
Oct. 4, 1938.

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2,131,987

ELECTRIC CABLE WITH AIR SPACE INSULATION

Filed Oct. 11, 1933



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2,131,987

ELECTRIC CABLE WITH AIR SPACE
INSULATION

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Application October 11, 1933, Serial No. 693,212
In Germany October 24, 1932

4 Claims. (Cl. 173—265)

It is known to reduce the capacity between the conductors of a telephone cable by surrounding the copper conductors with a paper and air space insulation, by first placing paper cord round the copper conductors and then winding thereon a covering of paper bands. By means of such insulated conductors it is possible to produce multi-conductor cables, between the conductors of which the dielectric constant of the dielectric is 1.6.

According to the invention the air space insulation of the conductors of the signalling cables is constructed of polystyrol, more particularly by means of threads, cords or bands of polystyrol, which are provided on the conductors, in the same way as paper threads, cords and bands. Such insulated conductors used either alone or stranded with other conductors into pairs, quads or groups of conductors of higher order, form the cable core, over which there is pressed an enclosing water-tight sheathing. The air space insulation may be constructed, more particularly in the case of land cables, by the simultaneous use of cords and bands of paper and polystyrol, a cord of polystyrol being placed round the copper conductor and a paper band winding round the said cord. The threads, cords and bands of polystyrol may be suitably used in a profiled form.

The properties which render pure polystyrol especially suitable for the formation of air space insulated conductors, as compared with other insulating substances, are its small dielectric constant ($\epsilon=2.5$), its very small angle of loss ($\tan \delta=0.2 \times 10^{-3}$), its inappreciably small water absorption and its good mechanical resistance.

An air space insulation constructed according to this invention has a dielectric constant which is at least equal to that of paper and air space insulation. Further, the small angle of loss of the polystyrol produces only small dielectric losses which, more particularly as regards high frequencies, are considerably less than the dielectric loss of paper and air space insulation. This is of special importance in the case of long land and submarine cables, since, as is well known, there is a gradual tendency to utilize the lines in a multiple way, by employing carrier frequencies, and since, in the case of small specific damping, the influence of the leakage is very noticeable. This is also of great importance in the case of cables for broadcasting and television, wherein use is made of comparatively high frequencies.

Further advantages of the air space insulation

constructed by means of polystyrol in contradistinction to paper, result from the property of the polystyrol of not being hygroscopic. Two improvements in the manufacture and in the mechanical construction of the signalling cable resulting from this property are to be especially referred to. As is well known, it is necessary to dry a paper and air space insulated cable before it is finally completed, in order to remove the moisture from the paper. This drying requires, more especially in the case of long cables, very expensive methods and apparatus. If according to this invention use is made of polystyrol for the construction of the air space insulation, it is possible to dispense with these drying processes, since the non-hygroscopic polystyrol does not contain or adsorb any moisture.

A further advantage which results from this property of polystyrol consists in that it becomes possible, in the case of air space insulated submarine cables, to replace the lead sheathing by a covering of gutta-percha or mixtures of polystyrol, gutta-percha, balata, pure or in admixture with caoutchouc, wax or like substances. The endeavours to use a covering of gutta-percha with air space insulated submarine cables have hitherto failed because the hygroscopic paper gradually draws moisture from the gutta-percha covering, whereby its electric properties are impaired. For this reason submarine cables, which are paper and air space insulated, have always been provided with an enclosing lead sheathing. By using polystyrol according to the invention this is no longer necessary. It is on the contrary possible to use especially light coverings of gutta-percha and similar substances which can easily be applied as an outer enclosing covering of the cable. The reduction in weight thereby secured is of great advantage in the manufacture and laying of submarine cables.

Owing to the great resistance of the polystyrol the air space insulation constructed according to this invention is considerably more resistant to pressures on all sides than paper insulation manufactured in the same way. Whilst cables having conductors which are paper and air insulated require a pressure protecting covering even at water depths of about 70 meters, a cable with conductors according to this invention can be used, as has been found by experiments, without any pressure protecting covering at water depths of about 1000 meters.

Hitherto, spacers provided on the conductors have generally consisted of cords and threads. According to one mode of carrying the invention

into effect use is made of tubular threads of polystyrol for the production of an air space insulation, instead of solid threads or cords. These tubular threads are wound round the copper conductors. Over this winding, there is then provided, for the completion of the insulation, a band winding or a hose-like covering, for instance of polystyrol.

Tubular threads of polystyrol can be manufactured with a very small wall thickness and yet possess throughout sufficient resistance to pressure so that an air space insulation constructed by means of tubular threads has a very small dielectric constant and the angle of loss is far below the value hitherto reached.

In order to render the insulation resistant also with respect to high outer pressures, with which the air space insulation constructed of threads, cords or bands as above referred to no longer can cope, without at the same time substantially impairing the dielectric properties, according to this invention, the air spaces between the individual turns of the winding are filled up by powdered or granular insulating substances of high dielectric values. Use may be made for this purpose of insulating ceramic materials, of powdered polystyrol, or of amber comminuted to powder. The powdered insulating material may be used in different degrees of fineness, according to the filling factor that is considered suitable in each particular case, for mechanical or dielectric purposes.

A further development of the invention relates to the construction of the air space insulation in cables with concentric arrangement of the conductors as used in high frequency transmissions, for instance in carrier frequency telephony or picture transmission. In the building up of the air space insulation in such concentric arrangements of conductors use is made of spacers between the inner and the outer conductor, which spacers consist of a material having high insulating properties and a dielectric constant, as small as possible.

According to the invention, the spacers are made of polystyrol. As compared with the most usual insulating substances used in the electrical industry, polystyrol has the special advantage that in the presence of moisture, its surface is not coated by a continuous layer thereof. The surface resistance of polystyrol, therefore, is not substantially reduced even when condensation water from the surrounding moist air is deposited on its surface with a change in temperature, since the moisture resolves itself into a number of individual small drops which are separated from one another by zones of high surface resistance. This is of special importance in the case of concentric arrangements of conductors, since the spacers of a line which has already been laid, as a rule is no longer directly accessible so that it is very desirable, when the line is being constructed, to use spacers of high quality, the insulating capacity of which is to a large extent independent of weather conditions and of other phenomena which would influence the moisture between the conductors.

The accompanying drawings illustrate, by way of example, several constructions with air space insulation constructed by means of polystyrol.

In the drawings:

Fig. 1 is a perspective view of one form of the cable constructed in accordance with the invention.

Fig. 2 is a perspective view illustrating a modified spacer element.

Fig. 3 is a perspective view partly in section showing another form of insulation.

Fig. 4 illustrates a modification of the invention as applied to concentric conductors and

Fig. 5 is a perspective view of an insulating thread provided with a tension resisting insertion.

Figure 1 illustrates a signalling cable in which the air space insulation of the conductors is constructed from threads and bands of polystyrol. The cable comprises four quads, each of which consists of four single conductors stranded together. The copper conductor 1 is surrounded by the thread 2 wound thereon in an open helix, a covering band winding 3 being placed thereon. Both, thread and band, are made of polystyrol. Four conductors, each constructed as just referred to, are stranded to a quad 4 and held together by a band of polystyrol 5. Four such quads stranded together form the cable core, which is surrounded by the water-tight sheathing 6 and the armouring 7.

Alternatively, the individual air space insulated conductors of the cable may be insulated in the manner shown in Figure 2. The copper conductor 1 is surrounded by a tubular thread 8, acting as a spacer, over which the covering 9 is placed, which consists of a tube of polystyrol.

Figure 3 illustrates a further modification of the air space insulation which is especially pressure resistant. As in the case of Figure 1 the copper conductor is surrounded by a thread and a band winding, 2 and 3 respectively. A granular mass 10, e. g. granular polystyrol, is placed in the gaps between the turns of the thread 2, the said mass preventing the insulation from being compressed.

Fig. 4 illustrates a modification of the invention as applied to concentric constructions of conductors.

In this figure, the outer tubular conductor 11 is supported by a profile band 15 of polystyrol serving as spacer and laid with a long pitch around the inner conductor 13.

It is possible to make bands and threads of polystyrol in such a manner that they are flexible. It has, however, been found that the polystyrol bands and threads which are otherwise crystal clear when they are wound on small diameters are easily clouded and have a milky appearance, from which it is concluded that the structure is too strongly stressed. Moreover, the resilient force inherent in the polystyrol bands and threads prevents the thread winding from lying firmly on the copper conductor and causes it to have a tendency to unwind and spring apart.

In order to avoid this, according to the invention, the bands and cords of polystyrol or like artificial substance are heated to about 70-80° centigrade, before they are wound on. This may be effected either by passing the threads or bands, between the storage reel and the winding on device, through a heated tube or, for instance in the manufacture of covered copper conductors, by arranging the whole of the winding device, including the storage reel, in a heated container.

When the bands and threads of polystyrol attain a temperature of 70-80° centigrade, they can be placed around the conductor without any resistance and they remain clear as crystal.

A drawback of the method described consists in that the tensional resistance of the threads decreases with increasing heating, so that the threads can be wound on only at a low speed if the danger is to be avoided that the threads

will break or that their thickness will change during the winding on. In order to overcome this drawback, according to another feature of the invention, as shown in Fig. 5 the threads 21 are provided with an insertion of tension resisting material, for instance hemp or wire 22. Such threads can be wound on at great speed also when in a heated condition, without breaking or without changing their thickness.

10 If small dielectric losses of the conductors have first to be taken into consideration in the manufacture of air space insulated conductors, it is an advantage to use metallic insertions in the threads of artificial substances. It is true that
15 in this way the capacity of the conductors during working is slightly increased. The position is just the opposite if non-conducting insertions, such as cotton yarns or hemp, are used. These do not cause an increase in the capacity during
20 working but a small increase in dielectric losses. In any case, however, the deterioration of the electrical values remains within very small limits.

Having now described our invention, what we claim as new and desire to secure by Letters Patent is:—

25 1. In an electrical conductor with air space insulation, a central metallic wire, an open helix of polystyrol wound around the metal wire, and a covering surrounding said wire and helix, the
30 helix thus forming a spacer between said covering and the metallic wire and providing the air

spacing, and the helix of polystyrol being in the form of a tube.

2. In an electrical conductor with air space insulation, a central metallic wire, an open helix of polystyrol wound around the metal wire, and
5 a covering surrounding said wire and helix, the helix thus forming a spacer between said covering and the metallic wire and providing the air spacing, and the helix of polystyrol being in the
10 form of a tubular thread with a tension-resistance insertion provided in the interior of said tubular thread.

3. In an electrical conductor with air space insulation, a central metallic wire, an open helix of polystyrol wound around the metal wire, and
15 a covering surrounding said wire and helix, the helix thus forming a spacer between said covering and the metallic wire and providing the air spacing, and a granular insulating substance in the free spaces between the turns of the spacer.
20

4. In an electrical conductor with air space insulation, a central metallic wire, an open helix of polystyrol wound around the metal wire, and
25 a covering surrounding said wire and helix, the helix thus forming a spacer between said covering and the metallic wire and providing the air spacing, and a granular insulating substance in the free spaces between the turns of the spacer consisting of powdered polystyrol.

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